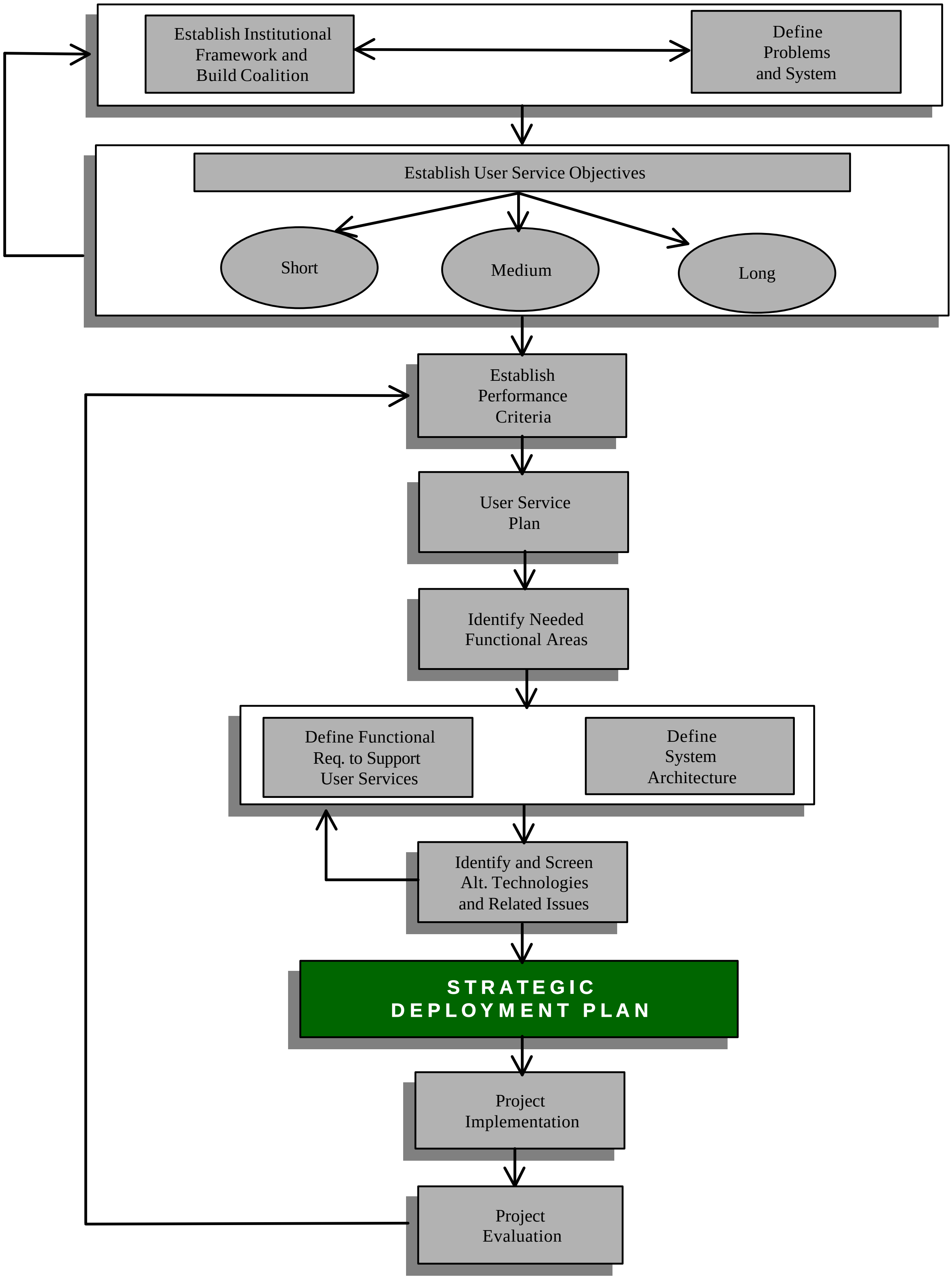
PENNSYLVANIA TURNPIKE COMMISSION

ITS EARLY DEPLOYMENT PROGRAM

STRATEGIC DEPLOYMENT PLAN



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PENNSYLVANIA TURNPIKE COMMISSION

ITS EARLY DEPLOYMENT PROGRAM

Strategic Deployment Plan

Prepared for: Pennsylvania Turnpike Commission

Prepared for: Frederic R. Harris

February 1996

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Section 1.0 Introduction

1.0 INTRODUCTION

The ITS Strategic Plan for the Pennsylvania Turnpike is following the basic ITS planning process established by the Federal Highway Administration (FHWA). This ITS Planning Process is shown in Figure 1-1. 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 have been completed as part of this project. The remaining two steps involve the actual implementation of the projects that are selected on the basis of these initial activities.

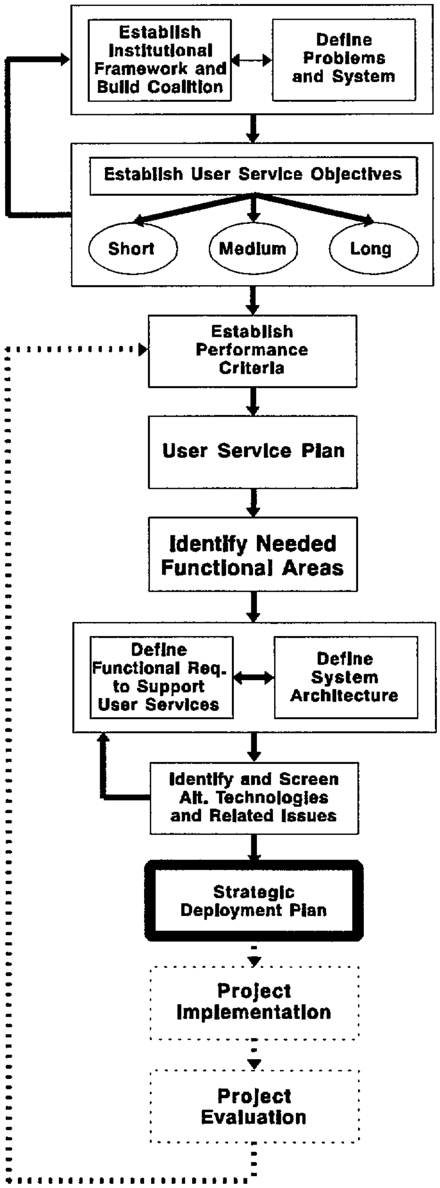


Figure 1-1
ITS PLANNING PROCESS

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 1, 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. This includes 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.

The content of this report is summarized below:

Section 2, Existing and Proposed Systems, sets the context for the project through its documentation of the current baseline conditions. This section includes discussion on traffic volumes, accidents, incident management, the Turnpike's Communications Center, and other existing and proposed ITS projects in the area.

Section 3, Institutional Framework, identifies several aspects of the organizational structures within which ITS projects will be implemented. These aspects include identification of the major management positions within the Turnpike, revenue sources, the way the Turnpike interfaces with other agencies, the units of the Turnpike that will be closely involved with the design and deployment of ITS projects, and potential funding sources for ITS projects.

Section 4, Problem Definition and Opportunities, describes the extensive Outreach Program designed to obtain input from the various user groups that are affected by the operation of the Turnpike, including key personnel of the Turnpike and staff of nearby Pennsylvania Department of Transportation districts. These user groups included patrons at the service plazas, AAA members and their representatives, users of the Irwin Park & Ride lot, Commercial Vehicle Operators, traffic information providers, bus company managers, and managers of several major trip generators located along the Turnpike. A synthesized set of problems and opportunities that can be addressed by ITS initiatives is presented in the conclusion.

Section 5, User Service Objectives, presents the analysis that determined a core group of twelve ITS User Services that reflect the problems and opportunities previously identified. The section also reports on the assignment of short, medium, or long-term priorities to these User Services and the procedure used to determine these assignments.

Section 6, Performance Criteria, reports on the factors that were considered in selecting a set of performance criteria for the Turnpike's ITS deployment program. These criteria will be used to monitor changes in the quality of the core group of User Services that are brought about through the implementation of various ITS projects.

Section 7, Responsibilities of the Turnpike and Other Organizations, lays the groundwork for the development of funding scenarios by identifying the various groups that are involved, or could be involved, with the implementation of various aspects of the User Services. Section 7 also clearly points out that there are several User Services for which the Turnpike has little or no implementation responsibility.

Section 8, Functional Requirements, identifies the various sets of functional areas, known as alternative system configurations, which implement the user services and satisfy the regional goals. The alternative systems were evaluated at different levels of implementation and a preferred system configuration for each user service was selected from these alternatives.

Section 9, System Architecture, describes the characteristics of the equipment and the software that compose the recommended system, as well as the communication links between these components. This description includes a review of the design concepts that were used in developing the recommended architecture and an overview of how the roadside equipment, headquarters equipment, and remote user equipment work together to implement the ITS User Services. A detailed description of the individual subsystems is contained in Appendix 0.

Section 10, Implementation Plan, identifies the priorities of the functions that are associated with the User Services that will be implemented in the short-, medium-, and long-term A list of recommended projects is presented, along with figures that show the relationship among the projects recommended for implementation in the short-term and medium-term. A sample of the detailed project descriptions that are contained in the Appendix P is also presented. The section concludes with a discussion of alternative funding sources, and an introduction to the considerations that should be reflected in an operations plan.

Appendices containing details of the work performed have also been provided as part of this document.

Section 2.0 Existing and Proposed Systems

2.0 EXISTING AND PROPOSED SYSTEMS

2.1 General Background

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.

Within Pennsylvania, the mainline of the Turnpike is one of the state's three major east-west highways and the only road that directly links together the major metropolitan centers of Pittsburgh, Harrisburg and Philadelphia. The northeast extension provides further connectivity between these metropolitan areas and the cities of Allentown, Wilkes-Barre, and Scranton.

In summary, the Pennsylvania Turnpike is a major component of the Interstate Highway system and plays an important role in the national movement of people and goods by providing connections via key interchanges to:

- commercial airports in Pittsburgh, Greensburg, Johnstown, Altoona, Harrisburg, Lancaster, Reading, Philadelphia, Lehigh Valley and Wilkes-Barre, Scranton;

- the Pittsburgh, Harrisburg, and Philadelphia areas for private vehicle operators utilizing the highway as part of their daily commute;

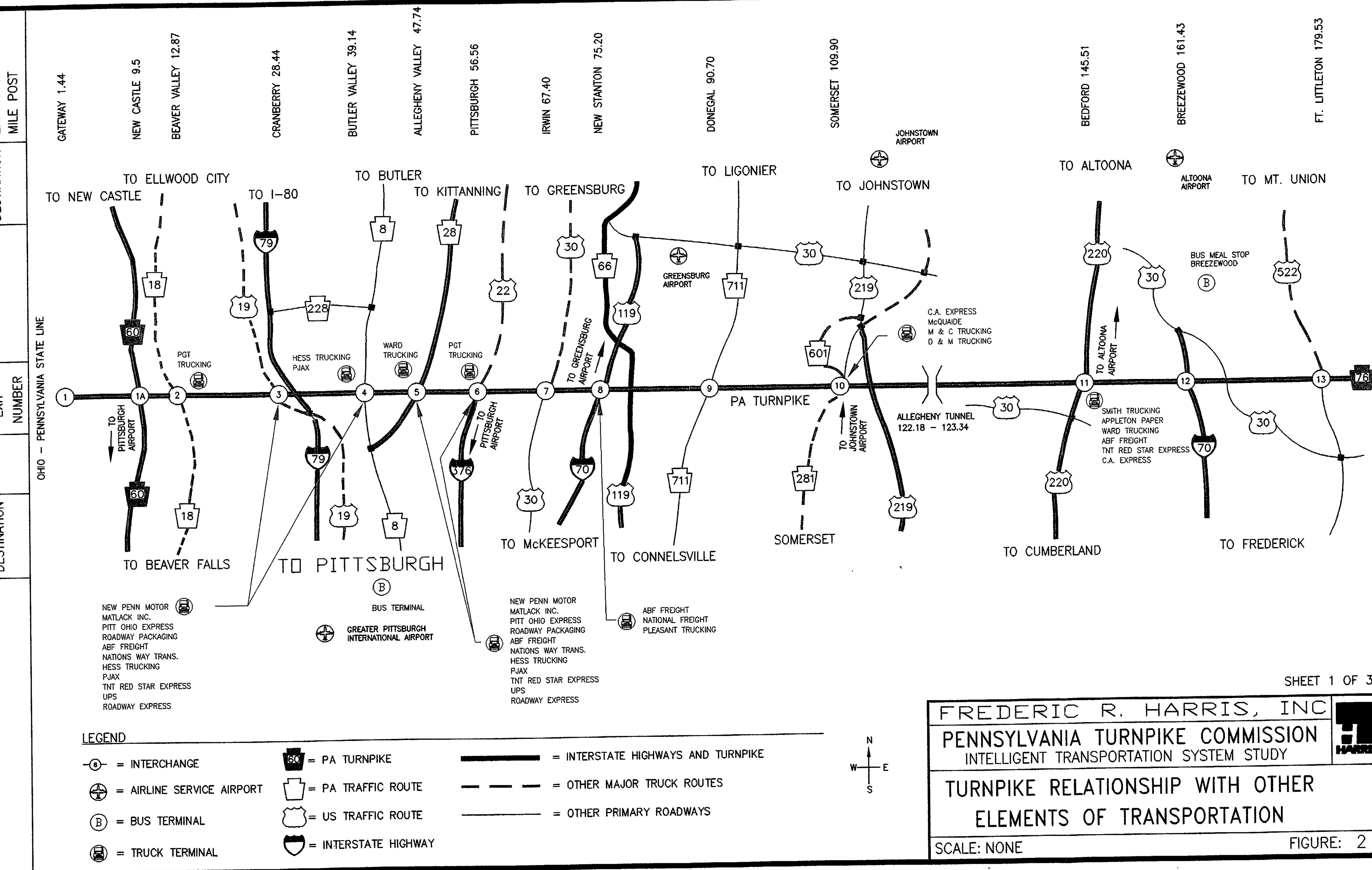
- terminals and transfer points ofvarious bus and trucking firms that have located their facilities near the Turnpike's interchanges; and

- many major trip generators such as the Seven Springs and Hidden Valley resort areas, other private or state recreation areas, the Rossmoyne Business Park, Regional Industrial Development Centers, and major shopping centers across the state.

Figure 2 shows the extensive transportation relationships the Turnpike has within Pennsylvania and with the eastern portion of the nation.

2.2 Turnpike Traffic Volumes

The Turnpike is extensively utilized by both private and commercial vehicle operators. Traffic entering the Pennsylvania Turnpike has grown to more than 114,000,000 total vehicles in 1994, which represents an increase of 4.2% from the previous year. This 1994 traffic volume consists of just over 100,000,000 passenger vehicles or 87.7% of the total The remaining 12.3% of the entering traffic volume consisted of commercial vehicles. It should be noted, however, that in 1994 the commercial vehicle traffic accounts for 46% of the total $288,000,000 in revenue collected by the Turnpike. In addition, the percent increase in commercial vehicle traffic between 1993 and 1994 was 7.2%, almost twice the increase in passenger vehicle traffic growth.



SHEET 1 OF 3

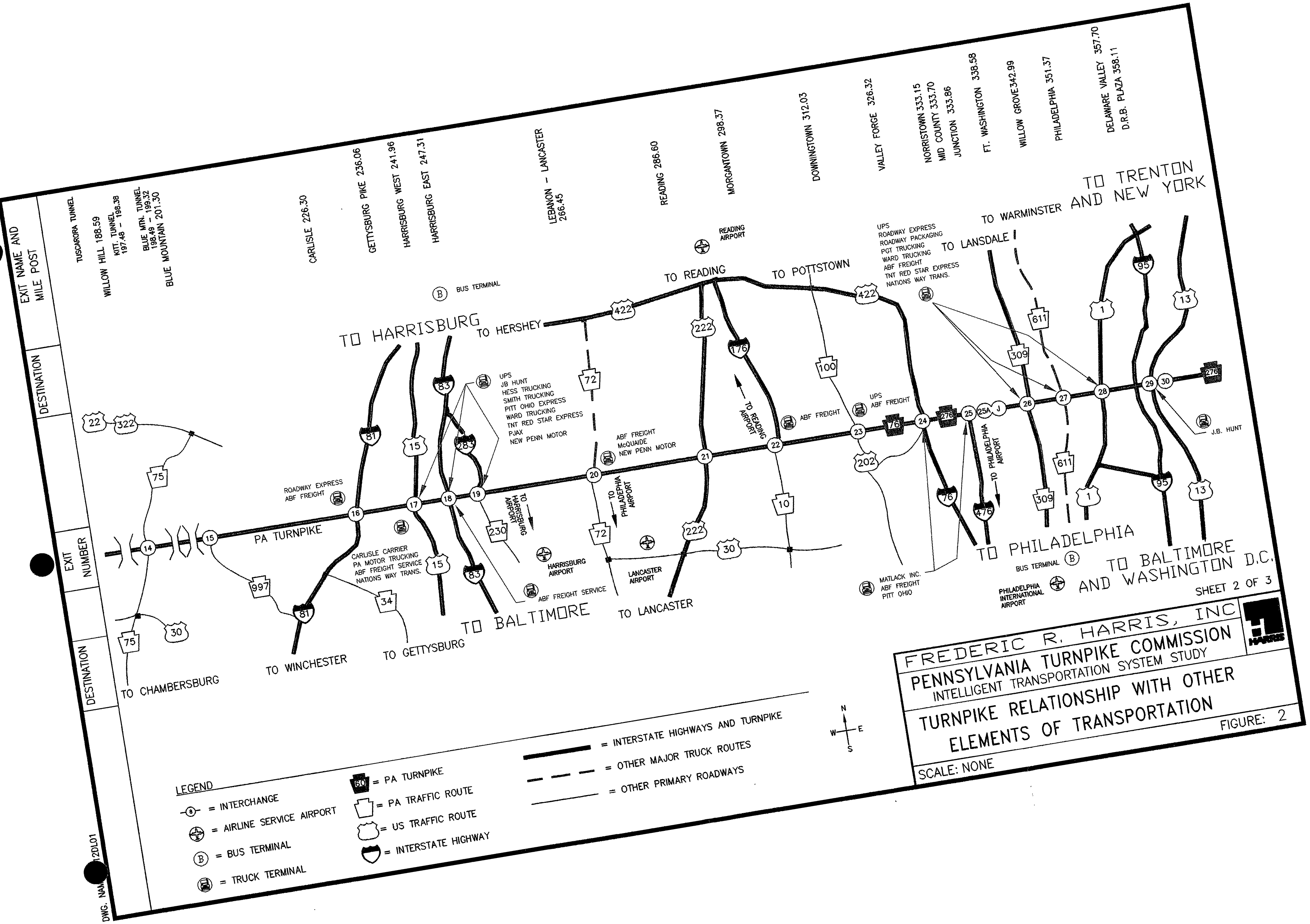
FREDERIC R. HARRIS, INC

PENNSYLVANIA TURNPIKE COMMISSION
INTELLIGENT TRANSPORTATION SYSTEM STUDY

TURNPIKE RELATIONSHIP WITH OTHER ELEMENTS OF TRANSPORTATION

SCALE: NONE

FIGURE: 2



EXIT NAME AND MILE POST
TUSCARORA TUNNEL
WILLOW HILL 188.59
KITT. TUNNEL 197.48 – 198.38
BLUE MTN. TUNNEL 198.49 – 199.32
BLUE MOUNTAIN 201.30
CARLISLE 226.30
GETTYSBURG PIKE 236.06
HARRISBURG WEST 241.96
HARRISBURG EAST 247.31
LEBANON – LANCASTER 266.45
READING 286.60
MORGANTOWN 298.37
DOWNINGTOWN 312.03
VALLEY FORGE 326.32
NORRISTOWN 333.15
MID COUNTY 333.70
JUNCTION 333.86
FT. WASHINGTON 338.58
WILLOW GROVE 342.99
PHILADELPHIA 351.37
DELAWARE VALLEY 357.70
D.R.B. PLAZA 358.11
DESTINATION
EXIT NUMBER
DESTINATION
TO HARRISBURG
TO HERSHEY
TO READING
TO POTTSTOWN
TO LANSDALE
TO WARMINSTER
TO TRENTON AND NEW YORK
READING AIRPORT
BUS TERMINAL
UPS
JB HUNT
HESS TRUCKING
SMITH TRUCKING
PITT OHIO EXPRESS
WARD TRUCKING
TNT RED STAR EXPRESS
PJAX
NEW PENN MOTOR
ABF FREIGHT
McQUAIDE
NEW PENN MOTOR
ABF FREIGHT
UPS
ABF FREIGHT
UPS
ROADWAY EXPRESS
ROADWAY PACKAGING
PGT TRUCKING
WARD TRUCKING
ABF FREIGHT
TNT RED STAR EXPRESS
NATIONS WAY TRANS.
ROADWAY EXPRESS
ABF FREIGHT
PA TURNPIKE
TO READING AIRPORT
TO HARRISBURG AIRPORT
TO PHILADELPHIA AIRPORT
TO PHILADELPHIA AIRPORT
J.B. HUNT
CARLISLE CARRIER
PA MOTOR TRUCKING
ABF FREIGHT SERVICE
NATIONS WAY TRANS.
HARRISBURG AIRPORT
ABF FREIGHT SERVICE
LANCASTER AIRPORT
MATLACK INC.
ABF FREIGHT
PITT OHIO
BUS TERMINAL
PHILADELPHIA INTERNATIONAL AIRPORT
TO PHILADELPHIA
TO BALTIMORE AND WASHINGTON D.C.
TO BALTIMORE
TO LANCASTER
TO WINCHESTER
TO GETTYSBURG
TO CHAMBERSBURG
SHEET 2 OF 3
LEGEND
= INTERCHANGE
= AIRLINE SERVICE AIRPORT
= BUS TERMINAL
= TRUCK TERMINAL
= PA TURNPIKE
= PA TRAFFIC ROUTE
= US TRAFFIC ROUTE
= INTERSTATE HIGHWAY
= INTERSTATE HIGHWAYS AND TURNPIKE
= OTHER MAJOR TRUCK ROUTES
= OTHER PRIMARY ROADWAYS
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FREDERIC R. HARRIS, INC
HARRIS
PENNSYLVANIA TURNPIKE COMMISSION
INTELLIGENT TRANSPORTATION SYSTEM STUDY
TURNPIKE RELATIONSHIP WITH OTHER ELEMENTS OF TRANSPORTATION
FIGURE: 2
SCALE: NONE
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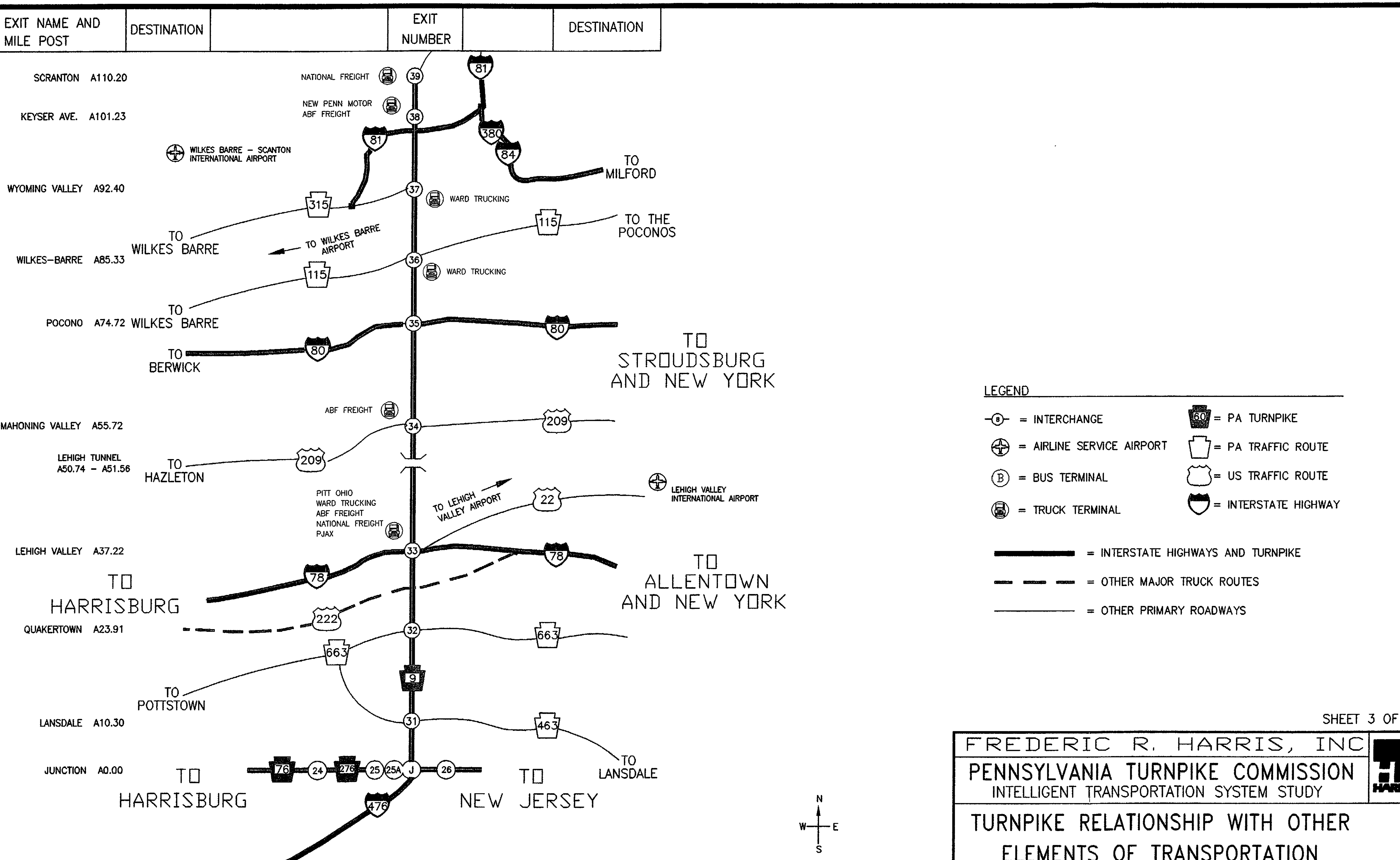


SHEET 3 OF 3

FREDERIC R. HARRIS, INC

PENNSYLVANIA TURNPIKE COMMISSION
INTELLIGENT TRANSPORTATION SYSTEM STUDY

TURNPIKE RELATIONSHIP WITH OTHER ELEMENTS OF TRANSPORTATION

SCALE: NONE

FIGURE: 2

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

The recent increases (between 1993 and 1994) in commercial vehicle volumes together with those demonstrated for the tie-year analysis period at key interchanges on the Turnpike emphasizes the increasingly important role the Pennsylvania Turnpike plays in commercial transportation throughout the eastern portion of the nation and within Pennsylvania. This fact is further supported by available system-wide data indicating that the average truck trip length (60.8 miles/trip) was nearly twice that of the average passenger vehicle trip length (3 1.9 mile&rip) from June 1993 through June 1994. The highest percentage of truck traffic on the mainline was found to occur between the New Stanton (8) and the Carlisle (16) Interchanges, which is the Turnpike's route through the Allegheny Mountains,

2.3 Accident Data

The Turnpike Commission is continually working to improve the safety conditions along the highway. This emphasis on improved safety conditions is partially reflected in the low rate of injuries and fatalities on the highway. Despite continual improvements, there are still several areas that are "hot spots" for accidents. An identification of mile-long segments demonstrating locations along the Turnpike where the highest number of accidents recently occurred was performed using accident data from 1992, 1993 and 1994. These data were used to generate the total number of accidents that occurred in one-mile intervals. Mile intervals which included an interchange were further highlighted. Figure 3 shows the 23 one-mile intervals with the highest number of total accidents.

The segment with the greatest number of accidents was in the vicinity of mile marker 333 (Mid County Interchange 25A) where traffic volume increases have been the greatest. In addition, the number of accidents from mile marker 326 at the Valley Forge Interchange (24) thru mile marker 35 1 at the Philadelphia Interchange (28) was significantly higher than in any other section of the Turnpike. Although these conditions may be partially attributable to a severe ice storm during the winter of 1994, the fact is the area of high accident locations occurs in the area of the Turnpike carrying the largest volumes. Likewise, at the western end of the Turnpike, several other mile long segments with high numbers of accidents occur in the vicinity of interchanges serving the Pittsburgh area.

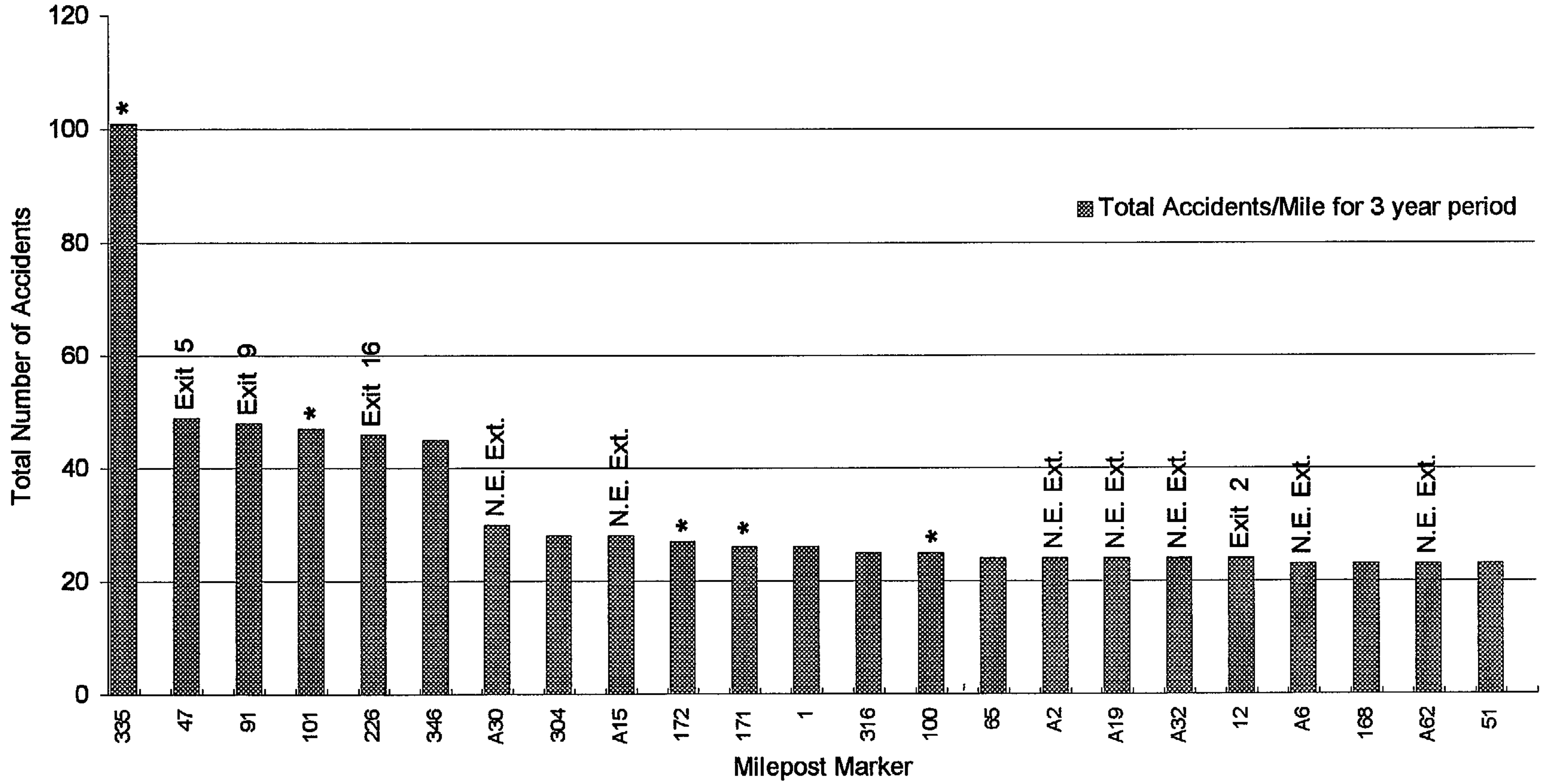
2.4 Incident Management

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
- * 11 Cellular telephone service
- Emergency 800 telephone service

ACCIDENT LOCATIONS FOR 1992, 1993, 1994

Pennsylvania Turnpike Commission



* - Roadway segment lies adjacent to a segment already plotted

FIGURE 3

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Since 1989 a system of push button call boxes placed at one-mile intervals along the Turnpike mainline has been used for identifying incidents. These call boxes allow the motorist to indicate the type of assistance needed by pushing a button for vehicle service, medical service, police assistance, or to report an accident. This indication is transmitted to the Turnpike's Communication Center through a microwave radio system The distribution of the types of assistance requested through these call boxes is shown in Figure 4.

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 also directly linked to the Communications Center. Figure 5 shows the volume of communications traffic handled by the Communications Center from a variety of different sources. As can be seen in this figure, 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. This system is supplemented by a rotation of Senior Turnpike Personnel acting as Duty Officers who can commit additional Turnpike resources to the clearance of an incident and who will provide a report of the incident to higher levels within the Turnpike organization. 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.

2.5 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 routine maintenance and law enforcement activities.

The Turnpike's communication equipment is upgraded on an annual basis as funds allow. Unfortunately, many of the key features of this 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 improvements to the microwave system have been funded to date. The funds necessary to provide the Communications Center with additional

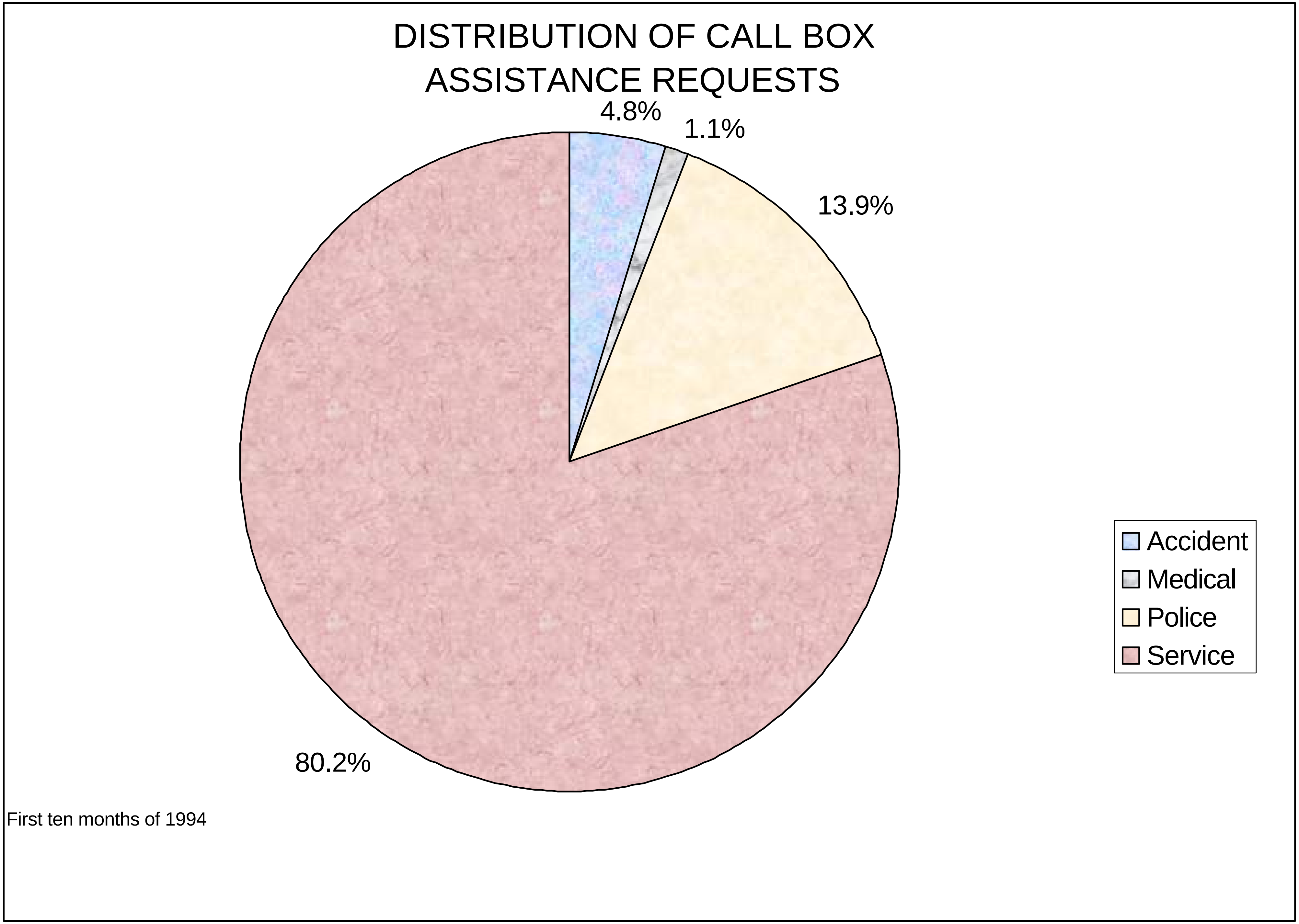

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FIGURE 4

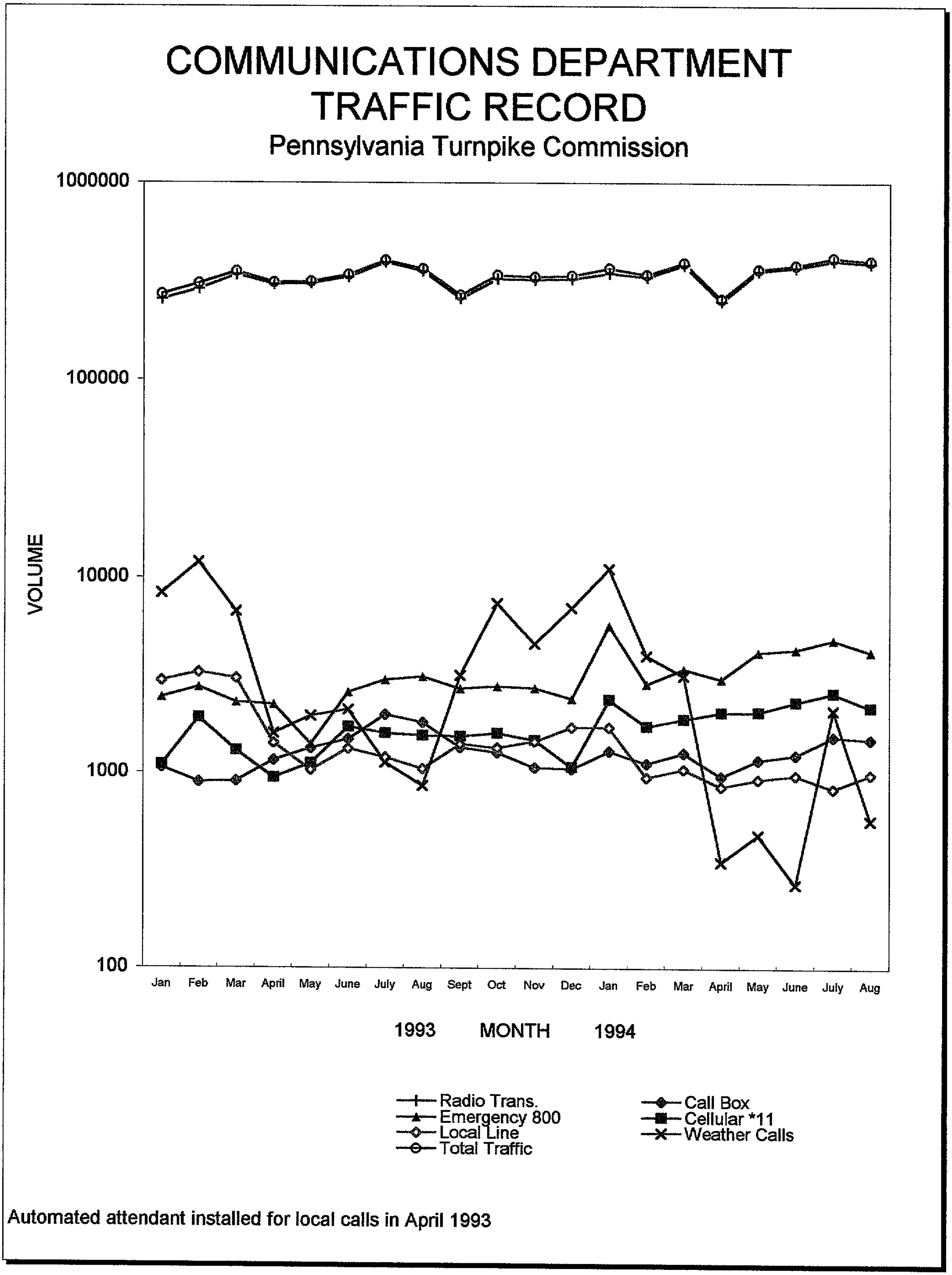


FIGURE 5

PENNS.XLS

state-of-the-art equipment have not been allocated. A summary of the age, quantity and locations of the major components of this system is included in Appendix A.

The Communications Center is in part hampered by a lack of personnel. The Center functions today with virtually the same number of people that it did 30 years ago, in spite of the ever increasing volume of communications traffic The situation results in a constant need for overtime work by the existing personnel Data from 1992 through 1994 shows an average overtime requirement each year that amounts to the equivalent of approximately three extra people. This overtime is also reflected in a major financial expenditure. Between 1992 and 1994 the annual cost of overtime work by Communication Center personnel climbed from $90,000 to more than $130,000.

2.6 Coordination with Existing and Proposed ITS Projects

In addition to the Pennsylvania Turnpike, PennDOT and the I-95 Corridor Coalition are also moving ahead with ITS projects in Pennsylvania. The following points briefly describe the ITS programs underway by PennDOT and the I-95 Coalition:

- **PennDOT, District 4-O - Wilkes-Barre, Scranton** is moving ahead with an early deployment study for a motorist advisory and incident management ITS project for the Wilkes-Barre and Scranton areas. The study is scheduled to begin in early 1996 with a one year duration.

- **PennDOT, District 6-O - Philadelphia** has constructed a limited ITS installation on I-95 that includes closed circuit televisions (CCTV) units and Variable Message Signs (VMS). The existing installation extends from the Philadelphia International Airport north to the Allegheny Street Exit.

  Other projects include a study of traffic monitoring and incident management systems for I-476 (Blue Route), activation of pavement detector loops on I-476 from I-76 to the Mid County Plaza and begin operation of a CCTV at the 1-76/I-476 interchange, and the installation of CCTV and VMS units on U.S. Route 202 from Ring of Prussia southwest to U.S. Route 30. These projects may interface with various Turnpike Interchanges. Activation of the loop detectors on I-476 and operation of CCTV at I-76/1-476 interchange is scheduled to begin in the midsummer of 1996. A construction schedule for the remaining projects is not currently available.

- **PennDOT, District 11-O - Pittsburgh is** proceeding with final design of a traffic surveillance and advisory system on the Penn Lincoln Parkway (I-376 and I-279) that will extend from the Turnpike Interchange 6, near Monroeville, to the 1-79/I-279 interchange. This 20-mile installation will include 27 CCTV cameras, 4 HAR stations, 8 VMS units, a communications system, and a new traffic management center to be constructed at the District Office in Bridgeville. Construction is scheduled for 1997.

District 11-O is also involved with an early deployment study for installation of ITS technology along the I-79 corridor extending from Washington, Pennsylvania north to Erie, Pennsylvania. This will interface with the Turnpike at Interchange 3 near Cranberry Township. The study is anticipated to begin by early 1996 with a one year duration.

- **I-95 Corridor Coalition - Philadelphia Area** is 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

Section 3.0 Institutional Framework

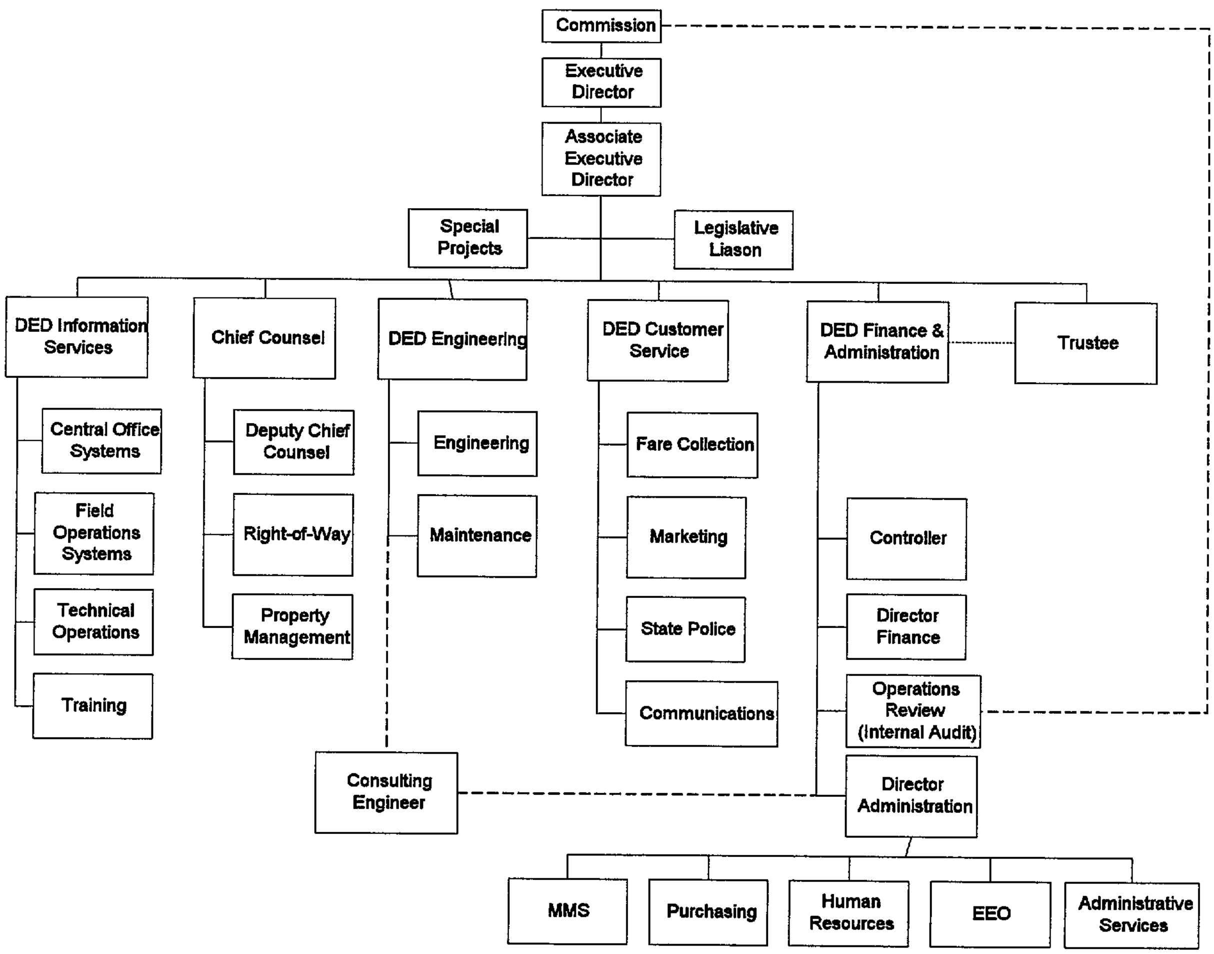
PENNSYLVANIA TURNPIKE COMMISSION

3.0 INSTITUTIONAL FRAMEWORK

The Pennsylvania Turnpike, 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 Senate.

3.1 Management Structure

Ongoing operations for the Pennsylvania Turnpike are carried out according to the management structure illustrated in the flow diagram below:



3.2 Toll System Operation and Revenue Sources

The Pennsylvania Turnpike is responsible for the operation and maintenance of more than 500 miles of toll roads. Revenues for the operations and maintenance of the Turnpike are secured primarily from user tolls. Recent state legislation also allocated 14% of Pennsylvania's Oil Franchise Revenue to the Turnpike annually. These funds may only be used on Act 26 projects. In addition, the Intermodal Surface Transportation Act of 1991 provided some opportunities for use of federal funds in constructing improvements to toll facilities. Currently, the bulk of state and federal monies received by the Turnpike is used for construction of committed toll road extensions. Additional construction funding for the toll road extensions was secured through bond financing.

Trust indenture established in conjunction with the sale of bonds requires an independent Consulting Engineer, currently Michael Baker Jr., Inc., to provide ongoing review of the Turnpike's 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.

3.3 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.

A unique agency coordination effort for ITS exists with the I-95 Corridor Coalition. The Coalition is a multi-state coordination agency established to provide a unifying force among the transportation agencies responsible for the operations of I-95 and the major intersecting routes extending from Maine to Virginia. The mission of the Coalition is to coordinate the efforts of the member agencies to create a seamless, state-of-the-art, multi-modal transportation network throughout the Northeast Corridor.

3.4 ITS Project Design Development

Design development and implementation of an ITS program will involve input from many of the functional departments of the Turnpike, as well as PennDOT and the FHWA. Currently, the

Turnpike has an internal committee “the ITS Working Group” that reviews design parameters, establishes 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 clients, i.e., system users. During the strategic planning phase input provided by motorists, AAA, traffic monitoring services, truck companies, bus companies and service plaza operators proved extremely valuable in defining user needs. This source of input should be continued through either a formalized advisory committee or informal meetings with various turnpike user groups.

Focus group meetings arranged and facilitated by the Marketing Department proved very effective in data gathering from the trucking industry, and AAA and could serve as the blueprint for future informal meetings.

3.5 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 for both design and construction of ITS projects is contingent on inclusion of the project on the annual improvement program These ITS projects must compete with other transportation related projects for funding Furthermore, 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 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 Pittsburgh and Philadelphia, by the Southwestern Pennsylvania Regional Planning Commission and the Delaware Valley Regional Planning Commission, respectively. The level of FHWA funding could range from 50% to 80%. Use of federal funding will require review and approval of all phases of the project by the FHWA and PennDOT as their funding conduit.

In general the use of the federal funds could substantially lengthen the project schedule for design and construction as compared to a typical PTC funded improvement.

Recent experience in the ITS marketplace and input gathered from various Pennsylvania 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 in-kind federal fund contributions toward the design and construction of specific ITS applications. Several potential projects identified during the Strategic Development Phase include:

- Truck Staging Areas for trailer storage and transfer located at key interchanges. Areas should include minimal level of driver services, i.e., rest areas, telephones, etc.

- Truck ID & Electronic Location Systems to identify specific owner trucks at key interchanges and alert local owner terminals to their arrival.

- Private installation of fiber optic communications cabling in PTC right-of-way with defined utilization privileges by PTC.

- Installation of Variable Message Sign (VMS) equipment to provide various motorist information messages. The use of VMS signs for information other than emergency traffic or weather related remains under debate by the ITS community.

- Privately operated, traffic information services could potentially serve the Turnpike in several ways.

  Currently the Turnpike has no formal agreements with any of the private traffic information companies serving the Pittsburgh, Harrisburg or Philadelphia areas. Historically these businesses have provided incident information to the Turnpike on an incident by incident basis. Lacking any formal arrangement, the services have provided traffic information to the Turnpike when it was convenient to do so. Better use of these services could be achieved by formalizing an arrangement between the Turnpike and traffic services including definition of the type and frequency of data needed.

  Secondly, several private traffic information companies have expressed an interest in providing manpower and equipment to assist in the operations of existing or proposed Traffic Management Centers. This offer has been extended to PennDOT in conjunction with their ITS projects in Pittsburgh and Philadelphia. However, the department for various reasons has not pursued this type of a partnership.

Section 4.0 Problem Definition & Opportunities

4.2 AAA Patron Survey/Irwin Park & Ride

To increase the survey response for Turnpike users who commute to/from work, as well as solicit input from nonusers, surveys were conducted at the Irwin Park & Ride lot (29 interviews) and others were administered by AAA to their members at various offices throughout Pennsylvania (177 interviews) that were in close proximity to the Turnpike. The survey form, together with a complete listing of important survey findings as well as a table summarizing the responses to each question, is contained in Appendix C. The following are selected highlight results of this survey:

- Nearly 30% of those surveyed use the Turnpike as part of their normal trip to work.
- Congestion and construction information, including the location and length of delays were the most important types of information to the motorists surveyed, followed by alternate routes. Information on weather conditions was not found to be as important
- The top choice for how these motorists would like to receive information was via TV at home or work. This was followed by commercial radio in the vehicle, a Turnpike information radio station (HAR) and Variable Message Signs along the roadway.
- Approximately 30% of those surveyed would be interested in using ETTM / E-Zpass even if a nominal fee was charged for the service.

4.3 Commercial User Group Survey

Nineteen commercial trucking firms participated in the commercial user group survey. Fourteen firms were interviewed via focus group meetings conducted in Pittsburgh, Breezewood, Harrisburg and Philadelphia. The other five firms were interviewed by telephone. The trucking firms interviewed were principally Turnpike account holders and varied in both size and function. Firms that participated included Jevic, J.B. Hunt, UPS, Roadway, Pitt-Ohio, RPS and Smith Transport. A copy of the commercial user group questionnaire, a listing of survey result highlights, together with a tabular summary of the results of the survey responses, is included in Appendix D. Also included in this appendix is a summary of the comments received from the commercial vehicle operators (CVO) during the focus group meetings. The following points highlight selected results of the commercial user group survey and comments received during the CVO focus group meetings:

- The location and length of a delay or congestion were the most important type of information to the truck drivers, followed by alternate routes, construction information and weather condition information
- The four top choices for how truck fleet operators and managers would like their drivers to receive information included a computer bulletin board service, FAX, commercial radio in the vehicle, and/or Variable Message Signs along the roadway.

- When asked if their company would be interested in using an electronic toll collection systemthat would enable their trucks to pay tolls automatically (with the addition of a nominal fee for the service), 30% said YES, 24% responded NO, and the remaining were undecided. Based on the focus group discussions, they are interested in improving the accounting aspect of the current billing system much more than getting another gadget put on their vehicles.

- CVOs generally liked the current Turnpike billing system the fax system for obtaining static information and the overall responsiveness to incidents.

- CVOs dislikes included single-lane operations through tunnels, ETTM on large fleets, elimination of wide areas on shoulders, and privacy concerns with toll charge reports.

- CVOs felt that there needed to be improved coordination with the Turnpike, regarding Hazmat incidents. Even with call boxes there is a long time span before the Turnpike or the trucking operator can identify that it is a Hazmat or larger truck incident and get the right equipment at the scene to handle the problem

- CVOs also want the Turnpike to be as user-friendly to commercial vehicle drivers as possible by providing more truck parking, shower facilities, AT&T phone service and/or tractor trailer storage, staging and transfer areas.

- Finally, CVOs want to be able to access and summarize account information "On-line" while providing more flexibility in formatting charge reports.

4.4 AAA Representatives Interviews

A focus group meeting was also conducted with representatives from six affiliated AAA clubs across Pennsylvania, as well as representatives from the Pennsylvania Federation of AAA and the Pennsylvania Travel Council The meeting provided insight into the needs of AAA members while allowing representatives of PTC to explain their operations and possible ways to coordinate information between the groups.

The following significant points were made during the focus group meeting:

- Many AAA members call to obtain real-time weather and roadway condition information Thus it would be beneficial for AAA offices to have access to whatever information network is established by the Turnpike.

- AAA members **regularly** request information on toll costs, service plaza locations, cellular *11 system and gas prices. AAA suggested that it could be included as part of TripTiks given out to members.

- It was also suggested that the Turnpike submit articles for publication in local AAA newsletters on a regular basis.

A further summary of comments received from representatives of AAA during the focus group meeting is included in Appendix E.

4.5 PennDOT District Staff and Other Public Agency Interviews

Interviews with PennDOT District staff were conducted either via telephone or face-to-face. This included PennDOT District traffic engineers and weather monitoring managers. Appendix F contains a summary of the comments received during meetings held with representatives of the various PennDOT District offices that share interchanges with the Pennsylvania Turnpike. These meetings centered around ITS technology currently in place or planned within the respective district, any traffic/information problems or insights at the Turnpike Interchanges, and any opportunities for implementation or coordination of ITS strategies between PennDOT the State Police and the Pennsylvania Turnpike Commission.

Interviews were also conducted with representatives of the Ohio Turnpike and West Virginia Department of Transportation regarding ITS applications. No significant projects or studies are underway or anticipated in the near future. The Ohio Turnpike does have a few limited ITS applications in place as part of a public/private partnership with trucking companies.

Ongoing activities at the eastern terminus of the Turnpike are being coordinated via the I-95 corridor coalition of which the Turnpike is a member.

4.6 Commercial Vehicle Operators

As part of the patron surveys conducted at the Turnpike rest areas, truck drivers and bus drivers were interviewed. These survey responses are compiled and summarized with the PTC patron survey database information included in Appendix B of this report.

4.7 Interviews with Traffic Information Providers

Interviews were conducted with traffic information providers serving Pittsburgh, Harrisburg and Philadelphia. These information providers included Metro, Traffax and Shadow, respectively. Key issues identified by these providers are summarized below:

- Real-time information on congestion, accidents and delays is crucial to their operations.

- PTC FAX reports are good for construction delays, closures, and large incidents; however, they are not a reliable source of real-time data.

- There should be a central point of contact for real-time information.

- All are interested in receiving video feeds and providing audio feeds for HAR stations, message feeds for VMS, etc.

- Several are establishing computerized Bulletin Boards/Internet home pages.

- Media Distribution would like to receive their information electronically.

4.8 Bus Companies

Interviews were conducted with three commercial bus operators, including Butler Motor Transit Company (Butler, PA), DeBolt Bus Company (Homestead, PA) and Anderson Bus and Tour. Key points identified are as follows:

- Weather information would be useful, particularly during closed conditions. Currently available weather information is unreliable and is not used.

- None of the companies currently receive regular information from the Turnpike FAX system on construction or other delays.

- Information on service plaza congestion provided to bus operators via HAR or VMS would be useful.

- ETTM is not of any particular value.

4.9 Major Traffic Generator Interviews

Interviews were conducted with four major traffic generators including Seven Springs Mountain Resort, Hidden Valley/Four Seasons Resort, RIDC Business Park near Cranberry Township, Pennsylvania and Rossmoyne Business Center in Lower Allen Township. Key issues are summarized below:

- Business centers did not identify any concerns about current Turnpike operations. They suggested information be made readily available on road conditions and delays, and that this information could be displayed at hotels and other establishments within the business parks.

- Recreational complexes requested information be made available on road conditions and that informational bulletin boards be installed at the service plaza to provide current information on ski conditions.

- In general, they have not had much cooperation from the Turnpike in promoting the resort areas, however the Turnpike is not aware of any specific requests for cooperation.

4.10 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. The following PTC Departments were interviewed:

- Communications
- Engineering
- Engineering Facilities
- Fare Collection
- Information Services
- Maintenance
- Marketing
- Pennsylvania State Police, including Troop ‘T”
- Baker Engineers

A complete set of the summary statements is contained in Appendix G. It should be noted that these statements are organized by the subject of the comments and not by the source of the comments. Most of the individuals who were interviewed had comments on the activities performed by other units which effect their ability to operate their own unit efficiently.

4.11 Interviews of PTC Maintenance Department

Interviews with each of the five PTC District Maintenance Superintendents were also conducted, with the exception of Al Ostrowski, who was on vacation. In his absence, we spoke with Harold Wenner. A summary of each of the district superintendents’ survey responses is included in Appendix G.

4.12 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, which is shown on Table 1, establishes the foundation for development of suitable User Service objectives and performance criteria that form the basis for determining the future ITS strategic deployment and implementation plan for the Turnpike. 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 1
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)

TRAFFIC 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

Section 3.0 – User Service Objectives

5.0 USER SERVICE OBJECTIVES

5.1 lTS User Services

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 2 shows the most current listing of the user service bundles and all 30 of these user services along with a brief explanation of these user services. A complete series of definitions for these user services is contained in Appendix H.

5.2 Relationship Between ITS User Services and Problem and Opportunity Statements

In conformance with FHWA's goal for the ITS Deployment Planning Process, the determination of the user service objectives for the project was based on the statements of ITS related problems and opportunities. A systematic evaluation of the relationships between these statements and the ITS User Services was performed for user services in the following four bundles:

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

Relationships between the problem and opportunity statements and the user services in the remaining three bundles, Public Transportation Operations, Emergency Management, and Advanced Vehicle Control and Safety Systems were not identified. User Services in the Public Transportation Operations bundle were not included because the Turnpike has no direct operational responsibilities in the area of public transit and none of the identified problems and opportunities dealt with public transit. However, the issue of better information for charter bus operators is addressed by several of the user services in the Travel and Transportation Management bundle.

Likewise, the Emergency Management bundle does not relate to any of the statements of problems and opportunities. This bundle consists of two user services, Emergency Notification and Personal Security and Emergency Vehicle Management. The functionality contained in the latter service focuses on fleet management, route guidance, and signal priority and/or preemption for emergency vehicles. This user service only applies to the Turnpike in very general terms. The problems that were identified in regard to emergency services are indicated in the statements regarding the Communications Center. As will be shown in the next section, these statements are also addressed by the user services in the Travel and Transportation Management bundle and are directly related to incident management.

TABLE 2
ITS USER SERVICE DESCRIPTIONS

Travel and Transportation Management

En-Route Driver Information - Provides driver advisories and in-vehicle signing for convenience and safety.
Route Guidance - Provides travelers with simple instructions on how to best reach their destinations.
Traveler Services Information - Provides a business directory, or “yellow pages,” of service information.
Traffic Control - Manages the movement of traffic on streets and highways
Incident Management - Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic
Emissions Testing and Mitigation - Provides information for monitoring air quality and developing air quality improvement strategies
Centralized Information Management - Provides the communications infrastructure needed to allow the various operating agencies to communicate and share information directly.

Travel Demand Management

Demand Management and Operations - Supports polices and regulations designed to mitigate the environmental and social impacts of traffic congestion.
Pre-Trip Travel Information - Provides information for selecting the best transportation mode, departure time and route.
Ride Matching and reservation - Makes ride sharing easier and more convenient.

Public Transportation Operations

Public Transportation Management - Automates operations, planning and management functions of public transit systems.
En-Route Transit Information - Provides information to travelers using public transportation after they begin their trip.
Personalized Public Transportation - Provides flexibly-routed transit vehicles to offer more convenient customer service.
Public Travel Security - Creates a secure environment for public transportation patrons and operators.

Electronic Payment

Electronic Payment Services - Allows travelers to pay for transportation services electronically.

Commercial Vehicle Operations

Commercial Vehicle Electronic Clearance - Facilitates domestic and international border clearance, minimizing stops.
Automated roadside Safety Inspections - Facilitates roadside inspections.
On-Board Safety Monitoring - Senses the safety status of a commercial vehicle, cargo and driver.
Commercial Vehicle Administrative Process - Provides electronic purchasing of credentials and automated mileage and fuel reporting and auditing.
Hazardous Material Incident Response - Provides immediate description of hazardous materials to emergency responders
Freight Mobility - Provides communication between drivers, dispatchers and intermodal transportation providers.

Emergency Management

Emergency Notification and Personal Security - Provides immediate notification of an incident and an immediate request for assistance.
Emergency Vehicle Management - Reduces the time it takes for emergency vehicles to respond to an incident.

Advanced Vehicle Control and Safety Systems

Longitudinal Collision Avoidance - Helps prevent head-on, rear-end, or backing collisions between vehicles, or between vehicles and other objects or pedestrians.
Lateral Collision Avoidance - Helps prevent collisions when vehicles leave their lane of travel.
Intersection Collision Avoidance - Helps prevent collisions at intersections
Vision Enhancement for Crash Avoidance - Improves the drivers ability to see the roadway and objects that are on or along the roadway.
Safety Readiness - Provides warnings about the condition of the driver, the vehicle and the roadway.
Pre-Crash Restraint Deployment - Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.
Automated Highway Systems - Provides a fully automated, “hands-off,” operating environment.

The user services in the Advanced Vehicle Control and Safety Systems bundle have also been excluded. The reason for this exclusion is that, with the exception of the Automated Highway Systems (which can be viewed as a joint public/private enterprise which the Turnpike supports as a member of the AHS consortium), all of the user services in this bundle will be implemented under the leadership of the private sector. Therefore, they are not service areas in which the Turnpike will be involved in the immediate future. Although several safety related problems and opportunities were identified, the Turnpike has elected to deal with these using traditional non-ITS countermeasures and analyses. The analysis of alternatives to two-way operation of traffic in the Turnpike's tunnels has been included as part of the Traffic Control user service in the Travel and Transportation Management bundle.

5.3 Ranking of the User Services

The relationship between the statements of problems and opportunities that were previously identified and the user services associated with the Travel and Transportation Management bundle, the Travel Demand Management bundle, the Electronic Payment bundle, and the Commercial Vehicle Operations bundle are shown in a series of matrices included in Appendix I.These relationships were determined by reviewing the complete definitions of the user services, as identified by ITS America and the Federal Highway Administration, and then indicating the statements of problems and opportunities that had some association with each service.

In addition to identifying the relationships between the problem and opportunity statements and the ITS User Services, the matrices were also used to produce a ranking of the user services based upon the number of synthesis statements that they are related to, and the priorities for those statements that were assigned at the steering committee meeting.

A reorganized sequence of user services, in order of their weights, is shown in Table 3. This list has been divided into three groups based upon these weights. These groups represent an overall prioritization of the user services based on the priorities of the problem statements that they address.

5.4 Ranking of the User Services Based on Ability to Implement

The ranking of the user services on the basis of the problem and opportunity statements was followed by a ranking of these user services based on their ability to be implemented.

This qualitative implementation ranking reflected a variety of factors related to the ability to implement the user service. These factors include the relative cost of the program, the degree to which the service can be disaggregated into a series of projects, efforts that are already underway to implement various aspects of the user service, and the dependance of some of these user services on others.

TABLE 3
RANKING OF ITS USER SERVICES BASED ON PROBLEM AND OPPORTUNITY STATEMENTS
(Weighted rankings)

High	En-Route Driver Information (18) Incident Management (18)
Medium	Centralized information Management (14) Electronic Payment Services (13) Demand Management and Operations (12) Freight Mobility (12)
Low	Traveler Services Information (8) Pre-Trip Travel Information (6) Commercial Vehicle Administrative Process (6) Hazardous Material Incident Response (6) Traffic Control (6) Ride Matching and Reservation (4)

It should be noted that this is an evaluation of the ability to implement a user service and not of a particular project that has a specific scope or cost. Therefore, costs can only be included in very general terms. The effect of their cost is further reduced because these costs may be allocated among several organizations which reap the benefits of their implementation, and because they can be divided among a series of projects, which are implemented over several years.

The implementability ratings that were assigned to the various user services are shown in Appendix J. Several columns have been included in this table to clarify the rationale behind the ratings that were assigned. These columns show the objectives for implementing the user service in terms of the problem and opportunity statements, the typical improvement programs that could be implemented, and a series of comments that contain other factors that were considered in assigning the implementability ranking.

As shown in Appendix J, none of these user services were assigned a low implementability rating. In hindsight this is likely to be the result of the preliminary elimination of several of the ITS User Service bundles and the subsequent screening of the user services against the problem and opportunity statements. These two steps eliminated many of the user services (such as the automated highway system) that are normally associated with low implementability ratings.

5.5 User Service Objectives

A composite ranking for the user services was produced by combining the two previous rankings which were based on their relationship to the problem and opportunity statements and their ability to be implemented. The matrix that was used to derive this ranking of the ITS User Services and establish the short-, medium and long-term implementation priorities is shown in Table 4.

TABLE 4
COMPOSITE RANKING FOR ITS USER SERVICES

		Rankings Based on Ability to Implement		
		High	**Medium**	**Low**
Ranking	**High**	**En-Route Driver Information**	**Incident Management**	
	Medium	**Centralized Information Management** **Electronic Payment Services**	**Demand Management and Operations** **Freight Mobility**	
	Low	**Pre-Trip Travel Information** **Commercial Vehicle Administration** **Hazmat Incident Response** **Traffic Control** Ride Matching and **Reservation**	Traveler Services Information	

Key: Short-term priority **Medium-term priority** **Long-term priority**

Initial assignments of implementation priorities to the ITS User Services were then made on the basis of their position within this matrix. The user services assigned a short-term implementation priority were those in the three cells on the upper left-hand side of this matrix. Medium-termimplementation priorities were given to the user services in the three cells along the diagonal from lower left to upper right. The remaining three cells in the lower right-hand corner of the matrix contained the user service that was assigned a long-term implementation priority.

These assignments were reviewed with the project steering committee and the steering committee concurred with the implementation priorities that were assigned to the ITS User Services through this process, with one exception. The committee felt that Pre-Trip Travel Information should be assigned a short-term implementation priority. Their rationale for this decision was based on several factors. These include the existence of a telephone information system which can be upgraded relatively inexpensively with existing technology; the fact that this system could be served by the centralized information management system which was assigned a short-term implementation priority; and the strongly held beliefthat this user service was of extremely high value to the patrons of the Turnpike.

The results of this composite ranking are presented in Table 5 showing the overall short-term, medium-term and long-term implementation priorities for the ITS User Services on the Pennsylvania Turnpike.

TABLE 5
OVERALL ITS USER SERVICE IMPLEMENTATION PRIORITIES

SHORT-TERM	MEDIUM-TERM	LONG-TERM
• En-Route Driver Information • Incident Management • Centralized Information Management • Electronic Payment Services • Pre-Trip Travel Information	• Demand Management & Operations • Freight Mobility • Commercial Vehicle Administration • Hazmat Incident Response • Traffic Control • Ride Matching & Reservation	• Traveler Services Information (Other ITS User Services)

Section 5.0

Performance Criteria

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6.0 PERFORMANCE CRITERIA

The degree to which the ITS User Services are achieving their objectives will be measured using a series of performance criteria. This evaluation of the performance of the user services is an essential part of the ITS Planning Process and the ongoing improvements to the operation of the Turnpike. Documentation of these improvements will also play an important role in securing additional funding for further enhancements of the Turnpike's ITS program

The selection of 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 rationale for the final selection of these criteria is described in the following section of this report.

6.1 Desirable Characteristics of Performance Criteria

The performance criteria that are selected should have several key features. Ideally, they should be:

- Determined from existing data sources - so that future conditions can be compared with current conditions.
- Determined by quantitative measurement - to avoid the subjective judgement of an individual or group who may be present at some times or locations and not at others.
- Capable of conversion to a dollar equivalent - so that benefit/cost ratios can be established.
- Specific to each of the user services - so that changes that are brought about through the implementation of the individual user services can be differentiated.
- Insensitive to anomalies that may occur during the data collection effort - statistical analyses which involve infrequent samples or rare events are subject to random effects that can mask a true change.
- Reflective of the needs and concerns of the stakeholders - the ongoing measurement of "important" parameters will receive more support than the collection of data that is perceived to be irrelevant.

Since it is impossible for a single performance criterion to have all of these attributes, it was necessary to select a set of criteria sensitive to the attributes of the ITS User Services selected by the Turnpike. Finally, before selecting the performance criteria for the user services it is important to review the objectives of the Turnpike's core group of user services to keep in focus what these criteria are attempting to measure. These objectives are shown in Table 6.

TABLE 6
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

6.2 Selection of Performance Criteria

The following paragraphs summarize the factors that were considered during the selection of the performance criteria for the core group of ITS User Services to be deployed on the Turnpike. The final set of recommended performance criteria is summarized in Table 7.

6.2.1 En-Route Driver Information

The performance of en-route driver information should be determined by the promptness, accuracy **and availability of real-time data describing traffic and weather related delays and other special** conditions.

Aside from measuring changes in traffic flow which is not feasible and tracking the number of HAR and VMS messages which does not capture the timeliness or quality of messages, the traveler's perception of message quality and accuracy is the best available measure for evaluating this user service. This measure can be obtained by adding a suitable question to the annual survey conducted by Penn State, through other surveys conducted by the Turnpike, or by keeping track of the number of complaints that are received. Although this measure is qualitative in nature, the mechanisms for collecting it have strong quantitative aspects which permit changes to be identified, even when they are relatively small.

6.2.2 Electronic Payment Services

This ITS User Service includes payment services that would be available under the E-ZPass system as well as payment service improvements that can be made through enhancements to the Turnpike's existing credit card system, Therefore the number or percentage of electronic toll payments using the credit card and E-ZPass system will be the measnrement criteria. In addition the length and duration of the backup at the toll lanes and a comparison of the length and duration of the backup on the regular lanes and EZPass lanes will be used to measure the effectiveness of the E-ZPass system The final criterion for this user service, number of days required to open and cancel a credit card account, will be utilized as a measure of improvements to the performance of the existing credit card system

6.2.3 Incident Management

The performance criterion for incident management generally consists of the measurement of the incident duration which can be divided into separate estimates of the response and clearance times. It is desirable to analyze these data by type of incident, so that the results are not skewed by major incidents that have a typically long clearance times. In addition to this direct measure of the Turnpike's ability to quickly respond and remove an incident, two additional criteria will be utilized to measure the Turnpike's ability to control incident related congestion. These measures are the length of the backup behind the incident and the number of secondary accidents. A fourth criterion, the number or percent of false alarms (where there is no incident) that are identified before assistance is dispatched, will be used to gauge the accuracy of the initial information about the incident.

TABLE 7
RECOMMENDED PERFORMANCE CRITERIA FOR ITS USER SERVICES

ITS USER SERVICE	PERFORMANCE CRITERIA [1]
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 times 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.

(1) These criteria measure improvements in the subject ITS user service and include both quantitative & qualitative measures.

6.2.4 Centralized Information Management

The essence of centralized information management is the rapid and widespread distribution of incident related information to all of the Turnpike personnel who may need to be aware of this information. It is envisioned as a database containing incident related information that could be accessed by personnel throughout the Turnpike. It would be difficult to directly estimate the reduction of the time that it would take to inform these individuals of incident related events therefore a surrogate or qualitative measures will be necessary. These will include the number of times that incident related data is entered or retrieved, and a qualitative perception of the availability and quality of the data that will be obtained by a periodic survey of Turnpike personnel and others outside of the organization who will be receiving this information.

6.2.5 Pre-Trip Travel Information

Pm-trip travel information can influence the route, departure time and mode for individual travelers which is difficult to quantify. Performance measures for this user service will include the extent to which demand volumes at the entrance booths are reduced or spread out over a longer time period when there is a significant congestion problem Also the number of people accessing the Turnpike's telephone information system will document how many travelers are actively seeking information. Finally, as an overall measure of the accessibility and quality of pre-trip travel information, qualitative assessments of the traveler's perception of this user service will be obtained through Turnpike surveys

6.2.6 Traffic Control (at Tunnels)

The objective of traffic control at Turnpike tunnels is to improve the safety of traffic flow in the tunnels at times when only one lane is available for travel in a particular direction. The number and severity of accidents would be the best direct measures of the performance of this user service, however, accidents in tunnels are relatively rare events and they are subject to random variations in their occurrence. As a result a surrogate criteria will be used (in addition to the number and severity of accidents) that quantifies the number of centerline crossings or illegal lane changes in the tunnels under some form of controlled conditions.

6.2.7 Commercial Vehicle Administration

The objective of this user service is to reduce the required paperwork for commercial vehicle operators (CVO) when they apply for a permit to haul hazardous materials on the Turnpike. The direct measure of the effectiveness of this program is the number of Hazmat permits that are issued, however this parameter can be influenced by a number of other external factors. As a result an indirect measurement of improvement will be the number of pages or lines on the required forms to assess the ease with which a permit can be obtained. In addition, a qualitative assessment of the Turnpike's success in streamlining their CVO administrative procedures will be obtained through surveys conducted by the Turnpike and a periodic review of the complaints that are received.

6.2.8 Freight Mobility

A direct measure of freight mobility would be the number of ton-miles of cargo that are carried on the Turnpike every year. Since this parameter cannot be directly obtained, it will be inferred through several surrogate measures. These will include the number of tolls paid by trucks passing through selected toll plazas and the number of tons of freight passing through these toll plazas (by using the product of the average weight of each vehicle class and the number of vehicles in that class).

6.2.9 Hazmat Incident Response

The response to incidents involving hazardous materials is a subgroup of the Incident Management user service which is unique and treated independently by the Turnpike. As indicated previously, it is difficult to estimate travel time and delay associated with these incidents because these major incidents occur relatively infrequently and the average delays produced by these incidents are heavily dependant upon the time of day and the location. Because of these factors, the performance factors selected for this user service are: the average incident duration for Hazmat incidents by type of incident, and the number or percentage of the incidents where the trucking company dispatcher was notified within one halfhour. This latter criterion will quantify the Turnpike's ability to work more closely with the shipping companies that are associated with the vehicles that are involved in these incidents.

6.2.10 Demand Management & Operations

Like the Ride Matching and Reservation user service, Demand Management and Operations seek to maintain and increase the number of people served by the facility through higher auto occupancy rates on short trips. Once again, the number or percentage of vehicles with two or more occupants is a direct measure of the performance of this user service. An assessment of the number of car pools will also be obtained through **periodic surveys. The final** criterion for this user service addresses the aspect of demand management concerned with the shift of travel to time periods when there is less congestion on the roadway. Thus, the ratio of the percent of vehicles traveling in "off-peak periods" and "peak periods" will also be utilized as a quantitative criterion for this user service.

6.2.11 Ride Matching & Reservation

This user service seeks to reduce the number of vehicles using the facility for short trips by achieving a higher auto occupancy rate. The direct measure of the performance of this program is the average auto occupancy or the percentage of vehicles with two or more people which is relatively easy to collect.

6.2.12 Traveler Services Information

The improvements in traveler services information on the Turnpike are aimed at providing travelers with information that they can use to avoid congestion at the service plazas. This congestion may be experienced by people having to wait for a parking space or in a long line to get gas. Other information related to the operation of the Turnpike will be provided as part of the En-Route Driver Information and Pre-Trip Travel Information user services. An evaluation of the quality of the services provided at the plazas will be obtained through a qualitative assessment of the availability of parking and other traveler information services identified through surveys and complaints.

Section 7.0 Responsibilities of the Turnpike & Other Organizations

7.0 RESPONSIBILITIES OF THE TURNPIKE AND OTHER ORGANIZATIONS

This section identifies the responsibilities of the various public and private sector organizations involved in the implementation of ITS User Services. These responsibilities are identified in a series of discussions based around the individual core group of twelve User Services that are of interest to the Turnpike. Note that for several of these User Services, the Turnpike has little or no 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.

7.1 En-Route Driver Information

The en-route driver information service provides travel related information to drivers after their trip has begun. The ITS National Program plan divides this user service into two sub-services: the Driver Advisory sub-service and the In-vehicle Signing sub-service.

The Driver Advisory sub-service provides real-time information. It is anticipated that both the public sector and the private sector will be involved in providing this sub-service to motorists. For the foreseeable future, the public sector will primarily be responsible for collecting data on traffic flow on major roadways, and providing this information to the public through the use of Variable Message Signs (VMS) and Highway Advisory Radio (HAR). However, these public sector activities will be supplemented by private sector travel information services which collect data from public sources and their own data collection services, and provide this information to travelers through periodic broadcasts on commercial radio stations or through a driver initiated cellular call to a phone messaging system

In the more distant future, the In-vehicle Signing sub-service will provide drivers with internal “echoes” of the roadside signing, as well as routing information to specific driver selected destinations. The devices for broadcasting the echoes of regulatory, warning, and guide signs will be provided by the public sector agencies that are responsible for these signs. The in-vehicle devices that are used to receive and present this information will of course be provided by the driver. Routing information will be provided by a private sector information service provider on the basis of the particular needs and desires of the driver.

In terms of the immediate deployment of systems on the Turnpike, the following organizations have, or could have, responsibilities for the Driver Advisory sub-service.

VMS - The Turnpike has responsibility for all signage that is erected on the roadway.

HAR - The Turnpike is responsible for any Traveler Information System that broadcasts on a frequency assigned to the Turnpike by the Federal Communications Commission. Discussions with PennDOT indicate a desire to form a coordinated HAR system that would include both the Turnpike and other roads under the jurisdiction of PennDOT.

7.2 Traveler Services Information

Traveler Services Information will provide the traveler with information regarding a variety of travel related services and facilities and should be available both pre-trip and en-route.

Information on tolls and other Turnpike restrictions must be available from the Turnpike, but could also be available from private sector organizations such as the AAA. Information on motorist services located at the service plazas is clearly the responsibility of the operators of these facilities. Information on services located outside of the Turnpike might be available through a service operated by a chamber of commerce, convention and visitors bureau, or other private sector group.

7.3 Traffic Control

The deployment and operation of signs, signals, markings, and other devices for the control of traffic in tunnels and on other roadways within the Turnpike right-of-way is the sole responsibility of the Pennsylvania Turnpike. The enforcement of these traffic control devices is the responsibility of the Pennsylvania State Police.

7.4 Incident Management

While the Turnpike is ultimately responsible for incident management on its facilities, there are a variety of groups that are involved from both the public and private sector. These include the Pennsylvania State Police, private tow truck services, fire and emergency rescue groups, ambulance services, and wrecker and recovery operators. These private sector businesses provide their services under contract to the Pennsylvania Turnpike.

7.5 Centralized Information Management

The Centralized Information System will provide incident related information to all of the Turnpike offices that may be concerned with these activities including headquarters, toll plaza and maintenance personnel as well as the State Police. Although selected organizations outside of the Turnpike may also have access to the database containing this information, the establishment, maintenance and operation of this Centralized Information System is the responsibility of the Pennsylvania Turnpike.

7.6 Demand Management and Operations

The Turnpike is normally not concerned with the operation of park and ride lots located outside of its right-of-way or with travel demand management (TDM) programs operated by other public and private sector organizations. However, the use of Federal funds is being considered to improve the Irwin park and ride lot at Interchange 7. The Pennsylvania Turnpike has also committed to build a park and ride lot near State Route 5 1 as part of the Congestion Management System (CMS) planning process for the Mon-Fayette Expressway.

7.7 Pre-Trip Travel Information

The activities associated with this user service includes collecting data describing traffic flow and transit systems and providing these data to travelers. As described previously under the En-Route Driver Information service, the collection of data based on traffic flow on the Turnpike is the responsibility of the Pennsylvania Turnpike. However, the dissemination of this information has become the responsibility of the Turnpike and several private sector traffic information providers.

The Turnpike will continue to provide and enhance the existing toll-free 800-number for Turnpike traffic and weather information. Current plans call for providing more direct contact for customers with customer service staff along with expanded use of recorded messages that are updated on an as needed basis. This could be further expanded to cover en-route driver information via a driver initiated cellular phone call.

The private sector will continue to provide pre-trip travel information through broadcasts on commercial radio and TV stations. In the future these travel information service providers may also provide pre-trip travel information that is customized to the trips made by individual travelers.

7.8 Ride Matching and Reservations

This user service will eventually provide real-time ride sharing for travelers. This includes ride sharing in vehicles owned by individual travelers and transit systems with flexible routings that can provide door to door service.

The services will be provided by a mix of private individuals, private sector firms and public transit agencies. The Turnpike has no current role in providing or supporting these services. It is anticipated that the Turnpike's future activities in these areas will be limited to providing signage along the roadway to inform travelers of these services and allowing activities which support these services (such as the transfer of travelers from one vehicle to another) to take place at selected locations.

7.9 Electronic Payment Services

The Pennsylvania Turnpike is a signatory to the multi-state agreement of the group governing the deployment of the E-ZPass Electronic Toll Collection System. Although the actual installation of the E-ZPass system by some members of the inter-agency group is just getting started, and there are many issues that have yet to be resolved, this system will eventually be available for the payment/collection of tolls on the Pennsylvania Turnpike. In addition, the Turnpike currently operates its own credit card system for toll payments by trucking companies that are major customers.

The responsibility for the operation of these electronic payment systems rests with the Turnpike. However, it is possible to contract with the private sector for various activities associated with the sale of tags or cards, or the replenishment of the funds that are maintained in the debit accounts.

7.10 Commercial Vehicle Administration Processes

This user service is associated with the administration of the various procedures associated with commercial vehicles includes opening and closing of commercial vehicle charge accounts and issuing permits for the transport of hazardous materials and oversize loads. The Turnpike is responsible for these activities as they pertain to trucks operating on the roadway. However, in the larger sense of commercialvehicle movement in Pennsylvania and the surrounding states, there are other operators of toll facilities and State DOT's that require similar information, assurances, and forms from commercial vehicle operators that transport goods on their roadways. While the Turnpike can make significant strides in reducing the burden of paperwork and simplifying procedures on an individual basis, it is also important to work with the other operating agencies to further streamline these processes through regional conformity.

7.11 Hazardous Materials Incident Response

As stated previously under the Incident Management user service, the Turnpike is ultimately responsible for incident management on its facilities. There are a variety of groups that are involved in incident management from both the public and the private sector including the Pennsylvania State Police, private tow truck services, fire and emergency rescue groups, ambulance services, and wrecker and recovery operators.

This also holds true at incidents involving hazardous materials. There are two other groups of private sector organizations that must be involved in hazardous material incident responses. The first of these groups covers the firms that specialize in the clean up of environmental contaminants. The second group includes the shippers and operators of the vehicles that are involved in the incident. In most instances, these shippers and operators are required to pay for the expenses incurred by the environmental clean up firms as well as for the costs incurred by the other organizations that responded to the incident.

7.12 F'reight Mobility

Productivity increases for commercial vehicle operators can be achieved through the ability to maintain real-time communications with vehicles on the road. This communication will 1) allow the driver to be efficiently dispatched to locations where a shipment can be picked up, 2) inform drivers of roadway and weather conditions that should be avoided, and 3) improve the coordination of vehicles carrying cargo that must be transferred from one vehicle to another. The responsibility for establishing this communications system clearly rests with the private sector commercial vehicle operators.

This communications capability also includes the concept of having real-time cost information for individual vehicles. This concept **does involve the** Turnpike in providing the commercial vehicle operators with information on its vehicles that have recently entered or exited the Turnpike. In essence, it would require that the Turnpike enhance its toll collection system to achieve a real-time database of transactions, and that the Turnpike make this information available to its commercial customers that have accounts.

Section [illegible]

Functional Requirements

8.0 FUNCTIONAL REQUIREMENTS

The previous chapters identified twelve Core User Services for the Pennsylvania Turnpike. Each of the user services can, to a greater or lesser degree, be implemented using some or all of the functional areas that are associated with the services as identified in the National ITS Program Plan (NPP). This chapter identifies various sets of functional areas (known as alternative system configurations) which implement the user services and satisfy the regional goals at different levels, and selects preferred system configurations for each user service from these alternatives.

The selection of the preferred set of functions began with a review of the functions identified in the NPP. 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.

Alternative system configurations were generated 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.

The analysis of alternative system configurations was based on two sets of factors. The first set of factors addresses aspects related to the difficulty of successful implementing the alternative system configurations (see Section 8.4 for a list of 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 recommendation of the preferred system configurations was selected based on a combination of factors that included the goal satisfaction to implementation difficulty ratios, as well as a reasonable expectation of being implemented in the foreseeable future Based on discussions with the Project Steering Committee, a preferred system configuration was selected with the aid of the committee from the initial set of preliminary recommendations.

8.1 Functional Areas

This section discusses the functions associated with the twelve Core User Services identified for the Pennsylvania Turnpike in Section 6.0 of this strategic deployment plan. The grouping of the functions into related categories is explained and a description of each function is given.

8.2 Functional Areas Associated with the Core User Services

The Core ITS User Services selected for the Pennsylvania Turnpike are shown in Table 8.

TABLE 8
CORE ITS USER SERVICES

ITS User Service
En-Route Driver Information
Electronic Payment
Incident Management
Centralized Information Management
Pre-Trip Travel Information
Traffic Control
Commercial Vehicle Administration
Freight Mobility
Hazmat Incident Response
Demand Management & Operations
Ride Matching & Reservations
Traveler Services Information

8.3 Description of Functions Associated with ITS User Services

The selection of the preferred set of functions with which to implement the ITS User Services began with a review of the functions that were identified in the NPP. These functions, or functional areas, have been grouped into seven broad categories based on the ongoing work that is being performed as part of the development of the National ITS Architecture. These broad categories are Surveillance, Traveler Interface, Navigation and Guidance, Communications, Traffic Control, Data Processing, Inter-Agency Coordination, and Payment Systems. The functions within these groups are summarized in the following paragraphs. A more complete description of each function is included in Appendix K.

The functions that are associated with these Core ITS User Services in the National ITS Program Plan (NPP) are shown in Figure 6. The NPP points out that these functions would be the ones utilized in a "mature" user service. It should also be recognized that it is possible to implement the user services using only some of these functions.

8.3.1 Surveillance Functions

Traffic Surveillance - involves the monitoring and collection of data on streams of traffic at a specific point or general area. This is achieved through the use of various detector or sensor technologies including: magnetometers, inductive loop or probe; infrared, radar and microwave; vision, machine or human; and sound. In order to be useful each of these methods require a communications medium, a user interface or monitoring device, and a storage mechanism.

Vehicle Surveillance - is concerned with the collection of data on specific vehicles and involves technologies such as weigh-in-motion devices and vehicle identification, classification and location. Some of these technologies may require specific driver action or cooperation, or the placement of devices that automatically respond on vehicles.

In-Vehicle Sensors/Devices - the technologies employed by this function provide the monitoring of various systems within a vehicle. Vehicle performance and driver performance may be monitored, while at the same time vehicle position relative to the roadway and other vehicles may be observed. These technologies together will provide for human safety, the protection of the environment, and the maintenance of vehicles.

8.3.2 Traveler Interface Functions

Variable Message Display - provides general information to travelers with visual or audible information controlled from a central location. This function is typically used at roadside variable message signs, and at monitors displaying the arrival times of airplanes, buses and trains. Requirements include communication to the displays through dial-up or direct lines or radio transmissions.

Individual Traveler Interface - provides information tailored to the needs of a specific traveler through the use of stationary kiosks, onboard display systems, portable personal communications devices, telephones and televisions. Technologies in use for this function include touch screens, keypads, graphics displays, computer voices and audiotex. This function requires the transmission of relevant information to the appropriate places in a timely fashion, possibly using several different media simultaneously.

8.3.3 Navigation and Guidance Functions

Navigation - the navigation function allows for the precise positioning of vehicles in real time. Several technologies exist which will meet the needs of such a system. They include GPS, LORAN, dead reckoning, localized beacons, map database matching, and cellular/radio triangulation. In order for any of these to be useful to the user, specialized receiving and processing devices must be installed in the vehicle.

Routing Data Processing - allows the guidance and scheduling of private and commercial vehicles, as well as multi modal dispatching. A user may enter a beginning and end point and receive turn-by-turn directions to their destination. Commercial carriers may optimize their operations through the use of such a database in their routing and scheduling activities. This function along with other technologies may be used in real-time navigation services.

8.3.4 Communications Functions

1-Way Mobile Communications - transmit information from a central location to a receiver at a field location which may be mobile. No provision is made for requesting or sending data from that field location to the central transmission site. Possible technologies for providing this service include Highway Advisory Radio (HAR) FM subcarrier, spread spectrum, microwave, infrared, commercial broadcasts, and infrared or microwave beacons. Requirements for this function are either a standard AM/FM radio or a specialized receiver.

2-Way Mobile Communications - allows for the bidirectional transmission of signals between two possibly mobile sites. Technologies such as cellular, 2-way radio, spread spectrum, microwave, infrared and 2-way satellites may be used. In order for this function to be successful it is required that both parties have transceivers that are capable of communicating with each other.

Stationary Communications - allows for communications between stationary sites. Technologies employed to meet this end include copper or fiber land lines (leased or owned) spread spectrum radio and microwave.

8.3.5 Traffic Control Functions

Signalized Traffic Control - allows for the real-time control of traffic flow through the use of optimized traffic signal plans, ramp metering and lane control methods such as reversible lanes or lane closings. Communication is a key requirement in order for this function to perform effectively.

Restrictions Traffic Control - traffic restrictions are generally used to meet some goal or set of goals for a specific region and may involve the use of High Occupancy Vehicle (HOV) lanes, part-time use of shoulders, parking restrictions, and road use pricing. Once in place, enforcement is a key issue.

8.3.6 Data Processing Functions

Traffic Prediction Data Processing - is a more specialized application of generic database processing used for prediction of future traffic situations.This may take the form of real-time prediction or traffic assignment. Real-time prediction of traffic volumes may be used to estimate the impacts of incidents or other non-recurring events. Traffic assignment is generally used in evaluating the effect of changes in network configuration or traffic restrictions on recurring congestion.

Traffic Control Data Processing - involves the real-time control of traffic. Optimal control and incident detection as well as the interaction of route selection and traffic control are possible uses of the algorithms being developed. Emerging signal systems using traffic adaptive strategies make use of this technology by continually monitoring volume and occupancy data in order to adjust signal timing in response to the current demands. A high degree of processing power may be required by this function.

Database Processing - involves the manipulation of transportation related data into useful information for reports or as input into other functions. Current database software exists, but may require special adaptation for use in the transportation field. Other requirements needed will vary depending on the intended use of the data, whether it is for input into another function or as information for the traveler.

8.3.7 Inter-Agency Coordination and Payment Systems

Inter-Agency Coordination - involves either direct or indirect sharing of information among various agencies such as PennDOT, police, emergency services, weather, transit operators **and** Traffic Management Centers. This requires the capability of either direct or on-demand communications.

Payment Systems - allows for the transfer of funds between a traveler and a service provider. Technologies which accomplish this are automated vehicle identification, smart cards and electronic funds management systems. The requirements for such a system include a secure credit or debit system

8.4 Alternative System Configurations

This section discusses the concept of alternative system configurations and the process used to develop alternatives for evaluation. Short descriptions of each alternative system configuration are given.

8.4.1 Development of Alternative Configurations

Each of the Core User Services identified in Table 8 of this report will be implemented using a subset of functionality defined in the National ITS Program Plan (NPP). The set of functions listed in the NPP for a given ITS user service represents a "full deployment” configuration for the user service; however, it is not necessary to use all of the listed functionality to implement a given user service.

Other system configurations which do not provide the 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

FIGURE 6
MATRIX OF FUNCTIONS VS. CORE USER SERVICES

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Data Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
En-Route Driver Information	●			●	●	●	●	●	●	●			●		●	●	
Electronic Payment		●		●	●			●	●	●					●	●	●
Incident Management	●			●		●		●	●	●	●		●	●	●	●	
Centralized Information Management				●	●			●		●					●	●	
Pre-Trip Travel Information	●			●	●	●	●		●	●		●	●		●	●	
Traffic Control	●			●						●	●		●	●	●	●	
Commercial Vehicle Admin.		●		●	●			●	●	●					●		●
Freight Mobility		●			●	●	●	●	●	●					●		
Hazmat Incident Response		●	●			●		●	●						●	●	
Demand Mgmt & Operations	●	●		●	●	●		●		●	●	●			●		●
Ride Matching & Reservations		●		●	●	●	●	●	●	●					●	●	●
Traveler Services Information				●	●		●		●	●					●		

Source: Core User Services as presented in the National ITS Program Plan. Centralized Information Management User Service based upon the COMPARE Project, Tidewater, VA immediate service to the customers. Ifdesigned carefully, this alternative configuration can be easily expanded at later stages of the ITS deployment process to allow greater capability and full compatibility with local, state, and federal ITS initiatives. Another possibility is that a reduced level of functionality would be appropriate as the final phase of implementation for a user service in which full functionality required large capital expenditures and where the benefits returned were only marginally greater than those achieved at the alternative configuration.

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. The resulting set of alternatives for the Core User Service was then used to create a matrix that could be used to visually compare alternatives.

For some Core User Services, developing the alternative system configurations required a slightly different approach than the additive approach described above. Some user services are better represented by a number of different options that can be implemented alone or in conjunction with one another. For example, the Demand Management & Operations user service could be provided using HOV lanes in major urban areas or by applying peak period surcharges (congestion pricing). These clearly represent different approaches to managing transportation system demand and which are not additive with regard to their functionality. Alternative system configurations for each of the Core User Services are given in Appendix L.

8.4.2 Description of the Alternative System Configurations

This section contains narrative descriptions of the alternative configurations for the twelve Core User Services identified in the User Service Plan along with their priority rankings.

Alternative Core User Service

En-Route Driver Information Service

A **Improved VMS System** - This alternative contains the functionality needed for an improved Variable Message Sign that provides information to drivers through a roadside display. All drivers will view this message, but the amount of information that can be provided is limited.

B **Improved EAR System** - This system configuration contains the functionality needed for an improved Highway Advisory Radio system that broadcasts current information to en-route drivers on or near the turnpike via radio signals. The information may include current weather conditions, incident and congestion reports, alternate route instructions, regulatory information or any other type of information deemed necessary for travelers. Drivers must tune to a particular station to receive the message, but this message can be quite extensive.

Alternative Core User Service

En-Route Driver Information Service (continued)

C **Improved VMS + HAR System** - This configuration includes the functionality of Alternative A and B, providing upgrades to both the VMS and the HAR systems.

D **Alternative C + Cellular Phone Link to En-Route Information** - This alternative provides travelers with access to en-route information such as current traffic weather, and route instructions. Access would be provided via a cellular telephone. En-route information could be provided by a private firm that directly charges the traveler for information access.

E **Alternative D Upgraded Kiosk at Service Plazas** - This configuration would provide upgrades to the Service Plaza kiosks in order to provide en-route driver information such as current weather conditions, route instructions, congestion information, or any other information useful to travelers.

F **Alternative E + Traffic Prediction Data Processing** - This system configuration adds traffic prediction capability to provide en-route drivers with the latest information on traffic conditions in areas that coincide with the route. This traffic information would be accessible via the upgraded Service plaza kiosks.

Electronic Payment

A **Debit of ATM/Credit Card at End of Day** - This alternative provides the functionality for electronic payment of tolls using a standard Automated Teller Machine (ATM) card or a personal credit card. The toll price and account information is saved to a storage device and downloaded at the end of the day for processing the electronic charges. This system requires that the driver stop at the Toll plaza, hand the card to the Toll booth attendant and wait for it to be returned.

B **Electronic Toll & Traffic Management (E-ZPass)** - This alternative implements electronic toll payment using the E-ZPass system, which transmits the toll price and account information for real-time processing. The vehicle may be required to slow down at the toll plaza but does not have to come to a complete stop while the transaction is being processed. The toll plaza-tovehicle communications would occur via 2-Way Mobile Communications functionality and a toll tag would be required on the vehicle to store toll and account information

Incident Management

A **Improved** Call **Boxes** - This alternative consists of the staged replacement of the existing push-button call boxes with new units capable of two-way voice communications. An increased support staff at the Communications Center would be required to handle the additional calls.

Alternative **Core User Service**

Incident Management (continued)

B **Improved Mobile Phone Notification** - This system configuration includes the functionality and additional support staff for an upgraded system that allows travelers to report incidents via a cellular phone.

C **Mobile Phone Notification + Surveillance - This** alternative adds the traffic surveillance function for providing visual monitoring of select areas via Closed Circuit Televisions, ETTM, detection loops, radar, or other surveillance technology. The surveillance capability would help to identify incidents quickly and provide real-time information and visual confirmation. The surveillance devices can be placed at strategic locations such as tunnels, interchanges, or other areas where congestion problems and incidents are common. In conjunction with a mobile phone call-in system, the effectiveness of incident management is increased.

D **Alternative C** + VMS + HAR - This alternative adds Variable Message Signs and Highway Advisory Radio capability to the Alternative C functionality. This provides incident managers with the ability to inform travelers that an incident has occurred. The VMS and HAR functions may also be used to give general directions or instructions for navigating around incidents that tie up all or part of the Turnpike.

E **Alternative D + Automatic Notification** - This more advanced configuration (which will be implemented in future vehicles) adds the Navigation and In-Vehicle Sensor functions to provide an automatic notification to the Communications Center in the event of an incident. In-Vehicle Sensors sense that an incident has occurred and the Navigation device reports the location of the incident for efficient dispatch of responders.

Centralized Information Management

A **Improved E-Mail System** - This configuration contains the functionality required for an upgraded E-mail system that would automatically send messages and alert agency personnel of the message. Such a communication system would allow important messages concerning Class 9 vehicles, incidents, weather, and other emergencies to be broadcast to selected persons or parties within the organization. Note that there is currently a message component of the E-mail system in place at the Turnpike; however, there is no alert component that brings the message to the receivers attention.

B **Improved E-Mail System** + **Fax** - This variation of the first configuration adds the ability to Fax messages to those people and/or parties that may not have access to the E-mail system.

C **Improved E-Mail** + **Message** Banner - This configuration provides functionality for installation of a banner message system. Specifically, the Variable Display function is added to allow various messages to be displayed at select locations. The variable **message** device could be in the form of a TV monitor that has a message scroll or a LED-type display sign that scrolls the message. These variable displays could be provided at key locations within the Administration Building or at other desired locations. The banner system should have an alert component that draws the attention of personnel.

Alternative Core User Service

Centralized Information Management (continued)

D **Improved E-Mail + General Alert System** - This alternative includes the improved E-mail system and adds a device that would alert individuals of a major incident or a Class 9 vehicle. This device could be a series of digital time clocks that begin to operate a flashing mode or any mechanism that subtly or overtly calls attention to the fact that a major incident is in progress or that a Class 9 vehicle is on the Turnpike. These devices would be placed at central locations within the administration bldg., maintenance offices, toll plazas, and other Turnpike facilities where they could be seen easily by personnel who would alert others by word of mouth.

E **Improved E-Mail + Widespread Paging System** - This more advanced alternative provides the functionality required to implement a wireless paging system that would allow key personnel to receive instant notification of any incidents, Class 9 vehicles, or other vital information. The pager device would be of the display type, allowing messages in the form of text to be read from the LED-type miniature screen.

Pre-Trip Travel Information

A **Enhanced Telephone Information System** - This configuration provides the Database Processing, Stationary Communications, and 2-Way Mobile Communications functions for allowing a traveler to obtain pm-trip information from the Turnpike via a fixed phone or mobile phone. A phone menu system is provided to allow the traveler to receive various types of information without the assistance of an operator.

B **Interjurisdictional Telephone Information System** - This upgraded version of Alternative A adds the Traffic Surveillance and Inter-Agency Coordination functionality for providing the traveler with additional pre-trip information on real-time traffic conditions and other information obtained through inter-agency coordination.

C **Alternative B + Individual Interface - This** configuration adds the Individual Interface function for providing potential travelers with an interface to a travel information database. This interface could be in the form of a home page for the Pennsylvania Turnpike on the World Wide Web (WWW). From a home computer, the traveler would obtain pm-trip information about the Turnpike or any other information provided as a courtesy of the Turnpike.

D **Alternative C + Traffic Prediction** - This configuration adds the more advanced function of Traffic Prediction Data Processing to provide pre-trip travelers with warnings of potential congestion problems on the Turnpike.

E **Alternative D + Navigation + Routing** - This more advanced pre-trip travel information system includes the additional functions of Navigation and Routing Data Processing to give travelers detailed route instructions and most efficient route information based on the location of the individual traveler.

Alternative **Core User Service**

Traffic Control

A Signal Control - This configuration provides the essential components for controlling traffic at the Turnpike interchanges, tunnels, and other fixed locations. This alternative includes Traffic Surveillance functionality for monitoring traffic flow conditions, especially in tunnels and major urban areas.

B Signal Control + VMS - This upgraded configuration provides the Variable Message Sign function in addition to the functionality of Alternative A. The VMS can be used to advise drivers of single lane tunnel operation, crossovers to the roadway normally used for the opposing flow, and reduced speed limits.

Commercial Vehicle Administration

A **Provide Supplemental Credential Information Only** - This basic configuration would allow commercial transport companies to file only the additional hazmat credentials required by the Pennsylvania Turnpike for transport of hazardous goods on the Turnpike system. Currently, all of the state mandated information and additional information and indemnification is required to be provided by the commercial transport company.

B **Electronic Filing of Credentials - This** more advanced configuration adds the Individual Interface Stationary Communications, and Payment Systems functionality to Alternative A. The additional functions would permit commercial transport companies to electronically file and pay for transportation credentials.

C **Alternative B + HAZMAT Permit Information on Transponder** - This configuration adds the indication of a valid hazmat permit to the E-Z Pass transponder attached to the vehicles.

Freight Mobility

A **Provide Staging Areas for Commercial Trucks** - This basic alternative would provide staging areas at key locations along the Turnpike or adjacent to interchanges where commercial truck drivers could pull over and exchange loads, drop off loads, or perform any other operational duties that would increase efficiency in the movement of goods. Note that this configuration does not require any ITS functionality

B **Add Credit Card Phones to Select Areas** - This configuration includes the 2-Way Mobile Communications, Stationary Communications, and Payment System functions for providing commercial drivers access to credit card phones at selected areas along the Turnpike. This would allow commercial truck drivers to place phone calls and have the charges electronically billed to a credit card. A fee would be collected by the Turnpike for the use of these phones. Note that there may be some concerns about the safety of access at egress.

Alternative	Core User Service
	Freight Mobility (continued)
C	**Real-Time Access to Toll Records** - This stand alone configuration provides commercial operators with access to a portion of the toll records database to obtain data for their administrative use, or tracking of the progress of their vehicles.
D	**Alternative B** + **Alteruative** C - This configuration combines the functionality of Alternative B and C to provide both credit card phones and real-time access to toll records. This combination may enhance communications and operations of commercial vehicle operators.
	Hazmat Incident Response
A	**Provide Hazmat Database Access** - This configuration provides the functions necessary to provide mobile access to a Hazardous Materials database that could be used to receive vital information in the event of a Hazmat incident. This information system would allow officials or responders to get information about the operator of a Hazmat load and agreements in place with wrecker operators and hazmat cleanup organizations.
B	**Automatic "MAYDAY" To Communications Center** - This separate configuratin provides the functionality for equipping commercial vehicles with a device that would sense vehicle conditions and automatically transmit a "MAYDAY" beacon in the event of a Hazmat incident. This beacon could provide the location of the incident automatically so that responders could be dispatched efficiently.
C	**Automatic "MAYDAY" and Remote Monitoring of Load Contents** - This upgraded version of Alternative B adds functionality for providing Hazmat incident responders with the ability to determine load contents from a tug or transponder that can be "read" without getting close to the vehicle.
	Demand Management & Operations
A	**HOV Lane in Major Urban Areas** - This alternative provides the functionality for operating a High Occupancy Vehicle lane in major urban areas on the Turnpike and its toll plazas. This would involve designating one or more travel and toll lanes as restricted to vehicles containing only a certain number of passengers during selected times of day. Functionality for Variable Displays, Stationary Communications, Restrictions Traffic Control, and Database Processing are provided. These items in conjunction with one another and enforcement of the HOV restrictions would provide smooth operation of the designated HOV lane.
B	**Off-PeakToll** Discounts - This separate alternative allows a congestion pricing system to be implemented, in which travelers are given incentive to travel at off-peak times. The net result would be a more evenly distributed traffic flow. The functionality for providing congestion pricing includes the functions indicated for implementing an HOV facility, but in addition would require a Payment System and perhaps Traffic Surveillance.

Alternative **Core User Service**

Demand Management & Operations (continued)

C **HOV Lane** with **SOV Premium** - This alternative allows Single Occupant Vehicles (SOV) to utilize the HOV lane if they pay a premium rate for this access. It is anticipated that these SOVs would record the number of HOV lane miles that were driven. Strong enforcement efforts using law enforcement personnel and electronic monitoring devices would be required in order to avoid rampant abuse of this system.

Ride Matching & Reservation

A **Basic Ride Matching System** - This basic system configuration provides Stationary Communications, Two-Way Mobile Communications, and Database Processing functions for providing prospective riders with information about car pooling and other ride arrangements. The ride information is stored in a ride-matching database and updated from time to time. Drivers can advertise open spots and riders can call from a fixed or mobile phone for car pooling arrangements. This functionality could be provided and administered by the Turnpike, or simply supported and/or promoted by the Turnpike.

B **Ride Matching System with Real-Time** Call-In - This system, operated by a public or private sector organization, provides the capability of real-time ride matching for travelers interested in a ride on a single occasion or on a sporadic basis. Drivers willing to accept a rider on a particular day would call into the Ride Matching System and provide a telephone number where they could by reached. The potential rider would call into the Ride Matching System and identify his or her travel needs and hold while the system queried for the best match and provided the driver's phone number.

C **Advanced Ride Matching System** - This advanced configuration includes the functionality from the basic system and adds the functionality for an Individual Interface and a Payment System. In this type of system, the users could access the ride matching system via a computer with a visual interface to the ride matching database and could pay for any services electronically.

Traveler Services Information

A **Upgraded Travel Boards at Service Plazas** - This configuration includes the functionality for improved Travel Boards at the Service Plazas, or at other select locations, to provide travelers with travel-related service information. Upgrades would include providing the automatic display of traffic and weather information via HAR and VMS system feeds.

B **Telephone Link to Traveler Service Information** - This alternative provides travelers with access to information about traveler services via a telephone. Traveler service information could be provided by a private firm that directly charges the traveler for information access.

Alternative **Core User Service**

Traveler Services Information (continued)

C **Advanced In-Vehicle System** - This more advanced configuration provides functionality for implementing a mobile travel services information system in which travelers can access information via a mobile communication device with an individual interface. The device could be a computer or Personal Digital Assistant (PDA). Such a system would allow owners of a compatible mobile communication device to get traffic, weather and other information without stopping at a Travel Board location.

8.5 Selection of Preferred Alternatives

This section discusses the procedure used to evaluate the alternative system configurations, the selection of appropriate evaluation factors, and the evaluation results. The product is a preliminary recommendation of a specific alternative for each of the Core ITS User Services for the Turnpike.

Although this evaluation process is entirely based on qualitative assessments, the results, shown in Appendix M provide valuable insights into the trade-off of goal satisfaction and implementation difficulty

8.5.1 Analysis Procedure

A modified trade-off analysis was performed on the alternative system configurations identified in Section 8.4 of this report. Two sets of factors were selected for this analysis. The first set of factors addresses aspects related to the difficulty of successfully implementing the alternative system configurations. A second set of factors assesses the degree to which the alternative system configurations satisfy regional goals for the Pennsylvania Turnpike.

The evaluations were performed for each of the twelve Core User Services. The Evaluation Tables for each Core User Service are provided in Appendix C at the back of this report. These evaluations are qualitative assessments of the relative ranking of the alternative configurations for a given factor within a particular user service. Equal values assigned to the same factor in different user services are not necessarily the same. For example, if within a given user service, alternative # 1 was assigned a cost factor of three and alternative #4 was assigned a cost factor of six, this would mean that alternative #4 was more expensive than alternative #1, but not necessarily twice as expensive. Furthermore, if an alternative in one user service and an alternative in a different user service both received a score of eight for Cost, it is not necessarily true that the *actual* cost of implementation is the same for both of these alternative configurations. The evaluation tables were only used to make comparisons among the alternatives within a user service.

8.5.1.1 Implementability Factors

Four factors were used to assess the difficulties associated with the implementation of the alternative system configurations. The assessment was a qualitative procedure that tried to include all the difficulties associated with the implementation of the alternative system configurations. A similar analysis procedure was used in the Hartford, Connecticut ITS Early Deployment Project. These four factors include:

- System Cost
- Compatibility with Existing Infrastructure
- Risk Factors
- Degree of Change

System Cost - As indicated previously, costs were assessed in relative terms. That is, the evaluation indicates how the total implementation, operation and maintenance cost of a particular alternative configuration compares with the costs of other alternatives associated with the same Core User Service.

Compatibility with Existing Infrastructure - This factor represents a qualitative comparison of the extent to which a given alternative can be incorporated with or built onto the existing Turnpike infrastructure In order to reflect a higher implementation difficulty a low rating indicates a high degree of compatibility with existing infrastructure and a high rating indicates incompatibility with existing infrastructure.

Risk Factors - The factor for evaluating the degree of risk associated with implementing a user service reflects the risk assessment indicated in the National ITS Program Plan (NPP) for each of the functions. The NPP assigned risks for each function in two broad categories: potential conformance with the National ITS Architecture and conformance with the standards associated with the architecture. Each function for a given alternative configuration was assigned a numeric value and the total risk for each alternative configuration was determined by averaging the values for the functions associated with that con&ration.

Degree of Change - The factor for degree of change is utilized to assess the relative changes that each alternative requires on the part of customers and the Pennsylvania Turnpike. For example, a Variable Message Sign system that conveyed basic information would require little or no change on the behavior of motorists, but a Highway Advisory Radio (HAR) system that required motorists to tune their radios to a particular frequency for information does rely on the motorists performing this action to receive the information. Similarly, improved interagency cooperation requires changing the way that these organizations are accustomed to working with each other.

All of these factors were assigned weights of 100, as reflected in the Evaluation Tables for each ITS User Service as shown in Appendix N. The following steps were followed to evaluate each alternative in terms of "implememability." First, each alternative was rated on a scale of one to ten for each Implementability Factor. Second, a product was computed for each factor by multiplying the factor weighting by the evaluation value assigned for the given alternative. Third, the products for each alternative were added to provide a subtotal. Finally, the subtotal for each alternative was divided by the maximum product of **4000** to get a normalized evaluation (called Normalized Implementation Dificulty).

8.5.1.2 Regional Goal Factors

The Regional Goal Factors for the Pennsylvania Turnpike were selected based on goals identified throughout the project and with guidance based on extensive experience in other ITS projects and guidelines established in the National ITS Program Plan (NPP). The Regional Goal Factors were assigned equal weights and include the following:

- Improve Service Level/Reduce congestion
- Improve safety
- Reduce Environmental Impact
- Enhance Goods Movement
- Improve Mobility
- Assist in Management & Maintenance of Infrastructure
- Supports Off-System ITS Initiatives

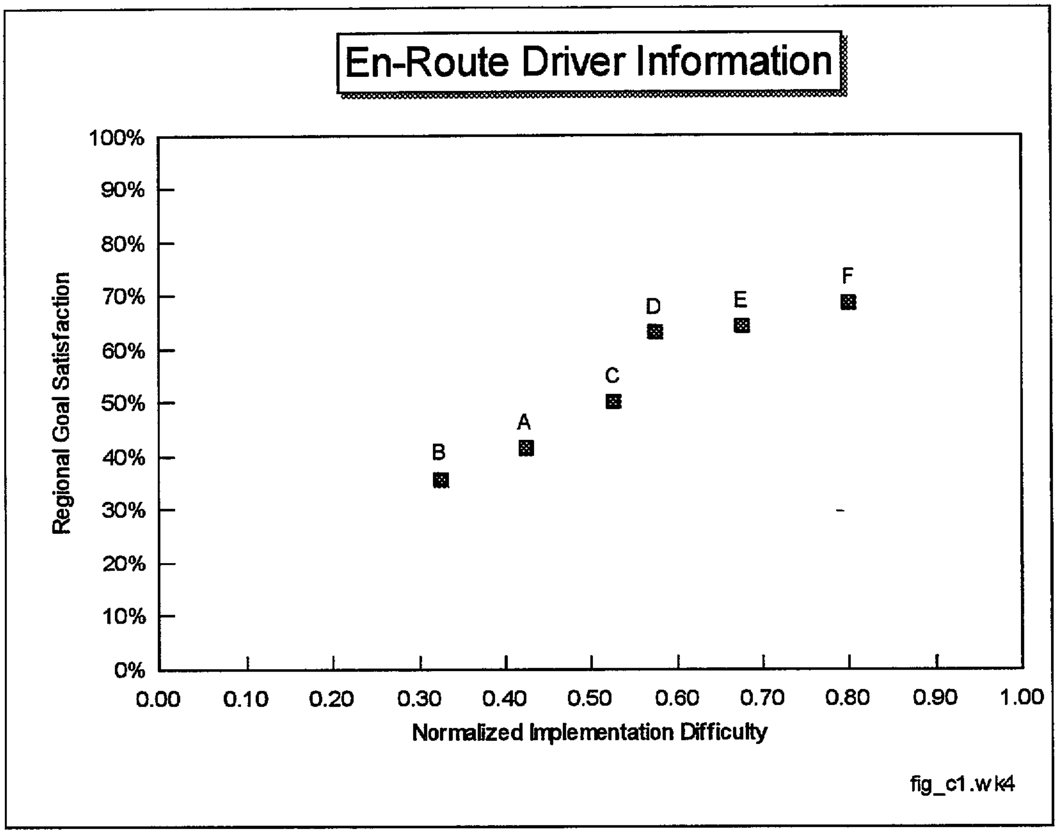
The alternatives were evaluated for their achievement of Regional Goals using the same method as described for the Implementability Factors. The result was a Regional Goal Satisfaction for each alternative, expressed as a percentage rather than a decimal. A Regional Goal Factor of 100% would indicate complete satisfaction of the regional goals; a Regional Goal Factor of 0% would indicate no satisfaction of the regional goals.

8.5.2 Comparison of Alternatives

A preliminary comparison of alternatives for each user service was performed by plotting the Regional Goal Satisfaction against the Normalized Implementation Difficulty. In essence this is similar to a graph comparing benefits and costs. However, 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 sample plot is illustrated in Figure 7.

The results of this functional area analysis are summarized in Table 9. The values of the ratios of the Regional Goal Satisfaction to Implementation Dificulty are shown in this table for each of the system configuration alternatives. The preferred system configuration alternative is highlighted.

FIGURE 7
COMPARISON OF SYSTEM ALTERNATIVES SAMPLE PLOT



Alternative A: Improved VMS System
Alternative B: Improved HAR System
Alternative C: Improved VMS + HAR System
Alternative D: Alternative C + Telephone Link to En-Route Information
Alternative E: Alternative D + Upgraded Kiosk at Service Plazas
Alternative F: Alternative E + Traffic Prediction Data Processing

TABLE 9
PREFERRD SYSTEM CONFIGURATION RECOMMENDATIONS

User Service	Preliminary System Configuration Recommendations	Implementation Ratio
En-Route Driver Information	A. Improved VMS System	**.95**
	B. Improved HAR System	**1.09**
	C. Improved VMS & HAR System	**.94**
	D. Alternative C+ Telephone Link to En-Route Information	**1.09**
	E. Alternative D+ Upgraded Kiosk at Service Plazas	**.94**
	F. Alternative E+ Traffic Prediction Data Processing	.86
Electronic Payment	A. Debit of ATM/Credit Card at End of Day	.62
	B. Electronic Toll & Traffic Management (E-Z Pass)	**.83**
Incident Management	A. Improved Call Boxes	.4
	B. Improved Mobile Phone Notification	.4
	C. Mobile Phone Notification + Surveillance	.62
	D. Alternative C+ VMS + HAR	**.87**
	E. Alternative D+ Automatic Notification	**.86**
Centralized Information Management	A. Improved E-Mail System	.36
	B. Improved E-Mail System + FAX	.63
	C. Improved E-Mail + Message Banner	**.84**
	D. Improved E-Mail + General Alert System	**.82**
	E. Improved E-Mail + Widespread Paging System	**.90**
Pre-Trip Travel Information	A. Enhanced Information	**1.13**
	B. Interjurisdictional 800 Information System	**1.13**
	C. Alternative B+ Individual Interface	.88
	D. Alternative C+ Traffic Prediction	.73
	E. Alternative D+ Navigation + Routing	.72
Traffic Control	A. Signal Control	**.94**
	B. Signal Control + VMS	**.92**

User Service	Preliminary System Configuration Recommendations	Implementation Ratio
Commercial Vehicle Administration	A. Provide Supplemental Credential Information Only[1]	1.27
	B. Electronic Filing of Credentials	**.68**
	C. Alternative B+ HAZMAT Permit Information on Transponder	**.62**
Freight Mobility	A. Provide Staging Areas for Commercial Trucks	**.71**
	B. Add Credit Card Phones to Select Areas	**.61**
	C. Real-Time Access to Toll Records	.37
	D. Alternative B+ Alternative C	.47
Hazmat Incident Response	**A. Provide HAZMAT Database Access**	**.64**
	B. Automatic "MAYDAY" to Communications Center	.54
	C. Automatic "MAYDAY" and Remote Monitoring of Load Contents	**.65**
Demand Management & Operations	A. HOV Lane in Major Urban Areas	**.54**
	B. Off-Peak Toll Discounts	**.48**
	C. HOV Lane with SOV Premium	**.48**
Ride Matching & Reservation[2]	A. Basic Ride matching System	N/A
	B. Ride Matching system with Real-Time Call-In	N/A
	C. Advanced Ride Matching System	N/A
Traveler Services Information	A. Upgraded Travel Boards at Service Plazas	.40
	B. Telephone Link to Traveler Service Information	**.88**
	C. Advanced In-Vehicle System	**.74**

Preferred System Configuration

(1) This alternative was not recommended because it does not significantly help achieve the Turnpike's regional goals.

(2) The Turnpike does not consider Ride Matching & Reservations to be a high priority user

Although Table 9 does indicate the system configuration alternative with the highest Goal Satisfaction to Implementation Difficulty ratio for each user service, it is also apparent that for most of the user services there are several alternatives with ratio values that are nearly the same. These ratios are indicated in a bold typeface. Because of the qualitative nature of this evaluation, it would be impossible to assert that the values should be taken as absolutes. In fact, the level of accuracy of this comparison is probably in the order of 15%. Thus, any of the system configuration alternatives shown in a bold typeface could be considered as equals with the "best" values for this ratio.

The recommendation of preferred system configurations based on these ratios is shown below in Table 10. The alternative that was selected was based on a combination of factors that included having one of the best Goal Satisfaction to Implementation Difficulty ratios, as well as a reasonable expectation of being implemented in the foreseeable future. These alternatives were selected following discussions with the Turnpike Steering Committee and taking into account their judgement and knowledge regarding Turnpike operations and potential for funding.

8.5.3 Synergistic Effects

The functionality associated with the preliminary configuration recommendations is shown in Figure 8. In this figure the functions that are needed for the recommended system configurations are shown as solid circles, and the functions that are associated with more "mature" system configuration alternatives are shown as open circles.

If the functions to be implemented can be applied to user services other than the one that these functions are directly associated with, all of the user services in these groups can be implemented at levels that are higher than the level initially recommended for implementation. That is, it should be possible to apply the functions of one user service to the other user services.

For example, on an individual basis the recommended configurations for En-Route Driver Information, Incident Management, and Traffic Control only provide part of the functionality associated with the mature implementation of these user services. However, when taken together as a group, the functions that will be provided include virtually all of the functionality that could be desired of a mature system for any of these services.

This does not mean that the Turnpike can immediately apply the functionality of one user service to other user services provided by that organization. However, it does imply that it should be possible for the Turnpike to provide these functions to other user services with far less implementation difficulty than would be possible if the function were not present in any of the user services implemented by the organization.

In light of this fact it should be possible to achieve higher levels of satisfaction for the regional goals than is initially indicated. Prudence dictates that the initial implementation of these user services is based on the initial recommendations. However, the description of the funtionality included in the detailed implementation plans for each user service should be sufficiently robust so that this function can also be applied and utilized in the other associated user services implemented by the organization.

TABLE 10
SUMMARY OF PREFERRED SYSTEM CONFIGURATION RECOMMENDATIONS

Priority	User Service	Recommended System Configuration
SHORT TERM	En-Route Driver Information	Alternative E - Improved VMS + HAR System + Telephone Link to En-Route Information + Upgraded Kiosks at Service Plazas - contains the functionality needed for an improved Variable Message Sign (VMS) system, an improved Highway Advisory Radio (HAR) system. En-route information would be provided by telephone access and at service plaza kiosks. Travelers would have access to information such as current traffic, weather, incident and congestion reports, alt. route instructions, regulatory information or other type of information deemed necessary for travelers. The VMS provides limited information to drivers through a roadside display. The HAR system would broadcast current information to en-route drivers on or near the turnpike via radio signals. En-route information via the telephone could be provided by a private firm that directly charges the traveler for information access.
	Electronic Payment	Alternative B - Electronic Toll & Traffic Management (EZPass) - implements electronic toll payment using the E-ZPass system, which transmits the toll price and account information for real-time processing. The vehicle may be required to slow down at the toll plaza but does not have to come to a complete stop while the transaction is processed. The toll plaza-to-vehicle communications would occur via 2-Way Mobile Communications and a toll tag would be required on the vehicle to store toll and account information.
	Incident Management	Alternative D - Mobile Phone Notification + Surveillance + VMS + HAR - includes the functionality and additional support staff for an upgraded system that allows travelers to report incidents via a cellular phone and a traffic surveillance function for providing visual monitoring of select areas via Closed Circuit Televisions (CCTV), ETTM, detection loops, radar, or other surveillance technology. The surveillance capability would help to identify incidents quickly and provide real-time information and visual confirmation. The surveillance devices can be placed at strategic locations such as tunnels, interchanges, or other areas where congestion problems and incidents are common. In conjunction with a mobile phone call-in system, the effectiveness of incident management is increased. The Variable Message Signs (VMS) and Highway Advisory Radio (HAR) provides incident managers with the ability to inform travelers that an incident has occurred. The VMS and HAR functions may also be used to give general directions or instructions for navigating around incidents that tie up all or part of the Turnpike.
	Centralized Information Management	Alternative E - Improved E-Mail + Widespread Paging System - provides the functionality required to implement a wireless paging system that would allow key personnel to receive instant notification of incidents, Class 9 vehicles, or other vital information. The pager device would be display type, allowing messages in text form to be read from the LED-type mini screen.
	Pre-Trip Travel Information	Alternative B - Interjurisdictional Information System - provides Database Processing, Stationary Communications, 2-Way Mobile Communications, Traffic Surveillance and Inter-Agency Coordination functionality allowing a traveler to obtain pre-trip information on real-time traffic conditions and other information obtained through inter-agency coordination from the Turnpike via a fixed or mobile phone. A phone menu system would allow the traveler to receive various types of information without the assistance of an operator.

Priority	User Service	Recommended System Configuration
MEDIUM TERM	Traffic Control	Alternative B - Signal Control + VMS - provides the essential components for controlling traffic at the Turnpike interchanges, tunnels, and other fixed locations. The traffic surveillance monitoring of traffic flow conditions, especially in tunnels and major urban areas. Variable Message Sign (VMS) can be used to advise drivers of single lane tunnel operation, crossovers to the roadway normally used for the opposing flow, and reduced speed limits.
	Commercial Vehicle Administration	Alternative C - Electronic Filing of Credentials + HAZMAT Permit Information on Transponder - allows commercial transport companies to file the additional hazmat credentials required by the Turnpike for transport of hazardous goods on the Turnpike as well as adding individual interface, stationary communications, and payment systems permitting electronic filing and payment for transportation credentials. Currently, all of the state mandated information and additional information and indemnification is required to be provided by the commercial transport company. This system also has the indication of a valid hazmat permit to the E-ZPass transponder attached to the vehicles.
	Freight Mobility	Alternative B - Add Credit Card Phones to Select Areas - includes the 2-Way mobile communications, stationary communications, and payment system functions for providing commercial drivers access to credit card phones at selected areas along the Turnpike. This would allow commercial truck drivers to place phone calls and have the charges electronically billed to a credit card. A fee would be collected by the Turnpike for the use of these phones. Note that there may be some concerns about the safety of access at egress.
	Hazmat Incident Response	Alternative A - Provide Hazmat Database Access - provides the functions necessary to provide mobile access to a Hazardous Materials database that could be used to receive vital information in the event of a Hazmat incident. This information system would allow officials or responders to get information about the operator of a Hazmat load and agreements in place with wrecker operators and hazmat cleanup organizations.
	Demand Management & Operations	Alternative B -Off-Peak Toll Discounts - allows a congestion pricing system to be implemented, in which travelers are given incentive to travel at off-peak times resulting in an evenly distributed traffic flow. The functionality for providing congestion pricing includes the functions indicated for implementing an HOV facility, but in addition would require a Payment System and perhaps Traffic Surveillance
	Ride Matching & Reservations	An alternative was not recommended for this user service because the user service does not significantly help achieve the regional goals
LONG TERM	Traveler Services Information	Alternative B - Telephone Link to Traveler Service Information - provides travelers with access to information about traveler services via telephone. Traveler service information could be provided by a private firm that directly charges the traveler for information access.

FIGURE 8
FUNCTIONS REQUIRED BY RECOMMENDED CONFIGURATIONS AND AVAILABLE THROUGH SYNERGIES

Functions / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Data Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
En-Route Information	●			●	●	o	●	●	●	●			o		●	●	
Electronic Payment		o		o	o			o	●	●					●	●	●
Incident Management	●			●		o		●	●	●	o		o	o	●	●	
Centralized Information Management				●	●			●		●					●	●	
Pre-Trip Travel Information	●			o	●	o	o		●	●		o	o		●	●	
Traffic Control	●			●						●	●		o	●	●	o	
Commercial Vehicle Admin.		●		o	●			o	●	●					●		●
Freight Mobility		o			o	o	o	o	o	●					o		
Hazmat Incident Response		o	o			o		o	●						●	●	
Demand Mngt & Operations	●	o		●	o	o		o		●	o				●		●
Ride Matching & Reservations		o		o	o	o	o	o	o	o					o	o	o
Traveler Services Information				●	●		●		●	●					●		

Source: Core User Services as presented in the National ITS Program Plan, Centralized Information Management User Service based upon the Compare Project, Tidewater, VA

Key: ● = Necessary Functions o = Mature Functions

Section 3.0 System Architecture

9.0 RECOMMENDED SYSTEM ARCHITECTURE

9.1 What is a System Architecture?

The term "system architecture" refers to the way that 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 described in earlier chapters. This system architecture describes:

- The equipment and software that compose the recommended system
- The communication links between the components.

Note that some of the actions recommended for improving user services are not reflected in the system architecture because they do not involve equipment or because they are not to be connected to other ITS equipment. One example is the expansion of the area from which motorists can make a toll-free call to get Turnpike weather and road condition information.

9.2 Considerations in Designing a System Architecture

In developing our recommendations concerning ITS system architecture, we considered the recommended Functional Area Plan described in the previous chapter as well as the Turnpike's existing communication and traffic management infrastructure These are summarized below.

9.2.1 Functional Area Plan

As previous chapters have indicated, the tools needed to adequately address Turnpike user needs fall into seven functional areas:

- **Surveillance**
- Traveler Interface
- Navigation and Guidance
- Communication
- Traffic Control
- Data Processing
- Coordination and Payment

The existing and recommended subsystems that should be implemented to achieve these functions are discussed in separate subsections below.

9.2.1.1 Surveillance

Motorists want four kinds of information that are based on surveillance of traffic flow, roadway conditions, and weather. The four types of surveillance are:

Incidents - because of State Police patrols, motorist assistance call boxes, the cellular telephone call-in system (* 11), and video surveillance at the tunnels, the Turnpike and State Police have good information about incidents, and respond promptly and appropriately to remove them However, there are some locations, such as the ramps at the Breezewood and Mid-County interchanges, where we recommend video surveillance to speed incident detection and the determination of what equipment is needed.

Work zones - with rare exceptions, only Turnpike crews and Turnpike contractors perform work in Turnpike right of way Therefore, the Turnpike has excellent information about lane closures due to construction and maintenance work. No actions to improve this information are necessary for construction and maintenance activities on the Turnpike. However, better information concerning work zones on the Pennsylvania Department of Transportation (PennDOT) roads leading to and from the Turnpike is desirable.

Weather - the Turnpike has no weather sensors along the roadway, so information about roadway conditions is limited to that provided by reports from Turnpike staff and two other sources: Accuweather, a private sector weather forecasting firm, and the National Weather Service. We recommend installing weather stations at selected locations along the Turnpike to detect hazardous conditions (icy pavement, high winds, dense fog) as well as the usual meteorological information. This information could also be provided to PennDOT in exchange for comparable data from its weather and pavement monitoring stations. Other jurisdictions have found that the information provided by such weather stations greatly improves their management of snow and ice removal crews.

Congestion - the Turnpike has no sensors to measure traffic speed or to detect congestion. Especially in the urban areas, congestion information is of great value to motorists who are selecting among alternate routes, so we recommend a subsystem to measure speed at regular intervals along the route.

Besides the surveillance of conditions of interest to motorists, we recommend that the Turnpike gather information about the performance of its roadside equipment so that equipment failures are detected quickly and the nature of the failure diagnosed from a central location.

9.2.1.2 Traveler Interface

The existing and recommended tools for notifying motorists about conditions on the Turnpike are:

Highway Advisory Radio (HAR) - transmitters along the Turnpike. These have not yet been installed.

Variable Message Signs - along and near the Turnpike. Permanent signs have not yet been installed, although Turnpike has used trailer-mounted signs very effectively to inform motorists of both work zones and incidents.

Travel Boards - at Turnpike service plazas. Installation of these Travel Boards is complete. The Travel Board includes a lighted map and advertising panels, variable message display, and a toll free telephone for obtaining reservations.

Recorded telephone messages - about Turnpike conditions. This system is currently in operation.

Written bulletins - about incidents and other special situations faxed to traffic reporters who will rebroadcast the information to the traveling public, certain trucking companies, and other transportation agencies. This system is currently in operation, but should be expanded to send the bulletins to selected Turnpike personnel via electronic mail.

Remote computer workstations - in the offices of other transportation agencies and traffic reporters. The workstations will provide the agencies and reporters with clear, detailed information about problems on the Turnpike so they can help disperse that information to motorists. The workstations will also enable other agencies and traffic reporters to notify the Turnpike of problems they have discovered.

An Internet Home Page - can also provide information to people and organizations that are interested in conditions on the Turnpike, but who do not have access to the written bulletins or remote workstations mentioned in the preceding paragraphs.

The first three of these target motorists who are on or approaching the Turnpike. The others target people who have not yet started their trips or who are on the road, but are still far from the Turnpike.

9.2.1.3 Navigation and Guidance

The navigation and guidance features are predominantly found in intelligent transportation systems that incorporate in-vehicle location and routing features. These features are not of primary importance to the Turnpike. However, many of the other infrastructure improvements that are being recommended will also support advanced in-vehicle routing and guidance when the private sector is ready to incorporate and provide these features.

Directional routing information - will be incorporated into advancements in the Turnpike’s telephone information system This system would respond to verbal requests for information such as “How do I get to . . . " that would be received from travelers on telephones located in people’s homes, information kiosks, pay phones, and cellular phones. It is believed that these requests for information can best be responded to by private sector firms that are paid to provide this service.

9.2.1.4 Communication

The communication function is deeply intertwined with some of the functions that have already been mentioned and others that will be mentioned in later paragraphs. The key components of the communication system are:

A fiber optic communication system - that will be used to support the exchange of data among the various facilities of the Turnpike. Examples of the ITS data that will be carried on this system are E-ZPass transaction data, control signals for the VMS units, messages that will be broadcast over the HAR system, and CCTV pictures from selected areas.

Upgrades to the microwave system - that will support and enhance data and voice communication with the State Police troopers and Turnpike maintenance personnel in the field These upgrades could also support interaction with ITS field components that are not located along the right-of-way, such as VMS units and HAR alert beacons located on PennDOT roadways approaching the Turnpike.

Upgrades to the existing Local Area Network (LAN) - in the headquarters building that would be needed to support workstations outside of the Communication Center (Commo Center), and provide access to the incident and work zone management subsystem from any computer that is now part of the Turnpike's E-mail system.

Upgrades to the existing Wide Area Network (WAN) -would provide the necessary communication support for workstations and **E-mail** locations outside of the headquarters **building. This would include Turnpike facilities and could also include selected public** agencies and private sector traffic reporting agencies, as well as any other organization that reaches an agreement with the Turnpike for accessing the incident status bulletin board.

The Turnpike should gather and exchange information about major incidents and hazards on neighboring roadways operated by PennDOT as well as the Ohio and New Jersey Turnpikes. This may be partially or fully implemented through the Information Exchange Network (IEN) that is being developed by the I-95 Corridor Coalition, of which the Pennsylvania Turnpike Commission is a member. This information network will link the organizations together. The information gathered through such a network will enable the Turnpike to provide its patrons with valuable information about unusual problems they will encounter when they leave the Turnpike, thus increasing customer service and satisfaction. Currently, other agencies use telephone calls, radio, and faxes to inform the Turnpike of major problems. We propose that telephone, radio, and fax be supplemented or replaced by an information network such as the IEN

9.2.1.5 Traffic Control

The primary traffic control function on the Turnpike is the operation of the lane control signals in the Turnpike's tunnels The primary improvements recommended for this system are as follows:

Lane control signals - should be upgraded to current standards so that the lanes in which the motorist is permitted to travel are clearly identified. In addition, the system should provide periodic information to the Communication Center so that the Communication Center staff knows when a tunnel is not operating in its normal mode.

VMS Interface - should be established with the lane control signals so that an appropriate warning message is automatically posted on the VMS unit upstream of the tunnel whenever there is two-way traffic in the tunnel. When motorists will be crossing over to the roadway normally used by traffic traveling in the opposite direction, the sign should warn other motorists automatically. Of course, an operator could override these messages, but only with special authorization.

9.2.1.6 Data Processing

The data processing functin consists of monitoring the data coming from the surveillance subsystems and using the traveler interface subsystems to get the appropriate information to motorists. It is recommended that data processing be performed by centralized equipment at the Turnpike headquarters. Data processing will be carried out by two primary components:

Traffic Management Subsystem - as a point of integration for data collected from surveillance devices and other sources; similarly, it acts as a point of control and dissemination for issuing commands and sending information. The subsystem alerts human operators to situations that may require action, proposes courses of action, and carries out actions selected by the operator. It ensures that warning messages are not left after the problem has gone away, and keeps a log of traffic problems and management activities.

User Workstations - we recommend that each user of the system have a single personal computer or "workstation" that enables the user to see, on a single map display, all the information available about traffic conditions, weather, and the current status of the equipment. We recommend a map display on the computer screen showing the location of each current incident relevant to Turnpike patrons. When a user of this system clicks on the symbol for an incident, a window appears giving the key facts, such as number of lanes blocked and likely clearance time. If the user is at a location that gets video from cameras along the Turnpike, the user will be able to display that video in a window on his or her workstation. If the user is authorized to control the notification subsystems, the same workstation provides him a means of doing so.

9.2.1.7 Coordination and Payment

The last group of functions relates to coordination with outside organizations and payment systems. This coordination function has already been mentioned several times and will not be repeated here. The principal focus of this section is electronic toll payment systems. The principal components of this system are:

Implementation of the E-ZPass system - which should increase the number of vehicles that can be processed through a toll plaza without adding toll lanes. New Jersey is rapidly moving ahead with its deployment of the E-ZPass system and it is anticipated that the Turnpike will also proceed with the implementation of this system in a timely fashion.

Providing real-time transaction information to commercial accounts - would help trucking companies analyze their operational costs more effectively and would also give them a better estimate of the arrival time of their vehicles at nearby facilities.

9.2.2 Existing Infrastructure

The Turnpike already has, or soon will have, much of the infrastructure needed to build the recommended intelligent transportation system The most expensive portion of any intelligent transportation system is the communication link between the field equipment and central equipment. Fortunately, the Turnpike has already made plans to install a state-of-the-art, high capacity, digital communication system along its entire length. This system will be well-suited to the needs of the recommended ITS subsystems. When ITS roadside equipment is installed, the only investment in communication infrastructure that will be required is the link from that equipment to the nearest point of access to the Turnpike communication backbone. This link, which could be as long as several miles, could be provided via Turnpike cable (copper or fiber optic), telephone company circuits, radio, or microwave.

The Turnpike already has a telemetry system the Larse system, for monitoring remote equipment. The Turnpike expects to upgrade or replace that system in the near future The new or upgraded telemetry system can be expanded to cover the ITS roadside equipment, providing the ability to detect power failures, high temperatures, and open cabinet doors. Other ITS elements that the Turnpike already has in place are presented in Table 11.

In addition, PennDOT has video surveillance cameras near the Mid-County interchange that might be available for viewing by Turnpike staff

9.2.3 Design Concepts

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 policy guide for future ITS project implementation, some of the design concepts are recommendations. The following is a list of the major design concepts:

Redundancy - the computing hardware should consist of redundant processors. For example, two or more central processors with multitasking operating systems should be used. Similarly, all mission critical equipment at the Communications Center should be backed up by a redundant piece of equipment. This feature prevents system breakdown in the event of equipment failure or a disaster.

TABLE 11
CURRENTLY INSTALLED ITS EQUIPMENT

Equipment	Location and Function
Call boxes	Along the entire length of the Turnpike
Mile markers	Along the entire length of the Turnpike
Special Incident Reporting Telephone Numbers	For reporting disabled vehicles
Video Cameras	At the tunnels
Toll-free Information Telephone Number	For providing patrons with recorded messages describing weather and roadway conditions
Travel Boards	For providing motorist information at plazas
Fax Service	Provide a means of faxing information about incidents to other agencies, traffic reporters, and certain fleets.
Computerized Incident Log	For keeping records of all Turnpike incidents
Local Area Network (LAN)	Provides communications with the currently installed call box subsystem
Wide Area Network (WAN)	Provides electronic mail (E-mail) capability

Open System Design - the system should be based, to the extent possible, on a hardware and software independent (or "'open") design. Many of the current standards and protocols promote open system design that provides the consumer with hardware and software choices without as much risk of obsolescence that is inherent in proprietary systems. Manufacturers that produce equipment and software that comply with accepted standards and protocols should be considered.

Modular System - the recommended system architecture is based on a modular approach through the use of "subsystems." 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. A modular design 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 system breakdown in the event of equipment failures or operator error. Modules or subsystems can be replaced with relative ease.

Centralized Processing - the processing architecture for the Turnpike intelligent transportation system is based on a centralized approach in which most of the information collected by roadside equipment and other sources is communicated to the Turnpike headquarters for processing and storage. This architecture design approach provides superior security and better control of critical tasks. Note that in the interest of efficiency, there may be some processing by roadside equipment before transmission of data to the Turnpike headquarters.

Communication Backbone - the communications architecture 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 - the concept of information integration should be used to provide Turnpike operators at the Communications Center maximum productivity and minimum response times 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. Multiple media such as video, voice, and data, can be integrated and displayed at workstations. A digital map display or a Geographic Information System (GIS) can provide the integration tool for giving operators access to many types and sources of information.

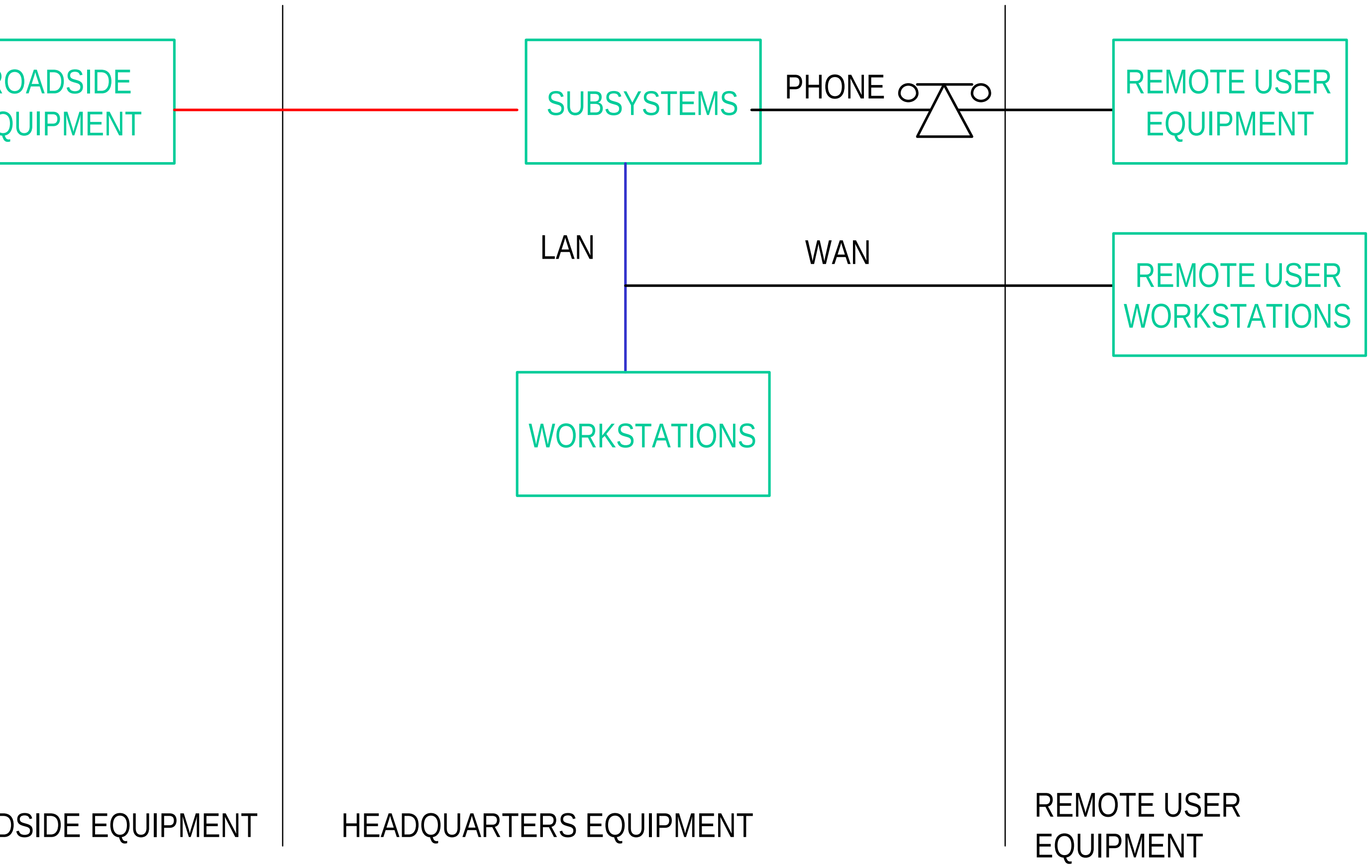
Semi-Automatic Operation - the hardware and software should be selected and designed so that control options are automatically provided to the operators. Operators should be able to approve the recommended option or edit the control option and initiate the desired command For a given situation, such as an incident that blocks all lanes of a given direction on the Turnpike, the operator should be presented with the appropriate options that are retrieved fiom a library of responses for the situation at hand. This semiautomatic approach optimizes response time and resources.

9.3 The Recommended System Architecture

This section discusses the recommended architecture for the Turnpike intelligent transportation system The architecture is presented in a top-down approach. First, an overview of the system is given to show the major components, then the detailed architecture is presented.

9.3.1 System Overview

Figure 9 shows an overview of the proposed Turnpike intelligent transportation system, indicating major system components as boxes and communication links as lines. A more detailed illustration of the system architecture is provided in Figure 10.



LEGEND

LAN

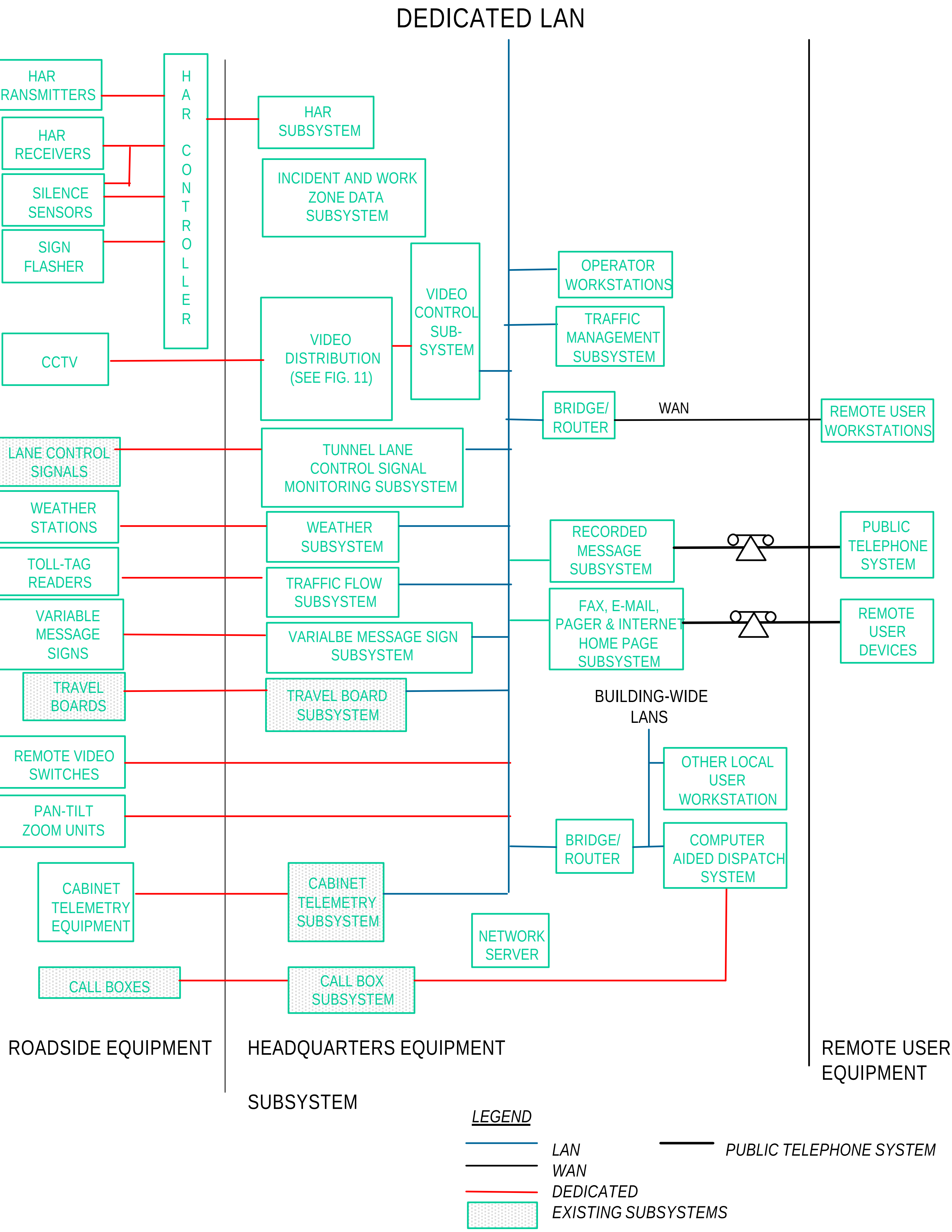
WAN

DEDICATED

PUBLIC TELEPHONE SYSTEM

SYSTEM OVERVIEW

FIGURE 9



RECOMMENDED SYSTEM ARCHITECTURE
VOICE AND DATA DISTRIBUTION
FIGURE 10

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. Examples of fixed location equipment are variable message signs (VMS), highway advisory radio (HAR), and Travel Boards at the 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 subsystems consist of physical components, hardware, and software located at the Turnpike headquarters. These 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 are a total of 13 subsystems proposed to provide the Core User Services identified in the User Service Plan. These subsystems are identified individually in Figure 10, recommended system architecture, and are described in detail in Appendix 0.

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 LAN and the WAN consist 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 transactions 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 his or her pager.

9.3.2 Detailed System Architecture

Figure **10** shows the voice and data distribution portion of the recommended system architecture for the Turnpike's intelligent transportation system Note that existing subsystems are indicated by shaded boxes. The figure excludes much of the equipment that handles video, but Figure 11 shows the video distribution system in detail

Note that in addition to the components illustrated in the recommended system architecture of Figure 10, software and communication are discussed in separate subsections. These elements, although they are not as physically apparent in the system must be carefully considered and planned for in implementation of the Core User Services.

9.3.2.1 Roadside Equipment

Roadside equipment represents physical infrastructure that is located within the Turnpike right-of-way or other places proximate to the Turnpike. As described in the system overview, this infrastructure provides collection and dissemination of vital information as an integral part of the intelligent transportation system Each piece of roadside equipment has a complementary subsystem that is located and operated within the Turnpike headquarters building, providing centralized control of the ITS infrastructure Table 12 provides an inventory of the proposed roadside infrastructure the associated subsystem, and a brief description of its function in providing the Core User Services for the Turnpike intelligent transportation system

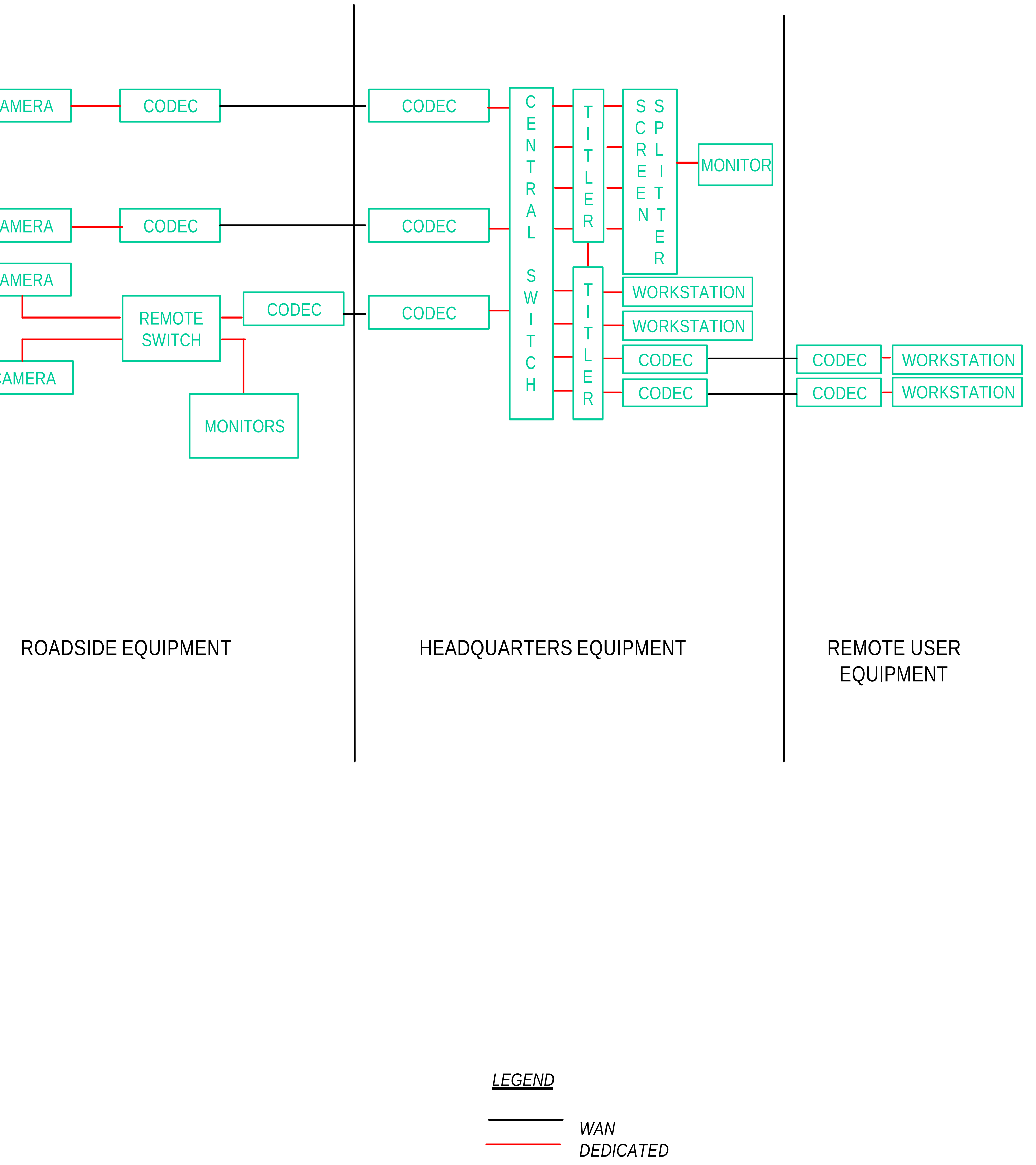
The detailed subsystem descriptions presented in Appendix 0 provide a full account of the information flow, communication links, and operation between the roadside equipment and the associated subsystems. Also, note that not all subsystems have associated roadside equipment.

9.3.2.2 Subsystems

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.

There are a total of 13 subsystems proposed for handling the ITS tasks required to implement the Core ITS User Services that were identified in the User Service Plan.

There are a number of technology options available for processing the data and controlling the subsystems. One possibility for the Turnpike is to use redundant multitasking processor units. With this configuration, each subsystem will be a processing task that shares processing time with other subsystems on a multitasking processor unit.



RECOMMENDED SYSTEM ARCHITECTURE
VIDEO DISTRIBUTION PORTION
FIGURE 11

TABLE 12
ROADSIDE EQUIPMENT

Equipment	Associated Subsystem	Function
HAR Transmitters	Highway Advisory Radio	Broadcast HAR signals to motorists
HAR Receivers	Highway Advisory Radio	Receive HAR messages for transmission
Silence Sensors	Highway Advisory Radio	Detect failures of HAR transmitters
Sign Flashers	Highway Advisory Radio	Activate flashing beacons that alert motorists to tune to the appropriate AM radio station
HAR Controllers	Highway Advisory Radio	Provide control of the field components of the HAR subsystem
Pan-Tilt Zoom Units	Video Control	Provide directional and focus control for video cameras
Remote Video Switches	Video Control	Allows operator to select desired video image for transmission
Lane Control Signals	Tunnel Lane Control Signal Monitoring	Provide for centralized monitoring of tunnel lane signals
Weather Stations	Weather	Collect atmospheric and pavement data at a fixed location
Toll Tag Readers	Traffic Plow	Electronically read patron toll tags for automatic tolling
Variable Message Signs	Variable Message Sign	Display lighted messages for motorists
Travel Boards	Travel Board	Provides interface between motorist at toll plaza and information system
Cabinet Telemetry Equipment	Cabinet Telemetry	Provides for monitoring of controller cabinets
Call Boxes	Call Box	Allow motorists to request help from the roadside

One option for implementing the subsystems is the use of dual processor units that have a multitasking operating system, so that each subsystem operates as an independent task. The redundant processor provides a backup in case the first processor fails.

9.3.2.3 **Networks**

The network allows different users and processes to share system resources. Each network serves users in a geographic area. The local area network (LAN) serves users in a small area, such as the Communications Center or specific departments or groups within the Turnpike headquarters building The wide area network (WAN) provides sharing of the centralized information with remote users such as toll and service plaza personnel and maintenance workers.

The networks will serve a variety of users throughout the Turnpike system Of course, not all of these users will have capabilities to control the system Different users will be authorized to perform different tasks, and a user-specific password will be used to enforce this differentiation of duties. For example, the Communication Center supervisor may be authorized to perform every function; the Communication Center staff may be authorized to perform any function except changing passwords, user privileges, or the event log file; other Turnpike staff may be precluded from controlling any equipment except video cameras; and outsiders may be able only to see the traffic information and post information about incidents. Because the responsibilities may change, the system should be designed so that it is easy to change the capabilities assigned to different users. However, to discourage mischief, we recommend that the workstation software at non-Turnpike locations be incapable of controlling equipment regardless of the user's password.

The three types of networks proposed for the Turnpike are:

> *Dedicated Local Area Network* - the Dedicated LAN serves mission critical tasks and operators in the Turnpike Communications Center. Use of critical resources is closely monitored by the dedicated LAN so that incident management, roadside equipment control, and other vital operations are not compromised.
>
> The network server handles such system functions as timekeeping, password management, network configuration, and printer spooling.
>
> *Building-Wide Local Area Networks* - these networks can be established to serve departments, groups, or any other set of Turnpike personnel so that the centralized resources and system can be shared. User privileges can be assigned to each group or an individual so that information and other Turnpike resources can be shared without compromising security.
>
> *Wide Area Network* - the WAN will provide the sharing of resources necessary for remote users to perform their tasks using the centralized resources of the Turnpike. Users can be assigned certain privileges on the network, similar to assigning user privileges on the local area networks.

9.3.2.4 Workstations

Figure 9 shows three kinds of workstations: operator, other local user, and remote user. The hardware and software are nearly the same for the three types of workstations; the main difference is in how they communicate with the subsystem computers.

> *Operator Workstations* - the operator workstations, used by the Turnpike Communication Center staff are connected directly to the dedicated LAN that links the subsystem computers to one another.
>
> *Local User Workstations* - the other local users are such Turnpike departments as Public Relations, Patron Services, and Maintenance, as well as the top Turnpike executives. These users are linked to the system via the existing building-wide LAN that serves the headquarters complex. That network is connected to the ITS network by a router.
>
> *Remote User Workstations* - another router links the ITS network to a WAN that extends to workstations at the Turnpike district offices, State Police barracks, PennDOT traffic operations centers, and traffic reporters.

9.3.2.5 Remote User Equipment

The remote user equipment consists ofportable electronic devices and fixed or portable workstations that provide various remote users with the ability to give information, receive information, and perform tasks. The remote user equipment in Table 13 represents the most common devices that are currently used for communication; note, however, that the technologies for communication are changing very rapidly. The emergence of new communication devices, such as personal digital assistants, will present new opportunities and challenges in providing ITS user services and conducting business. Table 13 also presents a current list of how this remote user equipment would function in the intelligent transportation system

9.3.2.6 Software

Essentially all of the software running on the workstations, most subsystems, and the traffic management processor will be custom written. Because systems using similar software are being installed in many cities, it will be possible to contract a software provider who has already written similar software. That should reduce the cost and debugging problems that would be associated with completely new software. Existing software such as that on the call box subsystem will require modification in order to provide integration with the recommended architecture.

The network server software would be a standard product from a software vendor like Novell. The software in the routers, automated telephone attendant, and roadside equipment would also be the manufacturer's standard product, except perhaps for the variable message signs. The sign software is likely to be a modification of software already written by the sign manufacturer with an open communications protocol, possibly the National Transportation Communication ITS Protocol (NTCIP).

TABLE 13
REMOTE USER EQUIPMENT

Equipment	Function
Remote User Workstations	Provide Turnpike personnel and others the ability to perform job tasks and retrieve vital information from remote field locations
Public Telephones	Allow Turnpike travelers and other parties to obtain travel, weather, and other information via fixed or portable telephones
Fax Machines	Allow Turnpike employees to receive and send urgent messages; allows other parties to be notified of important events or conditions and receive information
Personal Computers	Provide a variety of possibilities for sending and receiving video, text, and voice via different computer applications such as E-mail and the Internet
Pagers	Allow Turnpike personnel to be notified of important calls and event-related messages

9.3.2.7 Communication

Except for the LANs at the Turnpike headquarters, The Turnpike's forthcoming digital communication backbone will provide most of the communication links shown in Figures 9-2 and 9-3. The WAN links will be via the Turnpike backbone, with leased circuit or microwave links to locations off the Turnpike. Communication between the subsystem computers and the roadside equipment will also use the backbone, with radio, cable, microwave, or leased circuits to bridge gaps between the equipment location and the nearest access point to the backbone.

Some types of roadside equipment will have a dedicated communication link to each piece of equipment. This type of communication is called "point-to-point." Other types of equipment can conserve communication capacity by putting multiple devices on the same communication channel, much like a LAN. Messages from the subsystem computer are addressed to particular pieces of roadside equipment, and the roadside equipment transmits only in response to a command from the subsystem computer. This type of communication is called "multi point."

To send video over the Turnpike network, codecs will be used. These devices will convert each video signal to a T1 digital data stream Tbis process can degrade the picture quality depending upon the extent of the compression, but the picture is still adequate for traffic management purposes.

Section 10.0 Implementation Plan

10.0 IMPLEMENTATION PLAN

10.1 User Service and Functional Priorities

As discussed in the previous chapters, the analysis of problems and opportunities resulted in a ranking of the ITS User Services which was combined with a review of their implementation aspects to sort these user services into three improvement priority groups. The user services associated with these three priority groups were first shown in Table 5, and for convenience, are shown below in Table 14.

TABLE 14
OVERALL ITS USER SERVICE IMPLEMENTATION PRIORITIES

SHORT-TERM	MEDIUM-TERM	LONG-TERM
En-Route Driver Information Incident Management Centralized Information Management Electronic Payment Services Pre-Trip Travel Information	Demand Management & Operations Freight Mobility Commercial Vehicle Administration Hazmat Incident Response Traffic Control Ride Matching & Reservation	Traveler Services Information (Other ITS User Services)

As part of the Functional Area Plan an analysis was performed for these user services that identified different combinations of functions that could be used to implement each one. These combinations were referred to as system configuration alternatives. Based on this qualitative analysis, and discussions with the Turnpike staff, the preferred system configuration was selected for each user service. The analysis of the system configuration alternatives reflected an appreciation of the extent to which ITS goals could be implemented by each alternative, and the difficulties associated with the implementation of the alternative. The functions that are associated with the recommended system configuration alternatives for the user services were shown in Figure 8.

The functions that make up the recommended system configurations for the user services in the short-term priority group have the highest implementation priorities. These functions are:

- Traffic Surveillance
- Individual Interface
- 1-way Mobile Communication
- Stationary Communications
- Interagency Coordination
- Variable Displays
- Routing
- 2-way Mobile Communication
- Database Processing
- Payment Systems

Most of these high priority functions are also needed for the recommended system configurations for the user services in the medium-term implementation priority group. However, there are four additional functional capabilities that are needed to implement the recommended configurations that are part of this medium-term group. These additional functions are:

- Vehicle surveillance
- Signalized traffic control
- Restrictions Traffic Control
- Traffic control data processing

The three remaining functional capabilities identified in the ITS National Program Plan are needed for the long-term implementation of the remaining ITS User Services. These functional capabilities are:

- In-Vehicle Surveillance
- Traffic Prediction
- Navigation

It seems clear that the implementation priorities should first be focused on the high priority functions identified in the preceding paragraphs. The functions associated with the user services selected for implementation in the medium-term would be implemented next, and the remaining three functions implemented last.

10.2 Implementation Aspects of the Short-Term (High Priority) Functions

Although it is useful to view these required functions on an individual basis, few can be implemented in isolation. To be useful, a function should be implemented together with others to achieve some degree of implementation of a user service. Thus, one-way mobile communication, which is the information dissemination portion of an HAR system, must be implemented with some element of stationary communications, and some database processing. Together these functions provide a useful incremental step toward the full implementation of the En-Route Driver Information user service, even though they do not fully implement the functionality envisioned for this user service.

Because of the necessity of this holistic approach, a series of basic improvement projects were identified that involve each of the high priority functions. However, in examining these projects it is clear that many depend upon the implementation of others. Some of the major dependencies of the high priority functions are discussed in the following paragraphs.

> *Traffic Surveillance* - This function will be implemented through probe vehicle monitoring and the installation of CCTV units in selected areas. Implementation of the CCTV system cannot precede improvements to the comtmmications infrastructure Probe vehicle monitoring cannot take place before the implementation of the E-ZPass System Implementation of the E-ZPass system depends upon improvements to the fare collection system

Variable Display - Implementation of this function will be achieved by means of Variable Message Signs (VMS). Implementation of the VMS should not precede the completion of the communications infrastructure improvements.

Individual Interface - The individual interface recommended as the short-term implementation alternative is the telephone, either land-line or mobile. Complementary improvements should be made to automate the operation of the Turnpike's Travel Information System

Routing - This functin that is part of the Traveler Services Information user service, will help travelers on the Turnpike find their way to specific destinations. In the short-term this will be handled by operators responding to incoming telephone calls. In more distant phases these operators may be replaced or supplemented with enhancements to the Turnpike Traveler Information System and automated vehicle routing systems.

1. Way Mobile Communication - Highway Advisory Radio (HAR) is the one-way communications system of choice in the near-term for communication with travelers. As indicated above the HAR System will also require improvements to the communications system and the database processing at the communications center.

2-Way Mobile Communication - This function is closely associated with the implementation of many of the incident management related projects and is also a key part of the reading and writing on the transponder tags that are part of the E-ZPass system

Stationary Communications - As previously stated, the ability to communicate between the communications center and other fixed points is a key prerequisite to the implementation of many of the other functions. It is assumed that this function will be implemented through a fiber optic communication system running along the right-of-way, and also through upgrades to the microwave communications system

Database Processing - This function will be implemented through the establishment of a variety of different databases serving the needs of the individual improvement projects such as VMS and HAR

Interagency Coordination - Successful interagency coordination is the key to providing integrated information to the traveler which they can be put to meaningful use in comparing alternative routes. This coordination takes place at many levels and for many different kinds of data including the exchange of weather data; traffic flow, incident and construction related data; and CCTV images.

Payment systems - The implementation of the E-ZPass system is another key element of the Turnpike's ITS implementation plan and several other improvement projects are dependant upon the implementation of this system. E-ZPass requires an improved fare collection system

10.3 Implementation Aspects of the Medium-Term (Medium Priority) Functions

Four additional functions are needed as part of the user services that were assigned medium-term implementation priorities.

Vehicle Surveillance - Where traffic surveillance looks at the characteristics of the traffic stream as a whole, this function allows the tracking of the movements of individual vehicles. **Monitoring the** arrival time of probe vehicles at a series of tracking stations is an example of vehicle surveillance. This cannot be implemented until the installation of the E-ZPass system and supplementary tag readers at selected points on the mainline.

Signalized Traffic Control - In the medium-term this would provide the communications center with the ability to monitor the status of the traffic signals at the Tunnels. In the long-term this might include ramp metering at high volume on-ramps to smooth the entry of vehicles onto the mainline traffic stream during peak periods. Since some de-facto metering already takes place as part of the process of issuing toll tickets this is not envisioned in the near future.

Restrictions Traffic Control - This function includes items that provide preferential treatment for some vehicles and disincentives for others. Examples are HOV travel lanes, HOV toll lanes or discounts for HOVs, and surcharges for vehicles making short trips or trips in the peak periods. It is not likely that any physical changes will be made on the roadway to accommodate HOVs. However, changes in the toll structure which give the Turnpike the authority to implement some form of restrictions traffic control may be desirable in the future to give the Commission more flexibility in addressing the competing demands for the limited roadway capacity that is available in the urban areas.

Traffic Control Data Processing - In most signal control systems this would be the implementation of improved traffic signal timing algorithms. On the Turnpike this function has been limited to the interface and coordination of the lane control signals at the tunnels with new VMS units located upstream of the crossovers preceding these tunnels.

10.4 Implementation Aspects of the Long-Term (Low Priority) Functions

Of the fifteen functions that have been identified for the ITS User Services that will be implemented on the Turnpike only three remain to be implemented in the long-term.

In-vehicle surveillance - This function would enable the determination of the number of people inside the vehicle. This would be useful in the automated monitoring of compliance with HOV lane use restrictions, but is not anticipated to be important to the operation of the Turnpike in the foreseeable future.

Navigation - This function would provide the ability of a vehicle to know exactly where it is at all times. AVL should certainly be incorporated into State Police vehicles and maintenance vehicles as part of upgrades to the computer aided dispatch system However, there is no need for the Turnpike to support navigational systems purchased by the general public. Several alternative navigation systems have been proposed which vary in the degree of intelligence and computational power placed in the vehicle and alongside the roadway. Any decision that is made concerning this function should wait for the establishment of national guidelines and standards to assure full compatibility.

Traffic Prediction - This function provides estimates of future traffic conditions and is generally associated with traffic signal control. In the context of the Turnpike this might be applied in the assignment of Toll Collectors to particular shifts at particular plazas as a function of planned events that generate above average exit volumes, or unexpected high volume surges of traffic. However, current and future labor contracts would need to be reviewed in order to allow assignment of toll collectors. Implementation of the E-ZPass system may make it easier to detect these short-term traffic surges.

10.5 Projects Implementing Short-Term User Services

Table 15 is a complete listing of the projects that implement various functions associated with the user services. As can be seen in this table, the potential list of projects is quite extensive. These project titles can be somewhat cryptic and may not provide an adequate explanation of what they involve. A more detailed explanation of the nature of these projects is provided in Appendix P. Figure 12 contains the project description for the CCTV system as an example of the material contained in these descriptions.

The relationships between the projects and the short-term (high priority) user services are shown in Table 16. The first column of this table contains the project number and has been color coded to designate institutional projects and infrastructure projects. The institutional projects will pursue the finding initiatives identified in this document, will enhance the exchange of information and coordination among organizations, and will produce the required legislative and administrative changes.

The second column of Table 16 contains an abbreviated project title. The entries in this column that have been highlighted identify the projects that are required elements of the preferred system configurations identified in Table 9.

The remaining cohmms in Table 16 delineate the five short-term/high priority ITS User Services. The entries in these columns identify the projects that will improve the quality of each user service as it is perceived by travelers on the Turnpike. A "Related" designation indicates that the user service will be improved through the project. The highlighted "Required" designation indicates that the project is part of the recommended system configuration for that user service.

TABLE 15
PROJECTS IMPLEMENTING USER SERVICE FUNCTIONS

Traffic Surveillance Function	
Project TS10	Probe Vehicle Monitoring
Project TS20	CCTV Installation
Weather Surveillance Function	
Project WS10	Deploy Weather & Roadway Monitoring Sensors
Project WS20	Exchange Weather & Roadway Monitoring Information w/ PennDOT
Variable Displays Function	
Project VD1 0	Provide Traveler Information on Travel Boards
Project VD20	Variable Message Sign Installation
Individual Traveler Interface	
Project ITI 0	Enhance Turnpike Traveler Information System
Project IT20	Establish a Home Page for the Turnpike on the Internet
One-Way Communications	
Project OW10	Implement HAR System
Two-Way Mobile Communications	
Project TW1 0	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 SC1 0	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 TC10	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 TD10	Install Lane Control / VMS Interconnect for Two-way Tunnel Operation
Database Processing	
Project DP1 0	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

TABLE 15 (continued)
PROJECTS IMPLEMENTING USER SERVICE FUNCTIONS

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, NJTnpk

Payment Systems

Project PSlO	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 CVlO	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 CPlO	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

TABLE 16

RELATIONSHIPS AMONG THE PROJECTS AND SHORT-TERM (HIGH-PRIORITY) USER SERVICE

		SHORT-TERM / HIGH PRIORITY ITS USER SERVICES				
		En-Route Driver Information	Electronic Payment Services	Incident Management	Centralized Information Management	Pre-Trip Travel Information
TS10	Probe Vehicle Monitoring	Related		Related	Related	Related
TS20	CCTV Installation	Related		Required	Related	Related
WS10	Weather & Roadway Sensors	Related			Related	Related
WS20	Exchange Weather Info w/ PennDOT	Related			Related	Related
VD10	Information on Travelboards	Required		Related		
VD20	VMS Installations	Required		Required		
IT10	Telephone Information System	Required		Related		Required
IT20	Internet Home Page					Related
OW10	HAR System	Required		Related		
TW10	Digital Microwave System	Required	Required	Required	Required	Required
TW20	Add Comm Center Operators	Related		Required	Related	Related
TW30	CAD/AVL System			Related	Related	
TW40	Upgrade Comm- Troopers &			Related	Related	
SC10	Fiberoptic Comm System	Required	Required	Required	Required	Required
SC20	LAN at Headquarters	Related		Related	Required	Related
SC30	Upgrade WAN			Related	Required	Related
TC20	VMS at Tunnel Crossovers	Related		Related		
TC30	Rollover Warning System	Related				

		SHORT-TERM / HIGH PRIORITY ITS USER SERVICES				
		En-Route Driver Information	Electronic Payment Services	Incident Management	Centralized Information Management	Pre-Trip Travel Information
TD10	Lane Control Signal/VMS interconnect	Related		Related	Related	
DP10	Coordinate Broadcast Info (text)	Related		Related	Required	Related
DP20	Coordinate HAR and Phone Info System	Related		Related	Related	Related
IC10	Update Broadcast Fax System	Related		Related	Related	Related
IC20	Investigate Ops Center w/ PennDOT	Required		Required	Required	Required
IC30	Investigate Comm Upgrade w/ PennDOT				Required	Related
IC40	CCTV Pix from PennDOT			Related	Related	Related
IC50	Exchange Traffic Info w/ other Agencies			Related	Related	Related
PS10	Photobased Toll Violation Ticketing	Related	Related			
PS20	Transponder Placemnet on Windshields	Related	Related			
PS30	Implement E-Zpass		Required			
CP10	Private Sector Funding	Required				Required
CP20	Incident Alert Flashers				Required	
CP30	Add Location Markers			Related		
CP40	Upgrade Larse System				Related	
CP70	Performance Measure Collection	Related	Related	Related	Related	Related

KEY: High Priority Projects required for implementing preferred system configurations

XXOO Institutional projects
XXOO Infrastructure projects

FIGURE 12
SAMPLE PROJECT DESCRIPTION

Project: CCTV Installation (TS20)	
Priority: High	
Prerequisites:	Implementation of Fiber optic network or Microwave system improvements. (TWlO or SC 10)
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 back-ups 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.

Although there are many projects on which implementation can begin immediately, it is recommended that the implementation efforts concentrate on the highlighted projects. As will be seen in this table, most of these highlighted projects deal with the implementation of the communication system and the E-ZPass system.

The implementation of the other projects shown in this table can be deferred until sufficient personnel resources are available to deal with them, or until they are identified as priority projects because of safety or other reasons. A composite implementation diagram showing the relationships of all the identified short-term/high priority user service projects as well as the individual flowcharts for the preferred system configurations for each of the short-term/high priority user services are included in Appendix P.

10.6 Projects Implementing Other User Services

Projects that help achieve the implementation of the remaining user services have been shown in Table 17 under the medium-term implementation heading. Explanations of these projects are also included in Appendix P.

10.7 Collection of Performance Criteria

One of the recommended projects that the Turnpike should implement is the collection of performance data. These data will be used to evaluate the improvements to the user services that have taken place because of the ITS User Services that are being implemented. These criteria were previously shown in Table 7.

TABLE 17
RELATIONSHIPS AMONG THE PROJECTS AND MEDIUM-TERM AND LONG-TERM USER SERVICES

Projects		MEDIUM AND LONG-TERM ITS USER SERVICES						
		Demand Mngt & Operations	Freight Mobility	Commercial Vehicle Admin	Hazmat Incident Response	Traffic Control	Ride Matching & Reservat'ns	Traveler Services Information
IT10	Telephone Information System							Related
IT20	Internet Home Page		Related					Related
SC30	Upgrade WAN		Related					
TC10	Tunnel Lane Control Signal Monitoring					Related		
TC20	VMS at Tunnel Crossover					Related		
TC30	Rollover Warning System					Related		
TD10	Lane Control Signal/VMS Interconnect					Related		
DP30	Establish Hazmat Carrier Database			Related	Related			
PS30	Implement E-Zpass	Related	Related	Related				
CV10	Account Information Available to CVOs			Related				
CV20	Location Information Available to CVOs		Related					
CV30	Simplify Hazmat Permit Processing			Related	Related			
CV40	Private Partner Truck Staging Areas		Related					
CV50	Add Pay Telephones		Related					
CV60	Put Hazmat Permit on E-Zpass Tag			Related	Related			
CP50	Authorization for Surcharges	Related						
CP60	Encourage Ride Matching by Others						Related	
CP70	Performance Measure Collection	Related	Related	Related	Related	Related	Related	Related

XXOO Institutional projects
XXOO Infrastructure projects

10.8 Funding

These ITS projects will 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 Intermoclal Surface Transportation Efficiency Act of 1991 provided 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 include: the "sale" of CCTV pictures to the Media; the placement of advertisements in the scrolling text of the message on the Travelboards, 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.

10.9 Operations Plan Considerations

Appendix Q contains a series of comments on the preliminary operations plan for the ITS User Services identified in the project. This operations plan differs from others that are commonly prepared for Traffic Management Systems because of the fact that the Pennsylvania Turnpike has an existing 24-hour Management System in place as part of its incident management and fare collection activities. In addition, because of the sophisticated nature of the equipment utilized in the communications and fare collection systems, the Turnpike has already established in-house and contract maintenance procedures for these systems.

The major sections that are included in this appendix address issues that are related to: the increased staffing of the communications center and the training and skills of the people that are fulfilling this assignment; the need for additional space; elements that should be reflected in the annual budget estimates; and alternative procurement techniques.

Appendices

RIS

PENNSYLVANIA TURNPIKE COMMISSION

Appendix A

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX A

INVENTORY OF TURN-PIKE COMMUNICATIONS EQUIPMENT

INVENTORY OF TURNPIKE COMMUNICATIONS EQUIPMENT

Item No.	Equipment Item	Age (Years)	Units/ Quantity	Equipment Locations
Microwave Systems				
1	6 GHz Equipment	18-20	16 paths	Interchange 4 to 27 North to Interchange 35 + branch to Admin Bldg
2	2 GHz Equipment	16-20 6	13 paths 2 paths	Interchange 2-4 and North to Radio Hill
3	Multiplex (MUX) Equipment	20	N/A	All Microwave locations
4	Supvr & Control System	9	1	Administrative Building
5	MUX Interface System	20	approx 30	All Microwave locations
VHF/UHF Systems				
6	Consoles & Ancillary Equip	0	8	Adminsitrative Building
7	VHF Repeater Base Stations	4-10	approx 30	All Microwave locations
8	Mobile Radio Equipment	0-10	N/A	Turnpike Vehicles
9	Interchange VHF Units	0-17	Each Interchange	All Interchange
10	Maintenance Bldg VHF Units	10-14	9	All Maintenance Buildings
11	Tunnel VHF Units			
	Control Station	20	2	Alleghany & Lehigh Tunnels
	VHF Control; Station + Aux	N/A	1	Kittatinny & Blue Mtn Tunnels
	Direct Connection Via Cable	N/A	1	Tuscarora Tunnel
12	Administrative Bldg VHF	N/A	3	Adminstrative Building
13	Portable VHF/UHF Units	1	<2000	Maintenance Buildings Tradesmen PTC Engineers
14	CT Coded Squelch System	3	approx 2000	On all VHF radios
15	Ohio TPK VHF Interconnect	N/A	1	Interchange 1
16	CB Base Stations	Varies	30 +	Maintenance Buildings Tunnels PA State Police Bldgs

Item No.	Equipment Item	Age (Years)	Units/ Quantity	Equipment Locations
17	Mobile CB Units	Varies	130+	PA State Police Vehicles Foreman Trucks Admin Vehicles
18	Mobile Veh Repeater System	3	N/A	PA State Police Vehicles Safety Vehicles Maintenance Vehicles
19	Tunnel Repeater System 450 MHZ system	10+	5	Tunnels
20	Comm Ctr Tape Recorder	6	2 transporters 1 playback	Communications Center
21	Admin Bldg Repeater 450 MHZ system	1	1 UHF Repeater 12 Portable Radios	Administration Building
22	Telepanel System	N/A	N/A	Interchagnes Maintenance Buildings Tunnels
23	Patron Intercom System	N/A	Each Interchange	All Interchange
24	Patron Alarm System Pull Boxes Control Unit	 N/A N/A	 1 Ea 220 ft 1	All tunnels, except Lehigh Tunnel
25	Admin Bldg Emergency Public Address System	1	1	Administration Building
Telephone Equipment				
26	PABX System	3	N/A	Administration Building
27	Off Premise Extension (OPX)	N/A	8	Administration Building Lehigh Tunnel-Slatington Pocono Inter-Maintenance East Shore Interchange West Forge Interchange Quakertown Maintenance Wyoming Maintenance
28	Maintenance Telephone System	N/A	11	Maintenance Buildings

Item No.	Equipment Item	Age (Years)	Units/ Quantity	Equipment Locations
Motorists Aid System				
29	Motorist Call Boxes	3 - 7	1 Ea mile	Every mile along Turnpike
30	VHF Base Stations	3 - 7	N/A	Locations along Turnpike
31	Control Console	3 - 7	1	Comm Center at Highspire
Weather Printers				
32	Master Weather Printer	10	1	Administration Building
33	Slave Weather Printer	10	12	Microwave-accessible Maintenance Bldgs
Facilities				
34	HVAC Equipment	N/A	N/A	Microwave Equipment Rooms
35	Emergency Power Equipment	N/A	N/A	Microwave Equipment Rooms and Interchanges
36	Microwave Antenna System	15-21	N/A	N/A
37	Towers	4-14+	N/A	Bunches South Mountain Willow Grove Cornwall Thompsons Run Others
38	Uninterrupted Power Supply (UPS)	N/A	1	Communications Center
39	Closed Circuit Television (CCTV)	1-2+	9 7 8+ 18	Administration Building Eastern Regional Office Western Regional Office Blue Mountain Tunnel and Kittatinny Tunnel

Appendix

B

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX B

TURNPIKE PATRON SURVEY

PENNSYLVANIA TURNPIKE PATRON SURVEY
HIGHLIGHTS OF RESULTS

- More than half of those surveyed started or ended their trip out of state.

- 43% of the overall sample used the Turnpike at least once every other week.

- Less than half of those sampled knew about the Turnpike's toll-free roadway and weather information service.

- 31% of those surveyed had a cellular phone.

- The location and length of a delay or congestion were the most important type of information to Turnpike travelers, followed by construction information, alternate routes and weather condition information.

- Patrons would prefer to receive roadway and weather information prior to starting their trip and before entering the Turnpike.

- The three top choices for how Turnpike patrons would like to receive information include a Turnpike information radio station (HAR) Variable Message Signs along the roadway and commercial radio in the vehicle.

- Approximately 45% of those surveyed would be interested in using ETTM / E-ZPass even if a nominal fee was charged for the service.

- The following trends were noted for the 214 patron surveys in which the trip purpose was commercial delivery, commuter, or business travel:

  Approximately 47% of these travelers used the Turnpike at least once a week.

  Commercial delivery, commuter, and business travelers have a slightly higher percentage of vehicles with cellular phones (40.2%).

  m The top choices for how commercial and business travelers would like to receive information are generally the same as those for other patrons with the exception that displays in the service plazas are not as important.

  Almost 56% of commercial delivery, commuter, and business travelers would be interested in using ETTM / E-ZPass This is considerably higher than the 45% of the overall patron survey results.

- The following trends were identified for the 192 patron surveys in which the trip purpose was recreational or personal travel:

    They use the Turnpike less frequently.

    They have a lower percentage of vehicles with cellular phones (2 1%).

    Only 34% of these travelers would be interested in using ETTM / E-ZPass This is 22% less than the percentage of commercial, commuter, and business travelers who are interested in ETTM / E-ZPass.

Survey ID# Plaza Location: Date: Time: M F

PENNSYLVANIA TURNPIKE PATRON QUESTIONNAIRE

Hello,

We are conducting a survey on behalf of the Pennsylvania Turnpike Commission to assess current and future information needs of motorists traveling along the Turnpike. Your response will allow us to develop a strategic plan for implementing new technology and improving Turnpike user services and facilities in order to better serve you. Do you have about five minutes to answer a few questions?

1. What is the purpose of your trip?
   - A. ____ Toursit/Recreational
   - B. ____ Commuting to/from work
   - C. ____Personal travel
   - D. ____ Commercial Delivery
   - E. ____ Business travel
   - F. ____ Other *(Specify):* __________________

2a. On this trip where did you enter the Pennsylvania Turnpike?
(List interchange #, route # or name) ___________________________________

2b. On this trip where will you Exit the Pennsylvania Turnpike?
(List interchange #, route # or name) ___________________________________

3. Did you start or will you end this trip out of state? **YES** ______ **NO** ______

4a. What type of vehicle are you traveling in today?
1. ______ Passenger Vehicle *(If passenger vehicle, go to question 5)*
2. ______ Bus *(If bus passenger Stop interview)*
3. ______ Truck *(If truck, go to question 4b)*
4. ______ Other *(Specify):* ____

4b. List the class *(1 though 9)* or the approximate weight of your vehicle for this trip *(If known)* . . .

1. **Vehicle Class** __________ (or) 2**. Vehicle Weight** _____________

4c. If vehicle is a single unit truck or a semi-trailer please indicate whether the vehicle is . . .

1. **Owner/operator** ______________ (or) 2. **Part of a fleet** _________

4d. If owner/operator, do you primarily drive for one company? **YES** ____ **NO** ____

4e. Do you use a Turnpike charge card to pay tolls? **YES** ____ **NO** ____

5. How often do you use the Turnpike?
   - A. ______ Daily
   - B. ______ More than twice a week
   - C. ______ Weekly
   - D. ______ Every other week
   - E. ______ Several times a year
   - F. ______ About once a year
   - G. ______ Less than once a year

Which of the following Turnpike services are you familiar with? ***(Circle items 1 thru 4 as they apply)***

	6b. YES	NO
1. Emergency Call Boxes	______	______
2. Toll Free Roadway and Weather Information service	______	______
3. *11 Cellular Free Emergency service	______	______
4. Other ***(specify) :*** ______________________________	______	______

. Have you used the services listed above in the past?

Do you have any of the following in your vehicle?

		YES	NO
a.	Cellular Phone	______	______
b.	CB Radio	______	______

. What specific types of information would be of interest to you when traveling on the Turnpike?

	YES	NO	8b. RANK
1. The location and length of a delay or congestion	______	______	______
2. Alternate routes that could be used when there is a major incident	______	______	______
3. Information about service plazas	______	______	______
4. Delays at toll plazas	______	______	______
5. Construction information ***(Lane closed, duration, length, location, etc.)***	______	______	______
6. Weather information	______	______	______
7. Off Turnpike roadway information	______	______	______
8. Hotel/Tourist/Destination information	______	______	______
9. Other: ______________________________	______	______	______

. Please rank the top three types of information from the list above, in order of their importance to you ***(I for most important; 2 for second most important; and 3 for third most important)***

When would you like to receive information about Turnpike roadway and weather conditions (such as accidents, delays, vehicle restrictions, snowstorms, icy roads, fog, etc.)?

		YES	NO	9b. RANK
1.	Before starting your trip	______	______	______
2.	Before entering the Turnpike	______	______	______
3.	While driving on the Turnpike	______	______	______
4.	At the Service Plazas	______	______	______

. Please rank the above sources that you marked YES in order of their importance to you ***(1 or most important; 2 for second most important; and so on.. .)***

a. How would you like to receive information regarding Turnpike roadway and weather conditions?

	YES	NO	10b. RANK
1. TV at Home/Work	______	______	______
2. Telephone at Home/Work	______	______	______
3. Computer Bulletin Board at Home/Work	______	______	______
4. FAX at Home/Work	______	______	______
5. Commercial Radio at Home/Work	______	______	______
6. Commercial Radio in your Vehicle	______	______	______
7. Turnpike Information Radio Station	______	______	______
8. Changeable Message Signs along the Roadway	______	______	______
9. Displays within the service plazas	______	______	______
10. Through a car phone	______	______	______
11. Through a computer in your vehicle	______	______	______
12. Other: ______________________	______	______	______

b. Please rank the top three ways of how you would like to receive information in order of their importance to ***you (1 for most important; 2 for second most important; and 3 for third most important)***

. Would you use an electronic device to enable you to pay your toll without stopping, if a nominal fee was charged for this service?

YES ______ NO ______ **UNDECIDED** ______

. Is there any other information that could be provided to you that would improve your trip?

____

____

PENNSYLVANIA TURNPIKE PATRON QUESTIONNAIRE SUMMARY
Overall Survey Data Total

Survey Locations	**Surveys** collected	% of Total
New Stanton	100	24.6%
Sideling Hill	120	29.6%
P.J. Camiel	100	24.6%
Allentown	86	21.2%
Total	406	100.0%

Gender	**Total**	% of Total
Male	331	81.5%
Female	68	16.7%
Unknown	7	1.7%

Question #1: Trip purpose	**Total**	% of Total
Tourist/Recreational	40	9.9%
Commuting to/from work	6	1.5%
Personal Travel	148	36.5%
Commercial Delivery	75	18.5%
Business Travel	133	32.8%
Other	4	0.99%

Question #3 Trip starting or ending out of state

	Total	% of Total
Yes	216	53.2%
No	190	46.8%

Question #4a Vehicle Type	**Total**	% of Total
Passenger Vehicle	316	77.8%
Bus	6	1.5%
Truck/Tractor Trailer	78	19.2%
Other	6	1.5%

Question #4b Truck Class	**Total**	% of Total
Class 1	1	1.3%
Class 2	1	1.3%
Class 3	2	2.6%
Class 4	3	3.8%
Class 5	23	29.5%
Class 6	6	7.7%
Class 7	33	42.3%
Class 8	9	11.5%
Class 9	0	0.0%
Class 10	0	0.0%

Question #4c Truck operation

	Total	% of Total
Owner/ Operator	26	33.3%
Part of a Fleet	52	66.7%

Question #4d

	Yes	No	% of Total
Owner/ Operator:			
Drive for one company	24	2	92.3%

Question #4e Commercial Charge Card

Yes	No	% of Usage
26	52	33.3%

Question #5 Usage Frequency

	Total	% of Total
Daily	27	6.7%
More than twice a week	34	8.4%
Weekly	60	14.8%
Every other week	51	12.6%
Several times a year	184	45.3%
About once a year	36	8.9%
Less than once a year	14	3.4%

Question # 6 Current Turnpike Services

	Yes	No	% of Yes Responses	% of No responses
a.) Familiar with:				
Emergency call boxes	**389**	17	95.8%	4.2%
Roadway/ Weather Service	174	232	42.9%	57.1%
Cellular *1 1 Emergency Service	227	179	55.9%	44.1%

	Yes	No	% of Service Used
b.) Services used:			
Emergency call boxes	**29**	377	75%
Roadway/Weather Service	53	353	30.5%
*1 1 Cellular Emergency Service	28	378	12.3%

Question #7 Included in car

	Yes	No	% of Yes responses	% of No responses
Cellular phone	126	280	31.0%	69.0%
CB Radio	134	272	33.0%	67.0%

Question #8 Information interests

	Yes	No	RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
			Number	Percent	Number	Percent	Number	Percent
Delay or congestion	383	23	210	51.7%	74	18.2%	34	11.4%
Alternative Routes	376	30	46	11.3%	135	33.3%	70	23.5%
Service Plaza Information	195	211	6	1.5%	11	2.7%	17	5.7%
Toll Plaza delays	233	173	7	1.7%	17	4.2%	21	7.0%
Construction information	374	32	71	17.5%	107	26.4%	78	26.2%
Weather information	291	115	30	7.4%	30	7.4%	47	15.8%
Off Turnpike roadway information	262	144	7	1.7%	14	3.4%	15	5.0%
Hotel/Tourist/information	179	227	25	6.2%	15	3.7%	12	4.0%
Other			4	1.0%	3	0.7%	4	1.3%

Question #9 When Information is needed

	Yes	No	RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
			Number	Percent	Number	Percent	Number	Percent
Before starting trip	322	84	189	46.6%	37	9.20%	22	9.73%
Before entering Turnpike	371	35	136	33.5%	180	44.78%	20	8.85%
While driving	340	66	70	17.2%	126	31.34%	107	47.35%
At service plazas	304	102	11	2.7%	59	14.68%	77	34.07%

Question#10 How information is received

	Yes	No	RESPONSES RANKED FIRST Number	RESPONSES RANKED FIRST Percent	RESPONSES RANKED SECOND Number	RESPONSES RANKED SECOND Percent	RESPONSES RANKED THIRD Number	RESPONSES RANKED THIRD Percent
TV at Home/Work	161	245	31	7.6%	12	3.0%	16	5.2%
Telephone at Home/Work	267	139	53	13.1%	26	6.4%	19	6.2%
Computer Bulletin Board	100	306	3	0.7%	9	2.2%	6	2.0%
FAX at Home/Work	78	328	6	1.5%	7	1.7%	1	0.3%
Commercial Radio at Home/Work	233	173	30	7.4%	17	4.2%	6	2.0%
Turnpike Information Radio Station	328	78	50	12.3%	72	17.8%	37	12.1%
Changeable message signs	369	37	126	31.0%	97	24.0%	41	13.4%
Car phone	377	29	74	18.2%	108	26.7%	80	26.2%
Computer in Vehicle	330	76	11	2.7%	33	8.2%	78	25.6%
Other	130	276	6	1.5	13	3.2	12	3.9%
	62	344	4	1	3	0.7	6	2.0%
			12	3	7	1.7	3	1

Question #11 Electronic Toll Device

	Total	% of Total
Yes	184	45.3%
No	200	49.3%
Undecided	22	5.4%

PENNSYLVANIA TURNPIKE PATRON QUESTIONNAIRE SUMMARY

Commercial Delivery/Business/Commuter Travel Analysis

Survev Locations	Surveys collected	% of Total
New Stanton	52	24.3%
Sideling Hill	54	25.2%
P.J. Camiel	55	25.7%
Allentown	53	24.8%
Total	214	100.0%

Gender	Total	% of Total
Male	193	90.2%
Female	17	7.9%
Unknown	4	1.9%

Question #I : Trip purpose	Total	% of Total
Tourist/Recreational	0	0.0%
Commuting to/from work	6	2.8%
Personal Travel	0	0.0%
Commercial Delivery	75	35.0%
Business Travel	133	62.1%
Other	0	0.00%

Question #3 Trip starting or ending out of state

	Total	% of Total
Yes	104	48.6%
No	110	51.4%

Question #4a Vehicle Type	Total	% of Total
Passenger Vehicle	133	62.1%
Bus	3	1.4%
Truck/Tractor Trailer	77	36.0%
Other	1	0.5%

Question #4b Truck Class	Total	% of Total
Class 1	1	1.3%
Class 2	1	1.3%
Class 3	2	2.6%
Class 4	3	3.8%
Class 5	23	29.5%
Class 6	6	7.7%
Class 7	33	42.3%
Class 8	9	11.5%
Class 9	0	0.0%
Class 10	0	0.0%

Question #4c Truck operation	Total	% of Total
Owner/ Operator	26	33.3%
Part of a Fleet	52	66.7%

Question #4d	Yes	No	% of Total
Owner/ Operator:			
Drive for one company	24	2	92.3%

Question #4e Commercial Charge Card	Yes	No	% of Usage
	26	52	33.3%

Question #5 Usage Frequency	Yes	% of Total
Daily	23	10.7%
More than twice a week	29	13.6%
Weekly	49	22.9%
Every other week	39	18.2%
Several times a year	65	30.4%
About once a year	7	3.3%
Less than once a year	2	0.9%

Question # 6 Current Turnpike Services	Yes	No	% of Yes Responses	% of No Responses
a.) Familiar with:				
Emergency call boxes	207	7	**96.7%**	3.3%
Roadway/ Weather Service	97	117	45.3%	54.7%
Cellular *1 1 Emergency Service	123	91	57.5%	42.5%
			% of Service Used	
b.) Services used:				
Emergency call boxes	18	196	8.7%	
Roadway/Weather Service	31	183	32.0%	
*11 Cellular Emergency Service	18	196	14.6%	

Question #7 Included in car	Yes	No	% of Yes responses	% of No Responses
Cellular phone	86	128	40.2%	59.8%
CB Radio	93	121	43.5%	56.5%

Question # 6 Current Turnpike Services	Yes	No	% of Yes Responses	% of No Responses
a.) Familiar with:				
Emergency call boxes	207	7	96.7%	3.3%
Roadway Weather Service	97	117	45.3%	54.7%
Cellular *11 Emergency Service	123	91	57.5%	42.5%

			% of Service Used
b.) Services used:			
Emergency call boxes	18	196	8.7%
Roadway/Weather Service	31	183	32.0%
*11 Cellular Emergency Service	18	196	14.6%

Question #7 Included in car	Yes	No	% of Yes Responses	% of No Responses
Cellular phone	86	128	40.2%	59.8%
CB Radio	93	121	43.5%	56.5%

Question #8 Information interests

	Yes	No	RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
			Number	Percent	Number	Percent	Number	Percent
Delay or congestion	203	11	118	55.1%	39	18.2%	20	6.7%
Alternative Routes	197	17	27	12.6%	72	33.6%	32	10.7%
Service Plaza Information	94	120	1	0.5%	4	1.9%	11	3.7%
Toll Plaza Delays	123	91	4	1.9%	12	5.6%	17	5.7%
Construction Information	142	20	35	16.4%	58	27.1%	39	12..1%
Weather Information	133	72	14	6.5%	17	7.9%	23	7.7%
Off Turnpike roadway information	85	81	3	1.4%	6	2.8%	6	2.0%
Hotel/Tourist/information	3	129	10	4.7%	5	2.3%	4	1.3%
Other			2	0.9%	1	0.5%	3	1.0%

Question #9 When information is needed

	Yes	No	RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
			Number	Percent	Number	Percent	Number	Percent
Before starting trip	159	55	90	42.1%	20	4.98%	11	9.73%
Before entering Turnpike	195	19	80	37.4%	89	22.14%	7	8.85%
While driving	185	29	40	18.7%	70	17.14%	24	47.35%
At service plazas	159	55	4	1.9%	28	6.97%	39	34.07%

PENNSYLVANIA TURNPIKE PATRON QUESTIONNAIRE SUMMARY

Recreational/Personal Travel Analysis

Survey Locations	Surveys collected	% of Total
New Stanton	48	25.0%
Sideling Hill	66	34.4%
P.J. Camiel	45	23.4%
Allentown	**33**	17.2%
Total	192	100.0%

Gender	Total	% of Total
Male	138	71.9%
Female	51	26.6%
Unknown	**3**	1.6%

Question #1: Trip purpose	Total	% of Total
Tourist/Recreational	40	20.8%
Commuting to/from work	0	0.0%
Personal Travel	148	77.1%
Commercial Delivery	0	0.0%
Business Travel	0	0.0%
Other	0	0.0%
No Response	**4**	2.1%

Question #3 Trip starting or ending out of state

	Total	% of Total
Yes	112	58.3%
No	80	41.7%

Question #4a Vehicle Type	Total	% of Total
Passenger Vehicle	183	95.3%
Bus	3	1.6%
Truck/Tractor Trailer	1	0.5%
Other	**5**	2.6%

Question #4b Truck Class	Total	% of Total
Class 1	0	0.0%
Class 2	0	0.0%
Class 3	0	0.0%
Class 4	0	0.0%
Class 5	0	0.0%
Class 6	0	0.0%
Class 7	0	0.0%
Class 8	0	0.0%
Class 9	0	0.0%
Class 10	0	0.0%

Question #4c Truck operation

	Total	% of Total
Owner/ Operator	0	0.0%
Part of a Fleet	0	0.0%

Question #4d

	Yes	No	% of Total
Owner/ Operator:			
Drive for one company	0	0	0.0%

Question #4e Commercial Charge Card

Yes	No	% of Usage
0	0	0.0%

Question #5 Usage Frequency

	Total	% of Total
Daily	24	12.5%
More than twice a week	5	2.6%
Weekly	11	5.7%
Every other week	12	6.3%
Several times a year	109	56.8%
About once a year	19	9.9%
Less than once a year	12	6.3%

Question # 6 Current Turnpike Services

	Yes	No	% of Yes Responses	% of No Responses
a.) Familiar with:				
Emergency call boxes	182	10	94.8%	5.2%
Roadway/ Weather Service	77	115	40.1%	59.9%
Cellular *1 1 Emergency Set-vi	104	88	54.2%	45.8%

			% of Service Used
b.) Services used:			
Emergency call boxes	11	181	6.0%
Roadway/Weather Service	22	170	28.6%
*1 1 Cellular Emergency Service	10	182	9.6%

Question #7 Included in car

	Yes	No	% of Yes Responses	% of No Responses
Cellular phone	40	152	20.8%	79.2%
CB Radio	41	151	21.4%	78.6%

Question # 6 Current Turnpike Services

	Yes	No	% of Yes Responses	% of No Responses
a.) Familiar with:				
Emergency call boxes	182	10	94.8%	5.2%
Roadway Weather Service	77	115	40.1%	59.9%
Cellular *11 Emergency Service	104	88	54.2%	45.8%

			% of Service Used
b.) Services used:			
Emergency call boxes	11	181	6.0%
Roadway/Weather Service	22	170	28.6%
*11 Cellular Emergency Service	10	182	9.6%

Question #7 Included in car	Yes	No	% of Yes Responses	% of No Responses
Cellular phone	40	152	20.8%	79.2%
CB Radio	41	151	21.4%	78.6%

Question #8 Information interests			RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
	Yes	No	Number	Percent	Number	Percent	Number	Percent
Delay or congestion	180	12	92	47.9%	35	18.2%	14	4.7%
Alternative Routes	179	13	19	9.9%	63	32.8%	38	12.8%
Service Plaza Information	101	91	5	2.6%	7	3.6%	6	2.0%
Toll Plaza Delays	110	82	3	1.6%	5	2.6%	4	1.3%
Construction Information	180	12	36	18.8%	49	25.5%	39	13.1%
Weather Information	149	43	16	8.3%	13	6.8%	24	8.1%
Off Turnpike roadway information	129	62	4	2.1%	8	4.2%	9	3.0%
Hotel/Tourist/information	94	4	23	12.0%	10	5.2%	8	2.7%
Other			4	2.1%	2	1.0%	1	0.3%

Question #9 When information is needed			RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
	Yes	No	Number	Percent	Number	Percent	Number	Percent
Before starting trip	163	5295	99	51.6%	17	4.23%	11	9.73%
Before entering Turnpike	176	16	56	29.2%	91	22.64%	13	8.85%
While driving	155	37	30	15.6%	56	13.93%	83	47.35%
At service plazas	145	47	7	3.6%	31	7.71%	38	34.07%

Appendix

C

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX C

TURNPIKE AAA MEMBER SURVEY

PENNSYLVANIA TURNPIKE AAA PATRON SURVEY
HIGHLIGHTS OF RESULTS

- Nearly 30% of those surveyed use the Turnpike as part of their normal trip to work.

- More than 95% of those not using the Turnpike on their trip to work indicated that the Turnpike was not convenient or that they were retired.

- Generally, people surveyed at AAA locations and the Park & Ride lot were less familiar with current Turnpike services than the people who participated in the Turnpike patron survey conducted at the service plazas.

- 28% of those surveyed had a cellular phone.

- Congestion and construction information, including the location and length of delays were the most important types of information to the motorists surveyed, followed by alternate routes. Information on weather conditions was not found to be as important.

- The motorists surveyed would also like to receive roadway and weather information prior to starting their trip and before entering the Turnpike.

- The top choice for how these motorists would like to receive information was via a TV at home or work. This was followed by commercial radio in the vehicle, a Turnpike information radio station (HAR) and Variable Message Signs along the roadway.

- Approximately 30% of those surveyed would be interested in using ETTM / E-ZPass even if a nominal fee was charged for the service.

SUMMARY OF COMMENTS FROM REPRESENTATIVES OF AAA

- Members call AAA for real-time weather and road condition information.
- "Call Boxes are a definite asset."
- Pre-planned maintenance and lane closure activity should go to AAA offices in Harrisburg and AAA Headquarters in Heathrow, Florida.
- Members would like information on toll costs, service plaza locations, *11 system and gas prices.
- Members should be told that Turnpike towing services cannot assess special charges and the boundary limits of the towing service provided by these operations.
- Credit/Debit card should be good for all services on the Turnpike.
- Congestion pricing is not popular.
- Diversion routes should have trailblazers. Diversion routes received via FAX are only marginally useful.
- Turnpike can submit articles for publication in local AAA newsletter.
- AAA would like to have meetings with PTC on a regular basis.

llo,

This survey is being conducted with the assistance of AAA on behalf of the Pennsylvania Turnpike Commission to assess current and future information needs of motorists traveling along the Turnpike. We are particularly interested in your use of the Turnpike to commute to and from work. Your response will allow us to develop a strategic plan for implementing new technologies and improving Turnpike user services and facilities in order to better serve you. It will take approximately five minutes to answer all of the questions.

Please enter today's date, your age and your sex.

Date: ________ Age: ________ Male ___ Female ___

Do you use the Pennsylvania Turnpike as part of your normal trip to work?

YES _____ NO _____ ***(If YES, please go to question 2a)***

If NO, please select the primary and secondary reasons for not using the Turnpike on your trip to work. ***(Place a #1 on the line next to your primary reason and a #2 for your secondary reason)***

A ______The Turnpike is not a convenient route for my trip to work
B ______The Turnpike is too congested at the interchanges
C ______The through lanes of the Turnpike are too congested
D ______There are too many unexpected delays caused by accidents and/or construction
E ______The Turnpike is too expensive
F. ______The Turnpike does not seem safe
G _____ Other ***(Specify):*** ________________

(If you do not use the Pennsylvania Turnpike as part of your normal trip to work, please skip to question 5b.)

On your trip to work where do you enter the Pennsylvania Turnpike?

(List interchange #, route # or name) ________________

On your trip to work where do you exit the Pennsylvania Turnpike?

(List interchange #, route # or name) ________________

Do you start or end your trip to work out of state?

YES _____ NO _____ **SOMETIMES** _____

What type of vehicle do you travel in for your trip to work?

A ______Passenger Vehicle B ______Bus C ______Truck
D ______Other ***(Specify):*** ________________

. How often do you car pool or take a bus to work?

A _____ Daily
B. _____ More than twice a wee k
C _____ Weekly
D _____ Every other week
E _____ Several times a year
F. _____ About once a year
G _____ Less than once a year
H. _____ Never

. How often do you use the Turnpike?

A _____ Daily
B. _____ More than twice a week
C _____ Weekly
D. - Every other week
E. _____ Several times a year
F. _____ About once a year
G _____ Less than once a year
H. _____ Never

. Which of the following Turnpike services are you familiar with ***(Circle items 1 thru 4 as they apply)***

	YES	***NO***
1. Emergency Call Boxes	_____	_____
2. Toll Free Roadway and Weather Information service	_____	_____
3. Toll Fre e*11 Cellular Emergency service	_____	_____
4. Othe r ***(specify):*** _______________	_____	_____

3b. Have you used the services listed above in the past?

Do you have any of the following in your vehicle?

	YES	***NO***
a. Cellular Phone	_____	_____
b. CB Radio	_____	_____

. What specific types of information would be of interest to you when traveling on the Turnpike?

	YES	***NO***	**RANK**
1. The location and length of a delay or congestion	_____	_____	_____
2. Alternate routes that could be used when there is a major incident	_____	_____	_____
3. Information about service plazas	_____	_____	_____
4. Delays at toll plazas	_____	_____	_____
5. Construction information ***(Lane closed, duration, length, location, etc.)***	_____	_____	_____
6. Weather information	_____	_____	_____
7. Off Turnpike roadway information	_____	_____	_____
8. Hotel/Tourist/Destination information	_____	_____	_____
9. Other: _______________	_____	_____	_____

3b. Please rank the top three types of information from the list above, in order of their importance to you
(1 for most important; 2 for second most important; and 3 for third most important)

. When would you like to receive information about Turnpike roadway and weather conditions (such as accidents, delays, vehicle restrictions, snowstorms, icy roads, fog, etc.)?

		YES	NO	RANK
1.	Before starting your trip	____	____	____
2.	Before entering the Turnpike	____	____	____
3.	While driving on the Turnpike	____	____	____
4.	At the Service Plazas	____	____	____

)b. Please rank the above locations that you marked YES in order of their importance to you ***(1 for most important; 2 for second most important; and so on...)***

a. How would you like to receive information regarding Turnpike roadway and weather conditions?

	YES	NO	RANK
1. TV at Home/Work	____	____	____
2. Telephone at Home/Work	____	____	____
3. Computer Bulletin Board at Home/Work	____	____	____
4. FAX at Home/Work	____	____	____
5. Commercial Radio at Home/Work	____	____	____
6. Commercial Radio in your Vehicle	____	____	____
7. Turnpike Information Radio Station	____	____	____
8. Changeable Message Signs along the Roadway	____	____	____
9. Displays within the service plazas	____	____	____
10. Through a car phone	____	____	____
11. Through a computer in your vehicle	____	____	____
12. Other: ____________	____	____	____

10b. Please rank the top three ways of how you would like to receive information in order of their importance to you ***(1 for most important; 2 for second most important; and 3 for third most important)***

. Would you use an electronic device to enable you to pay your toll without stopping, if a nominal fee was charged for this service?

YES ____ ***NO*** ____ **UNDECIDED** ____

2. Is there any other information that could be provided to you that would improve your trip?

____

____

Thank You for your participation!

e: AAA1surv.wp6\311204

PENNSYLVANIA TURNPIKE PATRON QUESTIONNAIRE SUMMARY

AAA Patron Response Analysis

urveyLocations

	Surveys Collected	% of Total
Philadelphia	7	3.4%
Harrisburg	4	1.9%
Pittsburgh	85	41.3%
Lehigh	16	7.8%
Lancaster	61	29.6%
York	4	1.9%
Irwin Park & Ride	29	14.1%
Total	206	

Gender

	Total	% of Total
Male	112	54.4%
Female	92	44.7%
Unknown	2	1 .0%

uestion #la: Pennsylvania Turnpike use for travel to work

	Total	% of Total
Yes	57	27.7%
No	149	72.3%

)): Reasons for not using the Turnpike when going to work

	Total	% of Total
Not convenient	100	48.5%
Too congested at interchanges	3	1.5%
Through lanes too congested	0	0.0%
Unexpected delays	0	0.0%
Expensive	4	1.9%
Not safe	0	0.0%
Other	12	5.8%
No response	30	14.6%

uestion #3: Trip starting or ending out of state

	Total	% of Total
Yes	9	15.8%
No	45	70.9%
Sometimes	0	0.0%
No Response	3	5.3%

uestion #4a: Vehicle Type

	Total	% of Total
Passenger Vehicle	46	80.7%
Bus	1	1.8%
Truck/Tractor Trailer	5	8.8%
Other	2	3.5%
No Response	3	5.3%

uestion #5a: Bus or carpool frequency

	Total	% of Total
Daily	22	38.6%
More than twice a week	5	8.8%
Weekly	1	1.8%
Every other week	1	1.8%
Several times a year	3	5.3%
About once a year	1	1.8%
Less than once a year	1	1.8%
Never	20	35.1%
No Response	3	5.3%

uestion #5b: Usage Frequency

	Total	% of Total
Daily	30	14.6%
More than twice a week	17	8.3%
Weekly	23	11.2%
Every other week	22	10.7%
Several times a year	96	46.6%
About once a year	8	3.9%
Less than once a year	4	1.9%
Never	6	2.9%

uestion #6: Current Turnpike Service

a): Familiar with:	Yes	No	% of Yes Responses	% of No Responses
Emergency call boxes	172	34	83.5%	16.5%
Roadway/Weather Service	66	140	32.0%	68.0%
Cellular *1 1 Emergency Service	96	110	46.6%	53.4%
Other	2		1 .0%	

b): Services used:	Yes	No	% of Service Used
Emergency call boxes	45	161	26.2%
Roadway/Weather Service	29	177	43.9%
Cellular *1 1 Emergency Service	30	176	31.3%
Other	2		

uestion #7: Included in car

	Yes	No	% of Yes Responses	% of No Responses
Cellular phone	60	146	29.1%	70.9%
CB Radio	24	182	11.7%	88.3%

Never	6	2.9%

Question # 6 Current Turnpike Services

	Yes	No	% of Yes Responses	% of No Responses
a.) Familiar with:				
Emergency call boxes	172	34	83.5%	16.5%
Roadway Weather Service	66	140	32.0%	68.0%
Cellular *11 Emergency Service	96	110	46.6%	53.4%
Other			1.0%	

			% of Service Used
b.) Services used:			
Emergency call boxes	45	161	26.2%
Roadway/Weather Service	29	177	43.9%
*11 Cellular Emergency Service	30	176	31.3%
Other	2		

Question #7 Included in car	Yes	No	% of Yes Responses	% of No Responses
Cellular phone	60	146	29.1%	70.9%
CB Radio	24	182	11.7%	88.3%

Question #8 Information interests

	Yes	No	RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
			Number	Percent	Number	Percent	Number	Percent
Delay or congestion	201	5	129	62.6%	38	18.4%	22	10.7%
Alternative Routes	190	16	25	12.1%	90	43.7%	43	20.9%
Service Plaza Information	109	97	1	0.5%	6	2.9%	18	8.7%
Toll Plaza delays	127	79	4	1.9%	9	4.4%	17	8.3%
Construction information	194	12	36	17.5%	39	18.9%	62	30.1%
Weather information	140	66	3	1.5%	17	8.3%	20	9.7%
Off Turnpike roadway information	102	104	3	1.5%	4	1.9%	6	2.9%
Hotel/Tourist/information	82	124	2	1.0%	3	1.5%	4	1.9%

Question #9 When Information is needed

	Yes	No	RESPONSES RANKED FIRST		RESPONSES RANKED SECOND		RESPONSES RANKED THIRD	
			Number	Percent	Number	Percent	Number	Percent
Before starting trip	174	32	127	61.7%	29	14.1%	13	6.3%
Before entering Turnpike	182	24	57	27.7%	118	57.3%	11	5.3%
While driving	171	35	21	10.2%	16	7.8%	69	33.5%
At service plazas	125	81	1	0.5%	12	5.8%	35	17.0%

Appendix D

APPENDIX D

COMMERCIAL USER GROUP SURVEY

PENNSYLVANIA TURNPIKE COMMERCIAL USER GROUP SURVEY HIGHLIGHTS OF RESULTS

- Approximately 90% of the companies surveyed use computers to exchange data among business units and/or other organizations on a regular basis.

- 47% have communication capabilities with drivers while they travel. Types of communication included cellular phones, voice mail/telephone check-in, 2-way radios, as well as satellite and/or onboard computers.

- Less than 20% of the companies currently make use of equipment for automatically monitoring the position of their vehicles. However, approximately 60% said that it would be helpful to know the position of their vehicles when traveling along the Turnpike.

- When asked if their company would be interested in using an electronic toll collection system that would enable their trucks to pay tolls automatically (with the addition of a nominal fee for the service), 30% said YES, 24% responded NO and the remaining were undecided. Based on the focus group discussions they are interested in improving the accounting aspect of the current billing system much more than getting another gadget put on their vehicles.

- The location and length of a delay or congestion were the most important type of information to the truck drivers, followed by alternate routes, construction information and weather condition information.

- Commercial trucking firms would prefer their drivers to receive roadway and weather information prior to starting their trip. They also indicated that it is desirable to receive information both before and during travel on the Turnpike.

- The four top choices for how truck fleet operators and managers would like their drivers to receive information included a computer bulletin board service, FAX, commercial radio in the vehicle, and/or Variable Message Signs along the roadway.

- 30% of the firms surveyed have a need for a trailer storage area on or near the Turnpike.

SUMMARY OF COMMENTS FROM COMMERCIAL VEHICLE OPERATORS

- 4 Focus groups - 19 people representing 14 truck companies and PMTA.
- Great diversity of size and operating procedures.
- No overall consensus or uniformity.
- Some fleets have ability to communicate with drivers en-route, most do not.
- Drivers call-in to report their position and some must request and get an OK to change route.
- Sensors at some Ohio Turnpike exits are being used to identify vehicles and schedule operations at nearby freight transfer terminals.

SUMMARY OF COMMENTS FROM COMMERCIAL VEHICLE OPERATORS (Continued)

Likes

- The current billing system
- The FAX system for non-real-time information.
- The Turnpike's responsiveness to incidents
- Increasing the 55 MPH speed limit.

Dislikes

- Single lane operation in Tunnels.
- Takes too long to cancel a 'lost" credit card.
- ETTM on large fleets where every vehicle must be tagged. (It is expensive and the time savings of ETTM is not important on a long trip.)
- Better coordination with Turnpike at incidents particularly at Hazmat incidents. (Turnpike Call boxes only start the response process.)
- Elimination of wide areas on shoulders.
- Privacy concerns with toll charge reports.

SUMMARY OF COMMENTS FROM COMMERCIAL VEHICLE OPERATORS (Continued)

NEEDS, COMMENTS and SUGGESTIONS

General

- Reduce tolls for off-peak travel.
- Make CVO oriented facility improvements - More parking, showers, AT&T phone service, tractor-trailer staging, storage and transfer areas.

Accounting

- Make account information available 'On-Line".
- Provide more flexibility in formatting of the charge report.

Permits

- Encode Hazmat Permit information on the credit card and make both the same duration.
- Turnpike should accept PennDOT Hazmat permit with supplementary insurance information.

SUMMARY OF COMMENTS FROM COMMERCIAL VEHICLE OPERATORS (Continued)

Information

- VMS & HAR (at interchanges) with real-time traffic and weather information. (With warning of major delays drivers could divert or get “off the clock”)
- FAX information on construction and traffic delays should be released earlier and updated more frequently.
- Want to know if traffic is flowing smoothly through construction areas.
- FAX weather and traffic information directly to Central Dispatcher(s).
- More lines on the 800-number and make it accessible out of state.
- Use existing microwave towers to improve radio communication for trucks on the Turnpike.
- Establish a traffic and weather information broadcast on a CB channel.
- Provide information to commercial customers via a computer bulletin board.
- Vehicle location information is of interest to some.

SYSTEMS PROVIDING TRUCK OPERATORS WITH VEHICLE POSITION INFORMATION

QUALCOMM

- Satellite based data communications system
- Can provide position of vehicle (+/- l/4 mile or 100 meters).

HIGHWAY MASTER

- Private Cellular Phone network providing voice and data communication.
- Position of a truck can be requested (+/- l/4 mile).
- Will be upgraded with Motorola GPS positioning (+/- 100 meters).

SENSOR SYSTEM ON THE OHIO TURNPIKE

- Sensors installed at selected Ohio Turnpike toll booths detect the presence of “tagged” vehicles and provide the information to nearby warehouse facilities for several truck fleets.

rvey ID #　　　　　　　　　　　　　　　　Date:　　　　　　　　Time:

PENNSYLVANIA TURNPIKE COMMERCIAL USER GROUP QUESTIONNAIRE

ompany Name: ______________________________

ldress: ______________________________

ty/Town: ____________ State: __________ Zip Code: ____________

ontact (Name / **Position):** ____________________ / ____________________

lephone Number: ____________________

Where is the location of your main facility in Pennsylvania?

(street address) ____________________

(city or town/state) ____________________

(zip code) ____________________

Location of other company facilities that generate vehicle trips that use the Pennsylvania Turnpike:

(street address) ____________________

(city or town/state) ____________________

(zip code) ____________________

How large is your firm/company in terms of **. . .** ***(Only necessary to choose one of the following methods for indicating firm/company size)***

a. Fleet size/type of vehicle ____________ / ____________

b. Number of vehicle trips/year or day or month ____________ / ____________

c. Number of employees/members/drivers ____________________

d. Number of miles traveled/year or day or hour ____________ / ____________

e. Other ***(specify)*** ____________________

Does your company use computers to exchange data among your business units or with other organizations on a regular basis?

YES ______ (or) NO ______

Are drivers schedules/freight movements established with the aid of a computer?

YES ______ **NO** ______ **SOMETIMES** ______

Do you have any communication capabilities with your drivers when they are traveling?

YES ______ **NO** ______

If YES, how do you communicate? ____________________

If NO, does your company have any implementation plans for communications? ____________________

How important is it to be able to communicate with your drivers while they are traveling?
(Please check only one response)

_____ Very Important
_____ Somewhat important
_____ Somewhat unimportant
_____ Not important

Do you know where your trucks are when they are traveling? YES ______ NO ______

If YES, how do you know? ____________________

Does your company currently have or use any equipment for automatically monitoring the position of your vehicles?

YES ______ NO ______

If NO, does your company have any implementation plans? ____________________

a. Would it be helpful to know the position of your vehicles while they are traveling along the Pennsylvania Turnpike?

YES ______ ***NO*** ______

b. If Yes, explain why ____________________

. Does your company have a charge account with the Pennsylvania Turnpike?

YES ______ NO _____

. How much business does your company do with the Pennsylvania Turnpike per (month/year) in terms of vehicle trips or dollar volume? ____________ **Trips per** ____________

________ **Dollars per** ____________

. What Pennsylvania Turnpike interchanges does your company most frequently use?
(List interchange #, route # or name) ____

____

____

. List the class ***(1 through 9)*** or the approximate weight of your vehicles for . . .

	Vehicle Class	(or) **Vehicle Weight**
Local delivery routes	____________	____________
Interstate routes	____________	____________
Intrastate routes	____________	____________

. What is the average cost or the time value associated with operating your vehicles?
($/unit of time, ie. hour, minute, second, etc.) ____________ **Dollars per** ____________

a. How often does your company need to obtain "Class 9" permitting (for over dimensional vehicles)?

_____ Daily
_____ More than twice a week
_____ Weekly
_____ Every other week
_____ Several times a year
_____ About once a year
_____ Less than once a year
_____ Never

b. Approximately, how many hazardous materials permits does your company need to obtain yearly?
(Please express in #/year) ____________________________

a. Would your company be interested in using an electronic toll collection system that would enable your trucks to pay their tolls automatically, if a nominal fee was charged?

YES ______ NO ______ **UNDECIDED** ______

b. If YES, why? ____

____

____

. On a scale of 1 to 4 ***(with 4 being very important),*** give the relative importance for what specific types of information about roadway and weather conditions would be of interest to your drivers when traveling on the Turnpike? ***(Circle only one answer for each of the following)***

	Not Important	Somewhat Unimportant	Somewhat Important	Very Important
a. The location and length of a delay or congestion	1	2	3	4
b. Alternate routes that could be used when there is a major incident	1	2	3	4
C. Parking availability at service plazas	1	2	3	4
d. Delays at toll plazas	1	2	3	4
e. Construction information ***(Lane closed, duration, length, location, etc.)***	1	2	3	4
f. Weather conditions	1	2	3	4
g. Roadway surface conditions	1	2	3	4
h. Off Turnpike roadway information	1	2	3	4
I. Hotel/Destination information	1	2	3	4
j. Other: ____________	1	2	3	4

ote): ***Please place one asterisk * next to the single most important of the responses listed above***

. On a ***scale*** of 1 to 4 ***(with 4 being very important),*** what is the relative importance for when you would like your drivers to receive information about Turnpike roadway and weather conditions (such as accidents, delays, vehicle restrictions, snowstorms, icy roads, fog, etc.)? ***(Circle only one answer for each of the following)***

	Not Important	Somewhat Unimportant	Somewhat Important	Very Important
a. Before starting yourtrip	1	2	3	4
b. Before entering the Turnpike	1	2	3	4
c. While driving on the Turnpike	1	2	3	4
d. At the Service Plazas	1	2	3	4
e. Other ***(specify)*** ____________	1	2	3	4

Iote): ***Please place one asterisk * next to the single most important of the responses listed above***

. If accurate, up-to-the-minute information on Turnpike roadway and weather conditions were available to your drivers, how would you like them to receive this information? ***(Again, please rate on a scale of 1 to 4, with 4 being very important and circle only one answer for each of the following)***

	Not Important	Somewhat Unimportant	Somewhat Important	Very Important
a. TV at Home/Work	1	2	3	4
b. Telephone at Home/Work	1	2	3	4
C. Computer Bulletin Board at Home/Work	1	2	3	4
d. FAX at Home/Work	1	2	3	4
e. Commercial Radio at Home/Work	1	2	3	4
f. Commercial Radio in your Vehicle	1	2	3	4
g. Turnpike Information Radio Station	1	2	3	4
h. Changeable Message Signs along the Roadway	1	2	3	4
I. Displays within the service plazas	1	2	3	4
j. Through a car phone	1	2	3	4
k. Through a computer in your vehicle	1	2	3	4
1. Other ***(Specify)*** ________________	1	2	3	4

ote): ***Please place one asterisk * next to the single most important of the responses listed above***

. Does your company and/or drivers use the Turnpikes existing toll free roadway and weather information service?

YES ______ NO ______

a. Currently how does your company and/or drivers receive advance information regarding Turnpike roadway and/or weather conditions? ____________________

b. How reliable was this information? ____________________

a. Does your organization have any other intermodal activities that could be facilitated by the Pennsylvania Turnpike?

YES ______ NO ______

b. If Yes, please specify ____________________

. Does your organization have a need for a trailer storage area near/on the Turnpike?

YES ______ **NO** _______

. Any suggestions for ways in which traffic and/or weather information could assist your operations?

. Other Comments:

. Would you like to receive an update on the results of this project?

YES ______ **NO** ______

Thank You for your participation!

e: use3surv.wp6\311204

PENNSYLVANIA TURNPIKE PATRON QUESTIONNAIRE SUMMARY
Commercial Group Response Analysis

Question #4: Use Computers to exchange data among business units

	Total	% of Total
Yes	15	83.33%
No	3	16.67%
TOTAL	18	

Question #5: Schedules and freight movements established with aid of a computer

	Total	% of Total
Yes	11	61.11%
No	5	27.78%
Sometimes	2	11.11%

Question #6a: Capable to communicate with drivers while traveling

	Total	% of Total
Yes	8	44.44%
No	10	55.56%

Question #7 Importance of being able to communicate with drivers while traveling

	Total	% of Total
Very important	9	50.00%
Somewhat important	4	22.22%
Somewhat unimportant	4	22.22%
Not important	1	5.56%

Question #8a: Knowledge of truck location when traveling

	Total	% of Total
Yes	14	77.78%
No	4	22.22%

Question #9a: Capability to monitor vehicle

	Total	% of Total
Yes	5	27.78%
No	13	72.22%

Question #10a: Would it be helpful to know the position of your vehicle

	Total	% of Total
Yes	10	55.56%
No	8	44.44%

Question #11: Open charge account with Turnpike

	Total	% of Total
Yes	17	94.44%
No	1	5.56%

Question #16: Frequency of Class 9 permitting

	Total	% of Total
Daily	0	0.00%
More than twice a week	0	0.00%
Weekly		5.56%
Every other week	0	0.00%
Several times a year	3	16.67%
About once a year	0	0.00%
Less than once a year	1	5.56%
Never	13	72.22%

b) **Frequency of Hazardous Materials permitting**

	Total	% of Total
Less than 10 per year	2	11.11%
Greater than 10 but less than 25	1	5.56%
Greater than 25 but less than 50	2	11.11%
Greater than 50	4	22.22%
Zero	9	50.00%

Question #17: Electronic Toll Device

	Total	% of Total
Yes	4	22.22%
No	5	27.78%
Undecided	9	50.00%

Question #18: Information Interests

	Not Important	Somewhat Unimportant	Somewhat Important	Very Important	Most Important	Average
Delay or congestion	0	0	2	16	8	
Alternative Routes	0	0	5	13	4	**4**
Service Plaza Information	4	7	5	2	0	**3**
Toll Plaza delays	1	0	12	5	0	**3**
Construction information	0	1	6	11	0	**4**
Weather information	0	0	6	12	2	**4**
Roadway conditions	0	2	9	7	0	**3**
Off Turnpike roadway information	2	3	8	5	0	**3**
Hotel/Tourist/information	9	7	2	0	0	**2**

Question #19: when information is needed

	Not Important	Somewhat Unimportant	Somewhat Important	Very Important	Most Important	Average
Before starting trip	1	0	4	13	9	4
Before entering Turnpike	0	1	5	12	3	4
While driving	0	2	7	9	0	4
At service plazas	3	4	8	3	1	3

Question #20: How information is received

	Not Important	Somewhat Unimportant	Somewhat Important	Very Important	Most Important	Average
TV at Home/Work	9	4	4	1	0	**2**
Telephone at Home/Work	7	1	6	4	1	**3**
Computer Bulletin Board	6	2	7	3	1	**3**
FAX at Home/Work	5	1	5	7	4	**3**
Commercial Radio at Home/Work	8	2	5	3	0	**2**
Commercial radio in vehicle	2	3	7	6	2	**3**
Turnpike Information Radio Statio	1	5	6	6	0	**3**
Changeable message signs	1	3	6	8	1	**3**
Displays in service plazas	0	6	9	3	1	**3**
Car phone	11	4	3	0	0	**2**
Computer in vehicle	7	5	2	4	3	**3**
Other	2	0	0	0	0	**1**

Question #21: Currently use Turnpike weather and roadway information service

	Total	% of Total
Yes	10	55.56%
No	8	44.44%

Question #23a: Plan for other intermodal activities that could be facilitated by the Turnpike

	Total	% of Total
Yes	0	0.00%
No	18	100.00%

Question #24: Need for trailer storage area near Turnpike

	Total	% of Total
Yes	5	27.78%
No	13	72.22%

Appendix

E

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX E

SUMMARY OF COMMENTS FROM AAA

SUMMARY OF COMMENTS FROM REPRESENTATIVES OF AAA

- Members call AAA for real-time weather and road condition information.
- "Call Boxes are a definite asset."
- Pre-planned maintenance and lane closure activity should go to AAA offices in Harrisburg and AAA Headquarters in Heathrow, Florida.
- Members would like information on toll costs, service plaza locations, * 11 system and gas prices.
- Members should be told that Turnpike towing services cannot assess special charges and the boundary limits of the towing service provided by these operations.
- Credit/Debit card should be good for all services on the Turnpike.
- Congestion pricing is not popular.
- Diversion routes should have trailblazers. Diversion routes received via FAX are only marginally useful.
- Turnpike can submit articles for publication in local AAA newsletter.
- AAA would like to have meetings with PTC on a regular basis.

Appendix

F

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIXF

SUMMARY OF COMMENTS FROM PENNDOT DISTRICTS

SUMMARY OF COMMENTS FROM PENN-DOT DISTRICT OFFICES

1). **District 5-O - Allentown - David Erp**

- No ITS system in place or under design.
- Have initiated discussion regarding installation of VMS's along I-78 including major interchanges. No schedule available.
- No traffic concerns regarding operation of Turnpike Interchanges within District.

2). **District 6-O - Philadelphia**

- ITS project involving CCTV cameras and VMS's in place along I-95 extending north from Philadelphia Airport to the Allegheny Street exit.
- Study now underway for ITS applications along the full length of I-476.
- Consultant selected for preliminary and final design of an ITS system on U.S. Route 30. Anticipated to include HAR's, VMS's and CCTV.
- I-95 Corridor Coalition is a major contributor to the planning effort for future ITS program in the District.

3). **District 8-O - Harrisburg - Ron Brown**

- Have 17 portable VMS's
- Working to develop an ITS system in the Harrisburg area for traffic information/weather conditions.
- Desires to tie Harrisburg system with the PTC system--potentially one traffic management center.
- Interested in developing incident management teams for Interstate network.

4). **District 9-O - Hollidaysburg - Dick Fox and Jim Ickes**

- PTC and District 9-O share two VMS signs on I-70 approach to Breezewood. They are not currently being used.

- No serious problems or concerns at Bedford, Somerset or Breezewood Interchanges.

- Need improved signage on exit ramps at Bedford Interchange.

- District 9-O is making extensive use of remote weather forecasting stations, coupled with pavement monitoring units (temperature, precipitation, and salt content) to better manage snow and ice control.

- District has installed VMS signs at two locations to alert motorists to pavement icing and fog conditions.

5). **District 10-0 - Indiana - Joe Szczur**

- Request installation of VMS or HAR technology at new Cranberry interchange to alert motorists to problems off-system, i.e., I-79 and S.R 19.

6). **District 11-O - Pittsburgh - Tom Fox**

- Need coordination between Penn Lincoln Parkway ITS, I-79 ITS and PTC Study.

- Motorist information regarding traffic conditions, alternate routes, etc. should be made available to allow choices between Interchanges 3 through 6.

7). **District 12-O - Uniontown - Allan Bailey**

- Have two portable HAR'S in place along I-70 and I-79, neither being used at present.

- No interchange problem with PTC.

- Some congestion problems during ski season at Interchange 9.

APPENDIX G

SUMMARY OF COMMENTS FROM PTC STAFF

SUMMARY OF COMMENTS FROM INTERVIEWS WITH TURNPIKE STAFF

"PROBLEMS AND OPPORTUNITIES"

Note: The headings in this summary indicate the subject of the comments not the source of the comments.

Communications Center

- Radio system is 20 years old.
- Communication traffic has substantially increased.
- Communication channels are limited.
- Over half the people who call in are not reporting an accident they are requesting information.
- Equipment should be up-graded.
- Need Mobile Data Terminals in vehicles.
- GIS and other engineering information is not available after hours.
- Real-Time 111 motion video is not a priority.
- We overreact to incidents because of the limited information available.
- Status of facility should be upgraded to Emergency Management Center.
- New center is being considered for expanded Turnpike traffic operations and State Police use.

  Staffing has remained constant over the last 30 years.

- Qualifications, background checks, annual evaluations and training (including Emergency Medical Dispatch training) for communication center staff should be up-graded.

- Turnpike Departments cooperate when there are major weather related emergencies.

- On-call staff assistance at communication center gets one day of annual training, more is needed.

- Troopers in the field have major responsibilities, minimal law enforcement support staff at communication center.

SUMMARY OF COMMENTS FROM INTERVIEWS WITH TURNPIKE STAFF

"PROBLEMS AND OPPORTUNITIES” (Continued)

Special Permits

- Oversize vehicles - Incoming information is distributed to a variety of locations (Toll Plazas, Revenue, State Police, Engineering, other agencies)
- Over height vehicles are sometimes not detected.
- Hazmat permits - are issued on a routine basis after proper forms are received.

Information / Marketing

- Weather information is very important and should be more reliable and readily available.
- Make traffic information more available.
- Make permit and fuel price information more available.
- Make credit cards more available.
- More sensors for roadway conditions (wet, freezing, etc.) are desirable, particularly in mountains and near tunnels.
- Provide more parking for trucks.
- Provide more parking for car-pools.
- Traffic count and classification stations between interchanges are desirable to predict congestion and short-term forecasts for toll plaza staffing needs.
- A new trunk communications system will be installed but may have constrained bandwidth.

- Computer and networking capabilities will be improved.
- Telephone system improvements are being made.
- E-ZPass information could be made available for monitoring vehicle location.
- E-ZPass could reduce the land needed for toll plazas and enable new "E-ZPass only" interchanges with other roadways.

SUMMARY OF COMMENTS FROM INTERVIEWS WITH TURNPIKE STAFF

"PROBLEMS AND OPPORTUNITIES" (Continued)

Funding

- There is an $8 billion dollar wish list ofprojects.
- Highest priorities are good quality roadway and service plaza maintenance.
- Almost all funding goes into the maintenance of the existing roadway.
- Legislature has forced Turnpike into some unprofitable activities.
- TMS (ITS) and E-ZPass funding requirements are not programmed into the system
- Likelihood of federal aid is not good.
- Off-system problems sometimes constrain solutions.
- ITS must pay for itself in increased throughput and the reduced cost of system operations.

Safety

- Drivers drive too fast and too long.
- Lighting and ventilation systems in the Lehigh Tunnels will be upgraded.
- The possibility of allowing trucks with Hazmat in Tunnels is being studied.

Summary of Comments From
PTC Maintenance Department

1). **Maintenance District #1 - Paul Hoover** (Superintendent)

- Communicate with Central Office via:
    - 2-way microwave radio communication;
    - Microwave and cellular telephone communication;
    - FAX communication; and
    - Computer network electronic mail (E-mail)
- No direct radio contact with other maintenance districts. Have to be linked through Central Office.
- Maintenance supervisors and foreman are equipped with cellular phones having direct access and dial-up service to the Central Office.
- Accident or incident communications are conducted from the incident site to PTC Central Office via repeater base stations located at remote microwave sites.
- No pavement sensors are currently in place to detect roadway conditions. Use maintenance personnel and responders to visually examine condition of pavement.
- Weather conditions are updated every half hour and received by FAX linked to Accu-Weather Forecast Center located at the Pennsylvania State University. Doppler radar forecasts are provided every 2 hours by Central Office to all maintenance districts.

2). **Maintenance District #2 - Rick Schaffer** (Superintendent)

- When asked how maintenance facilities communicate with the Central Office, Mr. Schaffer's comments were similar to those responded by Paul Hoover of District 1.
- Have individual maintenance crews and radio control stations located at each tunnel portal service area.

- Tunnels (exclusive to Lehigh Tunnel) are equipped with a Patron Alarm System Push button alarm boxes are spaced throughout the tunnel at **220** foot intervals that when activated alert the tunnel operator that an incident has occurred and provides the exact location of the incident within the tunnel.

- Tunnels are equipped with a 450 MHZ repeater communication system used by Turnpike personnel while working in the tunnels. This system is linked to the main control room operator located in the portal area of the **tunnel.**

- Mr. Schaffer indicated one draw back to the existing system is that during an accident or incident on the Turnpike, emergency communications receive priority while all other Turnpike communications have to yield until the airwave is clear to transmit message. This sometimes hinders maintenance operations.

3). **Maintenance District #3 - Michael Hainey** (Superintendent)

- Mr. Hainey offered no additional information about the current communication system and/or how maintenance operations could be enhanced through the implementation of ITS technologies. When asked about current communications with the Central Office the information he provided was similar to the information given by Paul Hoover from District 1.

4). **Maintenance District #4 - Nate Brogno** (Superintendent)

- Mr. Brogno spoke very highly of the existing communications system He could not identify any shortcomings in the system

- Offered a suggestion to be considered during our ITS Study to aid congestion at Toll Plazas. Coordinate with PennDOT to improve state roadways where they adjoin toll areas so as to accommodate adequate channelization of vehicles exiting from multi-lane toll facilities onto one or two lane arterial roads.

5). Maintenance District #5 - Al **Ostrowski** (Superintendent) (Talked with Harold Winner)

- Spoke highly of the communication system currently employed. When asked about current communications with Central Office he offered similar information to that provided by Paul Hoover of District 1.

- Each Maintenance district is assigned two radio channels. Odd Districts 1,3 and 5 are each assigned two separate channels that are different from Districts 2 and 4. This eliminates cross communications between adjacent Maintenance Districts.

- He spoke of the same system shortcoming as indicated by Mr. Schaffer of District 2; during an accident or incident on the Turnpike, emergency communications receive priority and all other Turnpike communications have to yield until the airwave is clear to transmit message. This sometimes hinders maintenance operations.

Appendix

H

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX H

ITS USER SERVICE DEFINITIONS

ITS USER SERVICES AND USER SERVICE BUNDLING

The National Program Plan (NPP) has identified the seven user service bundles shown in Table 1 of this appendix. The twenty nine user services recognized in the NPP were sorted into bundles according to several criteria. In some cases, services were bundled together based on the institutional perspectives of the organizations that will deploy the services. Other services were bundled based on common technical functionalities.

The following are detailed descriptions of each user service bundle and the associated user services as presented in the NPP. An additional user service, Centralized Information Management has been recommended for inclusion in the Travel and Transportation Management bundle, and is described as the last user service within this bundle.

1.0 Travel and Transportation Management

The Travel and Transportation Management user services weregrouped in a single bundle because of the information they share about the surface transportation system These services collect and process information about the surface transportation system, and provide commands to various traffic control devices. Travel management services disseminate this information to the traveler. When used in concert, these services can provide a comprehensive travel and transportation management system These services also provide information to support the Travel Demand Management and the Public Transportation Operations bundles. Thus, the Travel and Transportation Management bundle will be of interest to transportation policy makers, public and private sector operators of transportation management centers, those involved in incident response or travel demand management, and private sector vendors supplying travel information products and services.

1.1 <u>En-Route Driver Information</u>

Provides driver advisories and in-vehicle signing for convenience and safety.

Driver advisories are similar to pre-trip planning information, but they are provided once travel begins. Driver advisories convey real-time information about traffic conditions, incidents, construction, transit schedules, and weather conditions to drivers of personal, commercial and public transit vehicles. This information allows a driver to either select the best route, or shift to another mode in mid-trip if desired.

In-vehicle signing, the second component of en-route driver information, provides the same types of information found on physical road signs today, directly in the vehicle. The service could be extended to include warnings of road conditions and safe speeds for specific types of vehicles, such as autos, buses, and large trucks, but potential users include drivers of all types of vehicles. This service might be especially useful to elderly drivers, in rural areas with large numbers of tourists, or in areas with unusual or hazardous roadway conditions.

1.2 Route Guidance

Provides travelers with simple instructions on how to best reach their destinations.

The route guidance service provides a suggested route to reach a specified destination. Early route guidance systems are based on static information about the roadway network or transit schedules. When fully deployed, route guidance systems will provide travelers with directions to their destinations based on real-time information about the transportation system The route guidance service will consider traffic conditions, status and schedule of transit systems, and road closures in developing the best route. Directions will generally consist of simple instructions on turns or other upcoming maneuvers. Users of the service include not only drivers of all types ofvehicles, but also non-vehicular travelers, such as pedestrians or bicyclists, who could get specialized route guidance from a hand-held device.

1.3 Traveler Services Information

Provides a business directory or "yellow pages," of service information.

Traveler services information provides quick access to travel-related services and facilities Examples of information that might be included are the location, operating hours, and availability of food, lodging, parking, auto repair, hospitals, and police facilities. Traveler services information would be accessible in the home, office or other public locations to plan trips, and would also be available en-route. When fully deployed, this service will connect users and providers interactively to request and provide needed information. A comprehensive, integrated service could support financial transactions, such as automatic billing purchases.

1.4 Traffic Control

Manages the movement of traffic on streets and highways.

The traffic control user service provides for the integration and adaptive control of the freeway and surface street systems to improve the flow of traffic, give preference to public safety, transit or other high occupancy vehicles, and minimize congestion while maximizing the movement of people and goods. Through appropriate traffic controls, the service also promotes the safety of non-vehicular travelers, such as pedestrians and bicyclists. It requires advanced surveillance of traffic flows, analysis techniques for determining appropriate traffic signal and ramp metering controls, and communication of these controls to the roadside infrastructure. This service gathers data from the transportation system and organizes it into usable information to determine the optimum assignment of right-of-way to vehicles and pedestrians. The real-time traffic information collected by the Traffic Control service also provides the foundation for many other user services.

1.5 Incident Management

Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic

The Incident Management service uses advanced sensors, data processing, and communications to improve the incident management and response capabilities of transportation and public safety officials, the towing and recovery industry, and others involved in incident response. The service will enhance existing incident detection and verification capabilities to help these groups quickly and accurately identify a variety of incidents and implement a response. The improved response time will minimize the effects of these incidents on the movement of people and goods. This service will also help transportation officials predict traffic or highway conditions so that they can take action in advance to prevent potential incidents or minimize their impacts. While the direct users of this service are the public and private entities responsible for incident detection and response, the ultimate beneficiaries are commercial and transit operators, and the traveling public.

1.6 Emissions Testing and Mitigation

Provides information for monitoring air quality and developing air quality improvement strategies.

The Emissions Testing and Mitigation service uses advanced vehicle emissions testing systems to provide information to identify environmental "hot spots" and implement strategies to either reroute traffic around sensitive air quality areas or control access to such areas. Other technologies provide identification of vehicles that are emitting levels of pollutants that exceed state, local or regional standards, and provides information to drivers or fleet operators to enable them to take corrective action. The service also provides transportation planning and operating agencies with information that can be used to facilitate implementation and evaluation of various pollution control strategies.

1.7 Centralized Information Management

Provides the voice and data communication backbone required for sharing information with the various operating agencies.

The Centralized Information Management user service provides all of the centralized voice and data communication infrastructure and operations necessary to allow the various operating agencies to communicate and share information. This type of information exchange requires a commum'cation backbone and some type of wide area network (WAN) configuration. Furthermore, the need for rapid information exchange between disparate operating agencies warrants the use of an approach in which different data types and formats are easily communicated to a central management center regardless of hardware or software platform.

This user service is not directly accessible by the traveler; however, it is vital to the quality and efficiency of operation for the entire Intelligent Transportation System Central Information Management service provides all of the operational support required for data collection, processing, and storage; as well as the information that will be disseminated to travelers as part of other user services. This service is provided mainly at a centralized control facility for the transportation system

2.0 Travel Demand Management

The Travel Demand Management user services support policies and strategies that are aimed at reducing vehicle demand by developing and encouraging modes of travel other than the single occupant vehicle. The services in this bundle are designed to increase the use of high occupancy vehicles and transit by providing inter-modal information to travelers prior to the beginning of a trip, and by making ride sharing and transit more convenient and easier to use. These services are also aimed at decreasing congestion by altering the timing or location of trips, or eliminating vehicle trips all together.

From a technical perspective, these services rely on information collected and processed by the Travel and Transportation Management services and the Public Transportation Operations services. Travel Demand Management services also interact with the Travel and Transportation Management services in terms of implementing control strategies that can provide incentives, or disincentives, to change travel behavior.

2.1 Demand Management and Operations

Supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.

The Demand Management and Operations service generates and communicates management and control strategies that support the implementation of programs to reduce the number of individuals who choose to drive alone, especially to work; increase the use of high occupancy vehicles, transit, and commuter rail; and provide a variety of mobility options for those who wish to travel in a more efficient manner, for example in non-peak periods. Demand management strategies could ultimately be applied dynamically, when congestion or pollution conditions warrant. For example, disincentives such as increase tolls and parking fees could be applied during pollution alerts or peak travel periods, while transit fares would be lowered to accommodate the increased number of travelers changing modes from driving alone. Such strategies will reduce the negative impacts of traffic congestion on the environment and improve overall quality of life.

2.2 Pre-Trip Travel Information

Provides information for selecting the best transportation mode, departure time, and route.

Pre-trip travel information allows travelers to access a complete range of inter-modal transportation information at home, work, and other major sites where trips originate. Real-time information on transit and commuter rail routes, schedules, transfers, fares, and ride matching services are available to encourage the use of alternatives to the single occupancy vehicle. Information needed for long, inter-urban or vacation trips would also be available. Real-time information on accidents, road construction, alternate routes, traffic speeds along given routes, parking conditions, event schedules, and weather information is also included. Based on this information, the traveler can select the best route, modes of travel and departure time, or decide not to make the trip at all.

2.3 Ride Matching and Reservation

Makes ride sharing easier and more convenient

The Ride Matching and Reservation service provides real-time ride matching information and reservations to users in their homes, offices or other locations, and assist transportation providers, as well as van/car pools, with vehicle assignments and scheduling. This will expand the market for ride sharing as an alternative to single occupant vehicle travel and will provide for enhanced alternatives for special population groups, such as the elderly or the handicapped.

3.0 Public Transportation Operations

The Public Transportation Operations bundle reflects the commonality of the transit authority as the most probable provider of these services. The transit authority is responsible for implementing systems that are capable of better managing the public transportation system and providing improved transit and mode choice information

From a technical perspective, all of these user services will share a common public transit database. The data will be available for **all** of the services to customize for their specific function. This data will also support services in the Travel and Transportation Management and the Travel Demand Management bundles.

3.1 Public Transportation Management

Automates operations, planning and management functions of *public transit systems.*

The Public Transportation Management service provides computer analysis of real-time vehicle and facility status to improve transit operations and maintenance. The analysis identifies deviations from schedule and provides potential solutions to dispatchers and drivers. Integrating this capability with traffic control services can help maintain transportation schedules and assure transfer connections in intermodal transportation. Information regarding passenger loading, bus running times, and mileage accumulated will help improve service and facilities administrative reporting. Transit personnel management is enhanced by automatically recording and verifying tasks performed by transit personnel

3.2 En-Route Transit Information

Provides information to travelers using public transportation after they begin their trips.

The En-Route Transit Information service provides information to assist the traveler once public transportation travel begins. Real-time, accurate transit service information on board the vehicle helps travelers make effective transfer decisions and itinerary modifications as needed while a tip is underway.

3.3 Personalized Public Transit

Provides flexibly-routed transit vehicles to offer more convenient customer service.

Small publicly or privately-operated vehicles provide on-demand routing to pick up passengers who have requested service and deliver them to their destinations. Route deviation schemes, in which vehicles leave a fixed route for a short distance to pick up or discharge passengers, is another way of improving service. Vehicles can include small buses, taxicabs, or other small, shared ride vehicles. This service can provide almost door-to-door service, expanding transit coverage to lesser populated locations and neighborhoods. Potentially, this services can provide transportation at lower cost and with greater convenience than conventional fixed route transit.

3.4 Public Travel Security

Creates a secure environment for public transportation patrons and operators.

This service provides systems that monitor the environment in transportation stations, parking lots, bus stops, and on-board transit vehicles, and generate alarms, either automatically or manually, when necessary. This improves security for both transit riders and operators. Transportation agencies and authorities can integrate this user service with other anti-crime activities.

4.0 Electronic Payment

While this bundle contains only one user service, it supports deployment of many other services, both within and outside the transportation arena. This service will be developed, deployed, and operated by both public and private organizations.

4.1 Electronic Pavment Services

Allows travelers to pay for transportation services electronically

Electronic Payment services will foster intermodal travel by providing a common electronic payment medium for all transportation modes and functions, including tolls, transit fares, and parking. The service provides for a common service fee and payment structure using "smart cards" or other technologies. Such systems could be expanded to become truly multi-use, accommodating personal financial transactions that are made with today's credit/bank cards. The flexibility that electronic payment services offer will also facilitate travel demand management, if conditions warrant. They could, if local authorities so choose, enable application of road pricing policies which could influence departure times and mode selection.

5.0 Commercial Vehicle Operations

These user services support the goals of improving the efficiency and safety of commercial fleet operations, and will benefit both the States and the motor carrier industry. Thus the CVO bundle reflects the commonality of using advanced computer and communications technologies to improve the safety and productivity of the motor carrier industry throughout North America.

From a technical perspective, the foundation for all of the CVO user services is information systems. Each service will require some set of information on the motor carrier, the vehicle, the driver, and, in some cases, the cargo. The services are interrelated in terms of the specific types and functionality of information and data required. This network of information will be accessible by States and motor carriers nationwide.

5.1 Commercial Vehicle Electronic Clearance

Facilitates domestic and international border clearance, minimizing stops.

This service will enable transponder-equipped trucks and buses to have their safety status, credentials, and weight checked at mainline speeds. Vehicles that are safe and legal and have no outstanding out-of-service citations will be allowed to pass the inspection/weigh facility without delay.

By working with Mexico and Canada, a more efficient traffic flow would be provided at border crossings. The deployment of technologies in these countries could ultimately prevent overweight, unsafe, or improperly registered vehicles from entering the United States.

5.2 Automated Roadside Safety Inspection

Facilitates roadside inspections.

Automated roadside inspections would allow real-time access at the roadside to the safety performance record of carriers, vehicles, and drivers. Such access will help determine which vehicle or driver should be stopped for an inspection, as well as ensuring timely correction of previously identified problems.

This service would also automate as many items as possible of the manual inspection process. It would, for example, allow for more rapid and accurate inspection of brake performance at the roadside. Through the use of sensors and diagnostics, it would efficiently check vehicle systems and driver requirements and ultimately driver alertness and fitness for duty.

5.3 On-Board Safetv Monitoring

Senses the safety status of *a commercial vehicle, cargo, and driver,*

On-board systems would monitor the safety status of a vehicle, cargo, and driver at mainline speeds. Vehicle monitoring would include sensing and collecting data on the condition of critical vehicle components such as brakes, tires, and lights, and determining thresholds for warnings and countermeasures. Cargo monitoring would involve sensing unsafe conditions relating to vehicle cargo, such as shifts in cargo while the vehicle is in operation. Driver monitoring is envisioned to include the monitoring of driving time and alertness using non-intrusive technology and the development of warning systems for the driver, the carrier, and the enforcement officials A warning of unsafe condition would first be provided to the driver and then to the carrier and roadside enforcement officials. This warning notification would possibly prevent an accident from happening. This service would minimize driver-and equipment-related accidents for participating carriers.

5.4 Commercial Vehicle Administrative Processes

Provides electronic purchasing of *credentials and automated mileage and fuel reporting and auditing.*

The Commercial Vehicle Administrative Processes service provides the commercial carrier with the capability to electronically purchase annual and temporary credentials via computer link. It will reduce burdensome paperwork and processing time for both the State agencies and the motor carriers.

For automated mileage and fuel reporting and auditing, this service enables participating interstate carriers to electronically capture mileage, fuel purchased, trip, and vehicle data according to state. It would also automatically determine mileage traveled and fuel purchased in each state, for use by the carrier in preparing fuel tax and registration reports to the State agencies. This service would reduce the significant administrative burden on commercial carriers to collect and report mileage and fuel purchased within each State.

5.5 Hazardous Material Incident Response

Provides immediate description of *hazardous materials to emergency responders.*

The Hazardous Material Incident Response service enhances the safety of shipments of hazardous materials by providing enforcement and response teams with timely, accurate information on cargo contents to enable them to react properly in emergency situations. The materials or combinations of materials involved when an incident involving a truck or rail car carrying hazardous material occurs would be provided electronically to emergency responders and enforcement personnel at the scene so that the incident can be handled properly.

5.6 Freight Mobility

Provides communication between drivers, dispatchers, and intermodal transportation providers.

The Freight Mobility service provides real-time traffic information and vehicle location for commercial vehicles. This service significantly enhances fleet operations management by helping drivers to avoid congested areas and improving the reliability and efficiency of pickups and deliveries. These benefits are particularly important for operators of intermodal and time-sensitive fleets who can use this ITS service to make their operations more efficient and reliable.

6.0 Emergency Management

Police, fire and rescue operations can use emergency management services to improve their management of and response to emergency situations. These user services have common functional elements such as vehicle location, communications, and response.

6.1 Emergencv Notification and Personal Security

Provides immediate notification of *an incident and an immediate request assistance.*

The Emergency Notification and Personal Security service includes two capabilities: driver and personal security, and automatic collision notification. Driver and personal security capabilities provides for user-initiated distress signals for incidents such as mechanical breakdowns or car-jackings. When activated by an incident, automatic collision notification transmits information regarding location, nature, and severity of the crash to emergency personnel.

6.2 Emergency Vehicle Management

Reduces the time it takes for *emergency vehicles to respond to an incident.*

The Emergency Vehicle Management service provides public safety agencies with fleet management capabilities, route guidance, and signal priority and/or preemption for emergency vehicles. Fleet management improves the display of emergency vehicle locations and help dispatchers send the units that can most quickly reach an incident site. Route guidance directs emergency vehicles to an incident location and signal priority optimizes the traffic signal timing in an emergency vehicle's route. Primary users of this service include police, fire, and medical units.

7.0 Advanced Vehicle Control and Safety Systems

Although each of these services addresses a separate function, they all contribute to the common goal of improving vehicle safety. With the exception of Automated Highway Systems (AHS), all of these user services are characterized by near-term reliance on self-contained systems within the vehicle. The functionality of these user services, however, can be enhanced by supplementing the on-board capabilities with additional sensors deployed in the infrastructure. Within the vehicle, common functional elements, such as data storage, processing units, sensors, or actuators, could be shared among the user services in this bundle, including AHS.

7.1 Logitudinal Collision Avoidance

Help prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.

The Longitudinal Collision Avoidance service helps reduce the number and severity of longitudinal collision, such as head-on, rear-end or backing. It includes the sensing of potential or impending collisions, prompting a driver's avoidance actions, and controlling the vehicle temporarily.

7.2 Lateral Collision Avoidance

Helps prevent collisions when vehicles leave their lane of travel.

The Lateral Collision Avoidance service provides crash warnings and controls for lane changes and road departures. It will reduce the number of lateral collisions involving two or more vehicles, as well as, crashes involving a single vehicle leaving the roadway. For changing lanes, a situation display can monitor the vehicle's blind spot continuously, and drivers can be actively warned of an impending collision. If needed, automatic control can provide rapid response to a situation. Warning systems can also alert a driver to an impending road departure, provide help in keeping the vehicle in the lane, and ultimately provide automatic control of steering and throttle.

7.3 Intersection Collision Avoidance

Helps prevent collisions at intersections.

The Intersection Collision Avoidance service warns drivers of imminent collisions when approaching or crossing an intersection or railroad grade crossing that has traffic control (e.g., stop signs or a signal). This service also alerts the driver when the proper right-of-way at the intersection or grade crossing is unclear or ambiguous.

7.4 Vision Enhancement for Crash Avoidance

Improves the driver's ability to see the roadway objects that are on or along the roadivay.

The Vision Enhancement service provides drivers with improved visibility to allow them to avoid collisions with other vehicles, obstacles in the roadway, or parked or moving trains, as well as help them comply with traffic signs and signals. This service requires in-vehicle equipment for sensing potential hazards, processing this information, and displaying it in a way that is useful to a driver.

7.5 Safety Readiness

Provides warnings about the condition of *the driver, the vehicle, and the roadway.*

Safety Readiness services provide in-vehicle equipment that unobtrusively monitors a driver's condition and provides a warning if the driver is becoming drowsy or otherwise impaired. This service could also monitor critical components of the automobile internally and alert the driver to impending malfunctions. Equipment within the vehicle could also detect unsafe road conditions, such as bridge icing or standing water on the roadway, and provide a warning to the driver.

7.6 Pre-Crash Restraint Deployment

Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.

The Pre-Crash Restraint Deployment service anticipates an imminent collision by determining the velocity, mass, and direction of the vehicles or objects involved in a potential crash. The service activates safety systems in the vehicle prior to a collision, such as tightening lap-shoulder belts, arming and deploying air bags at the optimal pressure, and deploying roll bars. The response is based on the number, location, and major physical characteristics of any occupants.

7.7 Automated Highway Systems

Provides a fully automated, "had- off operating environment.

AHS is a long-term goal of ITS which would provide vast improvements in safety by creating a nearly accident-free driving environment. In AHS, the vehicle is guided automatically rather than by the driver. Driver error is reduced or possibly eliminated with full implementation. Drivers could buy vehicles with the necessary instrumentation or retrofit an existing vehicle. AHS benefits include increased roadway capacity, enhanced safety, reduced fuel consumption, and reduced emissions.

TABLE 1

USER SERVICE BUNDLES

Bundle	User Services
I. Travel and Transportation Management	1. En-Route Driver Information 2. Route Guidance 3. Traveler Services Information 4. Traffic Control 5. Incident Management 6. Emissions Testing and Mitigation
2. Travel Demand Management	1. Demand Management and Operations 2. Pre-Trip Travel Information 3. Ride Matching and Reservation
3. Public Transportation Operations	1. Public Transportation Management 2. En-Route Transit Information 3. Personalized Public Transit 4. Public Travel Security
4. Electronic Payment	1. Electronic Payment Services
5. Commercial Vehicle Operations	1. Commercial Vehicle Electronic Clearance 2. Automated Roadside Safety Inspection 3. On-board Safety Monitoring 4. Commercial Vehicle Administrative Processes 5. Hazardous Materials Incident Response 6. Freight Mobility
6. Emergency Management	1. Emergency Notification and Personal Security 2. Emergency Vehicle Management
7. Advanced Vehicle Control and Safety Systems	1. Longitudinal Collision Avoidance 2. Lateral Collision Avoidance 3. Intersection Collision Avoidance 4. Vision Enhancement for Crash Avoidance 5. Safety Readiness 6. Pre-Crash Restraint Deployment 7. Automated Highway System

Appendix

I

APPENDIX I

RELATIONSHIP BETWEEN USER SERVICES AND PROBLEMS AND OPPORTUNITIES

RELATIONSHIP BETWEEN USER SERVICES AND PROBLEMS AND OPPORTUNITIES

Travel and Transportation Management Bundle

USER SERVICES / **PROBLEMS AND OPPORTUNITIES (Weighted priorities)**	**En-Route Driver Information**	**Route Guidance**	**Traveler Services Information**	**Traffic Control**	**Incident Management**	**Emissions Testing & Mitigation**	**Centralized Information Mgmt**
Determining incident characteristics is sometimes inefficient (6)					●		
Timely & accurate information is not shared w/ traffic information providers & travelers (6)	●						●
Traffic information providers are interested in operating systems (4)	●		●				●
Bus drivers want advance notice of congestion at service plazas (4)	●		●				
More "Good Samaritan" calls/ incident, but information is sometimes inaccurate (6)					●		
Corn Center needs upgrading to match increased activity & responsibilities (6)					●		
Alternatives are needed for two-way operation of vehicles in tunnels (6)				●			
Congestion at toll plazas should be reduced (4)	●						●
Total points based on priorities	18		8	6	18		14

RELATIONSHIP BETWEEN USER SERVICES AND PROBLEMS AND OPPORTUNITIES

Travel Demand Management Bundle

USER SERVICES **PROBLEMS AND OPPORTUNITIES** (Weighted priorities)	Demand Mgmt & Operations	Pre-Trip Travel Information	Ride Matching & Reservations				
Minimal efforts are being made to encourage car-pooling (4)	●		●				
Off – Peak travel should be encouraged (4)	●						
Timely & accurate information is not shared w/ traffic information providers & travelers (6)		●					
Congestion at toll plazas should be reduced (4)	●						
Total points based on priorities	**12**	**6**	**4**				

Note: The statements of problems and opportunities that applied to more than one of the user service bundles are indicated in italics. Some of these statements have wide ranging implications and apply to user services in multiple bundles.

RELATIONSHIP BETWEEN USER SERVICES AND PROBLEMS AND OPPORTUNITIES

Electronic Payment Bundle

USER SERVICES **PROBLEMS AND OPPORTUNITIES** (Weighted priorities)	Demand Mgmt & Operations						
Electronic Payment system should be useable for other Turnpike services (6)	●						
Existing credit card system needs reporting & cancellation improvements (3)	●						
Congestion at toll plazas should be reduced (4)	●						
Total points based on priorities	**13**						

Note: The statements of problems and opportunities that applied to more than one of the user service bundles are indicated in italics. Some of these statements have wide ranging implications and apply to user services in multiple bundles.

RELATIONSHIP BETWEEN USER SERVICES AND PROBLEMS AND OPPORTUNITIES

Commercial Vehicle Operations Bundle

USER SERVICES / **PROBLEMS AND OPPORTUNITIES** (Weighted priorities)	Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-Board Safety Monitoring	Comm. Vehicle Administrative Processes	Hazardous Materials Incident Response	Freight Mobility	
Hazmat permit process should be coordinated w/ reqs. of other agencies (6)				●			
Collection & distribution of construction, weather & traffic information should be enhanced for drivers & dispatchers (6)						●	
Vehicle location systems are being utilized by several large operators (6)						●	
Determination of incident characteristics is sometimes inefficient (6)					●		
Total points based on priorities				6	6	12	

Note: The statements of problems and opportunities that applied to more than one of the user service bundles are indicated in italics. Some of these statements have wide ranging implications and apply to user services in multiple bundles.

Appendix J

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX J

ITS USER SERVICE IMPLEMENTABILITY

ITS USER SERVICE IMPLEMENTABILITY

ITS User Service	Specific Objectives	Typical Improvement Program	Implementability	
			Rating	Comments
En-Route Driver Information	Warn drivers of dangers and delays	HAR & VMS	H	Although full-scale implementation of this service will take many years, the Turnpike is moving ahead with plans for staged deployment of HAR units.
Incident Management	Improve timeliness & accuracy of information	CCTVs, Improved location markers & Call Boxes, upgrade Commo.	M	The Turnpike has instituted most of the low-cost operational procedures associated with this service. Many of the remaining elements of this user service are costly, but can be implemented in stages at location where accidents frequently occur.
Centralized Information Management	Improve availability of real-time incident data	Real-time data base, Local and Wide are comm. networks	H	Plans have already been developed to establish LAN and WAN systems for sharing a variety of data related to Turnpike operations. This is one subset of that system. Many of these elements exist and will be further facilitated by the communications network that is currently being negotiated.
Electronic Payment Services	Facilitate CVO & reduce congestion at tool plazas	Credit card improvement & EZ-Pass	H	Implementation of the EZ-Pass system is already proceeding on other facilities in the region. In addition, improvements to the Turnpike's existing credit card system have been developed and are being considered for implementation.
Demand Mgmt and Operations	Reduce peak hour travel	Park & ride lot program, time-of-day price differential	M	There is limited availability of land for Park and Ride lots on Turnpike property near the major cities, but the demand for these facilities is apparent. It may be possible to implement time-of-day pricing in conjunction with the next general toll increase.
Freight Mobility	Facilitate CVO	Traffic and Toll Account Info. system upgrades	M	The Turnpike has developed a variety of programs to help its CVO customers. Implementation of this program is contingent upon the existence of the Centralized Information Management service and the Electronic Payment system upgrades.
Traveler Services Information	Reduce congestion at service plazas	Monitoring systems & HAR/VMS	M	This service addresses a specific operational problem experienced by charter buses and other travelers at some of the service plazas. The improvement program would consist of two parts: a set of video detectors at the plazas to identify congestion and HAR or VMS units (possibly the same units serving the en-route driver information system.)

ITS User Service	Specific Objectives	Typical Improvement Program	Implementability	
			Rating	Comments
Pre-Trip Travel Information	Forewarn travelers of major incidents	Traffic Info. system upgrades	H	Implementation of this service would upgrade the automatic response capability of the existing telephone information system and would eventually get updated automatically from the database contained in the centralized information management system.
Commercial Vehicle Admin Process	Reduce Hazmat permit reqs.	Reduce Hazmat permit reqs.	H	Improvements to this user service involve coordinating and streamlining the Hazmat permit process. This appears to be an administrative change that would be relatively easy to implement.
Hazardous Material Incident Response	Improve info. & coordination at Hazmat incident	Give responders phone nos. of CVO dispatchers	H	Incident duration should be reduced by involving the shipper in the process of identifying suitable recovery and clean-up firms. This should be possible through low-cost communication and coordination measures
Traffic Control	Improve Safety in tunnel during maintenance	Lane Control Signals and VMS at Tunnels	H	Several head-on collisions have occurred in the tunnels in the past. It is important to address this issue before the beginning of tunnel reconstruction projects which will involved extensive lane closures.
Ride Matching & Reservation	Increase auto occupancy	Support existing car-pooling matching programs	H	Programs currently exist in the state, but are not advertised on the Turnpike. Programs promoting ride sharing would be relatively low in cost.

Appendix K

APPENDIXK

ITS FUNCTION DEFINITIONS

GENERAL DESCRIPTION OF ITS FUNCTIONS

Although user services are the main focus of ITS, it is also necessary to define and describe the functionality required by these services. The various user services draw upon one or more functions in their implementation. As indicated in the matrix at the end of this appendix, various combinations of functions may provide a user service in whole or in part. Services may first be implemented partially, providing some benefit to the user, and supplemented later with other functions. In all, seventeen functional areas have been identified. In most instances, these functions can be provided using several different technologies.

This section will provide a general description and provide basic requirements for each of the functions listed below. A matrix detailing the relationship between the various functions and user services follows as does an early deployment risk evaluation chart.

- Traffic surveillance
- Vehicle surveillance
- In-vehicle sensors/devices
- Variable message displays
- Individual traveler interface
- Navigation
- Routing data processing
- 1-way mobile communications
- 2-way mobile communications
- Stationary communications
- Signalized traffic control
- Restrictions traffic control
- Traffic prediction data processing
- Traffic control data processing
- Database Processing
- Inter-agency coordination
- Payment systems

Traffic Surveillance

Traffic surveillance involves the monitoring and collection of data on streams of traffic at specific points or general areas. This is achieved through the use of various detector or sensor technologies including: magnetism, infrared, radar, microwave, machine vision, CCTV, and sound. In order to be useful, each of these methods require a communications medium: a user interface or monitoring device, a storage mechanism or both. It is also expected that surveillance information may be gathered on a continuous basis using specially equipped vehicles as probes. Examples of the types of data collected through these systems include traffic volume, speed, density, travel time, and classification. These data may be accumulated and stored for historical purposes and trend analysis or used in real time. System operators utilize this data for incident detection and ramp metering. Planners, designers, and engineers may use this data for improvements to existing systems or as inputs into the design of new road or signal systems. Local and Federal transportation groups may use this information for emergency management and planning purposes. Early deployment risk is low for this function. Although some risk exists across regional boundaries, the use of existing standards compliant equipment reduces risk sensitivity.

Traffic surveillance can occur at specific fixed points using technologies such as loops, infrared or radar systems, and machine vision. These may be fixed permanently for the collection of historical data or placed in temporary fixed positions for certain studies. The data may be collected continuously or at selected time periods depending on the specific requirements of the user. Surveillance may cover an extended area such as an interchange, a section of roadway, or a key public transportation point such as a subway station, through the use of CCTV. This may aid in the reporting of real-time transportation data for commuters and emergency vehicles. Specially equipped cars may act as moving probes relating information on traffic conditions on a real-time basis. This will be especially useful for gaining data on segments of road not monitored by other surveillance methods.

While the majority of traffic surveillance technologies will be implemented by public agencies such as the state and federal DOT's, there will be some involvement by the private sector. Other data may be collected through the cooperation with commercial enterprises, such as airborne traffic surveillance firms, who already broadcast their information to the public on commercial radio stations. In the future the public at large may participate by allowing their vehicles to be used as probes, sending data back to some central facility for manipulation and dissemination.

<u>Vehicle Surveillance</u>

Vehicle surveillance is concerned with the collection of data on specific vehicles and involves concepts such as weigh-in-motion as well as vehicle identification, classification, and location. Input to this function may include attributes of a specific vehicle or person, such as vehicle weight for a truck or financial information for someone driving through a toll plaza. It may involve some measurement such as vehicle emissions content for the purpose of environmental control, or provide precise vehicle location for use in accident prevention and location systems. These actions may also initiate some procedure such as the permission for a truck to continue past a check point or warning a driver of oncoming traffic at an intersection.

Users of this information include individual drivers, transportation providers, regulatory agencies and safety authorities, both Federal and local The process of information gathering by these technologies takes place mostly at specific locations. Infrared technology used for the analysis of exhaust plumes may be used at some location where vehicles pass slowly such as toll plazas or ramp metering stations. Vehicle location technologies may be employed in a zone surrounding an intersection, while weigh-in-motion technology may be used at truck check points or prior to a restricted bridge crossing.

The function may take place on a continual basis from the point of view of transportation officials at a truck inspection station whereas to a passing truck, the function takes place at one specific moment. Vehicle surveillance may be performed by private agencies such as those collecting tolls on private roads and public agencies such as EPA for the collection of emissions data.

Technologies for this function are emerging, but there exists both a regional and national compatibility issue. Because of the need for national compatibility there is a high risk sensitivity associated with this function.

In-Vehicle Sensors/Devices

This function allows the monitoring of assorted on-board conditions. These may include both vehicle and driver performance, number of people in the vehicle, vehicle system safety status, emissions information, vehicle position relative to the roadway, other vehicles, and nearby objects. Improved vision and security issues may also be addressed by the various technologies employed by this function.

The technologies used in this function will be provided largely by the private sector, including automobile manufacturers as well as after market suppliers, though the necessary infrastructure used by these technologies will come from the public sector. A high degree of compatibility will be required between on-board devices and outside beacons, automated signals, and other communications devices. Both regional and product level compatibility issues arise causing a moderate level of risk in both standards and architecture development.

Inputs to this function may include proximity information of one vehicle to another vehicle or to the road, data from engine mechanical and safety systems, and signals from outside the vehicle. Enhanced vision through infrared technology, radio signals to safety inspection stations and warning signals represent some of the possible outputs from in-vehicle sensors and detectors. While these functions generally occur within the confines of a vehicle, communications with an external apparatus is a key to many of these technologies. These systems are designed to monitor conditions on a continuous basis and react accordingly when certain thresholds or situations are met. The larger the installed base of vehicles equipped with these technologies becomes, the more successful the user services they provide will be.

Variable Message Displays

A variable message display allows information from a central location to be presented to multiple users either visually or audibly. This technology is generally employed at locations such as roadside displays or transit terminals. There are several means toward accomplishing the transmission of the desired message to the appropriate outlet. Direct connections via copper or fiber cable, or transmission via radio, microwave or infrared signals are among the choices. The input for messages may come from several sources, but are generally controlled by an agency directly associated with the roadway or terminal in question. Requirements include a working data collection infrastructure which may include detectors, cameras, weather stations, and commum'cations with various authorities. Once information is collected regarding a particular situation, it is necessary to get the right message to the appropriate locations. A central control center is usually used for this, and messages often need to be stated succinctly. Large scale integration and standards are not considered key for this technology as it generally is relevant only to the area in the vicinity of the given display.

Individual Traveler Interface

An individual traveler interface involves a broad category of technologies including stationary kiosks, on board display systems, touch screens, portable personal communications devices, telephones, and televisions. These facilities may be located in an individual's car, at public transportation stations, or on buses and trains. An individual traveler interface may be interactive as with an on-board touch screen display or it may be a one way interface as with traveler information displayed at a kiosk.

Data for this fu nction come from diverse sources. The source may be detectors along roadways delivering real time traffic conditions such as volume or weather conditions. Depending on the complexity of the system, the output may be unprocessed volume data or a suggested travel route. This type of service could be useful for both pre-trip and en-route services.

Individual traveler interfaces will generally be used upon demand by individual users when they desire information relating to a planned or on-going trip. Emergency uses may include directions to the site of an incident or medical information required for an injured party. A traveler may visit a kiosk to gain information on fares to various locations using different modes of transportation. This could be accomplished through the use of touch screens with a combination of graphics and sound for relaying relevant information to the user. Interfaces may involve user interaction, as with a touch screen, or it may be no more than a warning light.

In a fully deployed system, several agencies and private firms may be involved in the collection and dissemination of information. A high level of cooperation and coordination will be necessary in order to develop processing and communications systems capable of interacting and passing data back and forth between users and providers.

Standards will need to be drawn up that allow for the manufacturing of equipment that meets these specifications. Because of these needs, risk levels are viewed as moderate for this function.

Navigation

The navigation function allows for the precise positioning of vehicles in real time. Several technologies exist which will meet the needs of such a system including GPS, LORAN, dead reckoning, localized beacons, map database matching, and cellular/radio triangulation. The users of this function include the individual driver, commercial fleets, emergency response agencies, and public transit authorities. The providers of this service may be private industry or public agencies depending on the particular use, and these systems may or may not be cross compatible. While an individual may sign on with a private provider using GPS, a particular region or public agency may install its own network of beacons or radios used for triangulation. The complexity of this function varies depending upon the method of implementation. A GPS system is quite complex and requires specialized receiving and processing devices, whereas map database matching is less complex. While the cost to an individual may be prohibitive, the public may benefit through the deployment of navigation systems by public agencies. One area where a public agency may derive the most benefit is the more precise positioning of traffic incidents which may provide for better emergency response or more timely and accurate information dissemination.

Due to the autonomous capabilities of these technologies the risk sensitivity is low for both architecture and standards.

Routing Data Processing

The routing data processing function allows for the generation of step-by-step driving instructions to specific destinations. Other algorithms under development may provide for the scheduling of drivers, vehicles and cargo, and multi-modal dispatching. Simple implementations may involve a static database creating a route based on user input of origin and destination. More complex systems may operate interactively with other technologies and user services to provide real-time route guidance based on existing location and prevailing conditions.

While the primary databases may be developed by private industry, data gathered by public agencies will be used in the advanced configurations. This function may occur occasionally on demand of a particular user or continuously by a large commercial carrier scheduling hundreds of carriers. Queries to this type of database may be made from a moving vehicle, from an office or from a central data processing location. Inputs will range from origin/destination points to real-time location coordinates derived from various navigation technologies.

Standards for mapping databases, while not yet fully developed pose a high risk level. The coordination and development of standards in the architecture of such a system are more important, creating a moderate risk level for early deployment.

1-Wav Mobile Communications

One-way mobile communications transmit in one direction only, to a receiver which may be mobile. Possible technologies for providing this service include Highway Advisory Radio (HAR), FM subcarrier, spread spectrum, and microwave or infrared commercial broadcasts and beacons.

Users of this function include public and private sector entities as well as individuals. The inputs may include GPS data providing location of a vehicle, weather or traffic data providing information to drivers, or registration information allowing for the proper billing and fee collection of interstate carriers.

These communications may take place on a continual basis or on a periodic basis as the result of an external request, such as a request for common carrier identification as it crosses a state line. Communications may be initiated as the result of certain activity as when two vehicles enter an intersection zone at the same time, causing a warning beacon to transmit. This function may be performed privately or publicly, but requires the use of both a transmitter and a receiver,

Compatibility issues are present at national, regional and product levels. The development of protocol standards is required in order to reduce risk.

2-Way Mobile Communications

Two-way mobile communication allows for the bidirectional transmission of signals between a fixed site and a mobile site or between two mobile sites. Technologies such as cellular, 2-way radio, spread spectrum, microwave, infrared, and 2-way satellites may be used. This function is used in the majority of user services for transmitting voice and data.

Data for this function may come from a multitude of sources including traffic data from detectors, cameras and aerial observations, financial data from financial service firms, GPS receivers or instructions from a central facility involved in inter-agency communications. Output may be in the form of a warning signal, a response to a request for directions or the acknowledgment of a message received.

This function requires that all parties possess the necessary transmitting and receiving equipment. This equipment may be of an interactive nature such as a device placed in a vehicle used for route guidance and en-route driver information, or, it may be invisible to the user, as that used in automated roadside safety inspections.

In order for this function to support all uses there must be coordination in the development of protocols and standards. Whereas this may not pose problems on a local level, the subsequent formation of standards on a regional or national level may increase the risk of incompatible standards.

Organizations involved in the administration of this function come from both the public and private sectors. The acceptance and use by businesses and the general public will be required in order for these technologies to reach their full potential.

StationarvCommunications

Stationary communication technologies allow for communications between stationary sites. Technologies employed for this purpose include copper and fiber land lines, and radio or microwave signals. A successful deployment of ITS requires the proper implementation of this function. These technologies provide for the transfer of data used in many of the specialized user services, and are required in order to achieve the overall communications and coordination sought to provide a cohesive, working organization capable of providing information to the right place at the right time and in a form that is beneficial to the end user.

In one way or another this function is tied to all user services. If it is not directly responsible for the delivery of a particular service than it most certainly is required as one of the functions which is needed. All users at some time will make use of stationary communications whether it is through viewing a variable message sign whose signal arrived over fiber lines from a TMC, or the sight of a red light which is receiving information via a microwave signal.

Stationary communications are being conducted continuously throughout a robust ITS. They may originate from a central location and terminate at various remote sites or be passed from one station to the next. Because this function is so vital to the successful deployment of an ITS, there will have to be involvement and coordination among public agencies, and good working relationships with private sector providers of service. A central coordinating function will be required in order to maintain an open, operational, and sustainable communication network. Due to the existing infrastructure and common protocols, risk is low for this function

Signalized Traffic Control

This function allows for the control of traffic signals in a manner which improves the flow of traffic by reducing delay and travel time. The newest technologies being researched and deployed are real-time traffic adaptive signal systems. Ramp metering and lane control methods such as reversible lanes or lane closings are also functions that fall under the heading of signalized traffic control. These technologies require varying amounts of input depending upon their implementation and configuration At a minimum, these systems require an internal clock or some other control that turns them on and off or indicates what plan should be in effect, and at the other extreme would be real-time data including volume, occupancy, and other measures of flow. This technology is generally aimed at the traveling public, although certain uses such as emergency vehicle pre-emption systems are aimed at a more specific user group. With the introduction of user services such as emissions control and mitigation and their required technologies, traffic control may take the form of closed lanes or ramps due to excessive pollution in a particular region.

This function, if not operating in a stand alone condition, requires communications between individual sites, such as a signalized intersection or an on-ramp, and a central control facility. Communications usually occurs using a physical medium such as copper or fiber, although other technologies such as spread spectrum radio may be employed. Although traffic signals themselves may be changing constantly the system itself may be in a time of day mode during which signal plans change at specific pre-determined times, often revolving around certain periods such as AM peak, Midday peak, PM peak and offpeak. Most ramp metering and lane control systems have their control based purely on time of day, however, newer adaptive systems may be continually measuring conditions and making changes on an ongoing basis.

Signalized traffic control technologies have a large installed base, risks due to architecture are low. Compatibility issues arise across jurisdictional boundaries causing a moderate degree of risk for standards.

Restrictions Traffic Control

Traffic restrictions are generally used to meet some goal or set of goals for a specific region and may involve the use of High Occupancy Vehicle (HOV) lanes, parking restrictions and congestion pricing for tolls and public transit. This function is brought about by political will and enforcement more than by technology, although several other user services and related technologies may be helpful in the successful implementation of this function and its eventual success. The users of this function tend to be various agencies and public policy groups, whereas in its implementation it may take the form of restrictions and incentives to the traveling public. While the goals of the user services which this function supports are of a general nature, such as to reduce vehicle emissions or to increase vehicle occupancy, in practice it is the public who must be motivated into action.

HOV restrictions are placed on major arteries for the purpose of encouraging car pooling. Parking restrictions often take the form of limiting on-street parking, or assigning preferred spaces to van pools and car pools at large employment centers. Congestion pricing may take the form of increased fees to drivers in the form of tolls.

A key issue in the success of these functions often lies in compliance, which is generally achieved through regular and consistent enforcement efforts. Regional coordination is required, as these policies are locally determined. Risk sensitivity is moderate for this function.

Traffic Prediction Data Processing:

This function is a more specialized application of generic database processing and is used for prediction of future traffic situations. The technology involves the development of specialized algorithms to be used in applications such as real time traffic prediction and traffic assignment. The development of algorithms may be particular to specific regions which would indicate problems in adoption of standards. System architecture on the other hand does not pose any significant risk in development due to the platform independence of this technology.

Various agencies may be involved in the formulation and implementation of this function depending upon use. State, local and Federal agencies may be interested in long-term planning activities which require functionality focused on a distant time horizon. Local and state DOTs would be interested in using the output of these programs as inputs for advanced traffic control systems requiring predictions based on a shorter time horizon.

Inputs to this function include current and historical traffic data such as volume and occupancy. Other data sources may include predictions of future traffic and associated levels of service based upon research conducted by both public agencies and private consultants. A requirement of this function is continual record maintenance and data archiving.

Traffic Control Data Processing

Traffic control data processing relates to the real-time control of traffic Algorithms being developed will allow for optimal signal control, incident detection and the interaction between route selection and traffic control. Inputs will come from other functions and include real-time volume and occupancy data. The data collected will be utilized by the program producing output in the form of dynamic signal timing plans, route selection, and warnings denoting possible incidents. Depending upon the complexity of the system being developed, actions may take the form of report generation or system control.

This function will generally reside in a Traffic Control Center where the various inputs are collected. Traffic control processing requires continuous collection and manipulation of raw data, placing high demands on the computer processor. Powerful database servers may be necessary to service large systems. Regional differences in algorithm development and the close interaction between software and hardware create a moderate risk environment for both architecture and standards development.

Database Processing

The database processing function involves the manipulation of transportation related data into useful information for reports or as input into other functions. Current database software exists, but may require special adaptation for use in the transportation field. The users of such data are generally those in the transportation industry or particular transportation departments as well as private companies creating products for the general public. Inputs include items such as: volume data, present and historical, speed limits, average speed, road configuration, mileage information, equipment inventories and geographic information. Output may include various reports useful to signal maintenance crews, or maps used by travelers produced from off the shelf software.

Although only briefly described here, the database processing function plays an important role in most user services. Standards should be adopted to provide for interagency data sharing and inter-component compatibility. Regional differences combined with the existence of multiple database structures increase the risk sensitivities of this function.

Inter-Aaencv Coordination

Inter-agency coordination involves either direct or indirect sharing of information and coordination of activities among various agencies, such as police, emergency services, weather stations, transit operators, and Traffic Management Centers. A communications network must be in place to enable the free flow of information and requests for services. Input to this function will come from a wide variety of technologies, and may also depend on the type and severity of the condition requiring a multi-agency response. This may come in the form of a request for emergency services with simultaneous requests for traffic management and public works personnel to support incident management.

When fully mature, this function would be utilized almost continuously for monitoring and responding to specific events requiring the services of multiple agencies. The coordination effort may be performed centrally with information flowing to all parties involved in a particular action. Inter-agency coordination technologies currently exist, and are not complex. However, many agencies are reluctant to share data with other agencies. Some risk exists across regional, and even agency boundaries.

Payment Systems

The payment system function allows for the transfer of funds between a traveler and a service provider. This function essentially makes up and describes the electronic payment user service. Technologies which accomplish this are Automated Vehicle Identification (AVI), smart cards and electronic fund management systems.

The requirements for this technology vary according to the particular implementation. A debit system allows the user to add value to a smart card at a station similar to an ATM. Each use of the card then reduces the value of the card by a certain amount. This is accomplished through physical contact using either magnetic strips or internal microchip electronics. Under this payment system there is no relation between the card and its holder, a lost card may be used by anyone. A more complex system could be established using PINs but would make ingress and egress inefficient at public transportation facilities. An advantage to the internal microchip smart card is its ability to keep track of transfers or miles traveled by the card holder.

An AVI system may work on either a debit or credit basis and may be employed for use in automatic toll collections or the collection of special fees from interstate carriers as they cross state borders. There are two complicating factors involved in this technology: one being the need for a transmission medium between the user and the fee collector, and the other being a requirement for unique user identification. The task oftransmission itself is not difficult but in order for success, especially in the commercial carrier industry, national standards need to be established. The combination of a transmitted medium along with the requirement of a user identification make the system susceptible to fraud. Security issues will also have to be considered.

Electronic fund management involves the transfer of funds between user accounts and the possible access to credit or banking accounts. The ATM system is an excellent example of the use of third party clearing houses used for the transfer of account information. A similar system will need to be established in order for the payment system to work across regional or state boundaries. These standards requirements, combined with the lack of maturity in the technology, bring high risk to this function.

Risk Evaluation Chart

Functions	Risks: Architecture	Risks: Standards
Traffic Surveillance	Low	Low
Vehicle Surveillance	high	Moderate
In-Vehicle Sensors/Devices	Moderate	Moderate
Variable Message Displays	Moderate	Moderate
Individual Traveler Interface	Moderate	Moderate
Navigation	Low	Low
Routing Data Processing	Moderate	Low
l-Way Mobile Communications	Low	Moderate
2-Way Mobile Communications	Low	Moderate
Stationary Communications	Low	Low
Signalized Traffic Control	Low	Moderate
Restrictions Traffic Control	Moderate	Moderate
Traffic Prediction Data Processing	Low	Moderate
Traffic Control Data Processing	Moderate	Moderate
Database Processing	Moderate	Moderate
Inter-Agency Coordination	Low	Moderate
Payment Systems	Moderate	High

Appendix

L

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PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX L

ALTERNATIVE SYSTEM CONFIGURATIONS

Alternative System Configurations for En-Route Driver Information Service

	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
User Service / **Function**	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Improved VMS System	●			●						●					●		
B. Improved HAR System	●							●		●					●		
C. Improved VMS + HAR System	●			●				●		●					●		
D. Alternative C + Telephone Link to En-route Information	●			●				●	●	●					●	●	
E. Alternative D + Upgraded Kiosk at Service Plazas	●			●	●		●	●	●	●					●	●	
F. Alternative E + Traffic Prediction Data Processing	●			●	●		●	●	●	●			●		●	●	

fig_bl.wpd

Alternative System Configurations for Electronic Payment Service

	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
Function / **User Service**	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Debit of ATM/ Credit Card at End of Day										●					●	●	●
B. Electronic Toll & Traffic Management (E- ZPass)									●	●					●	●	●

fig_b2.wpd

Alternative System Configurations for Incident Management Service

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Improved Call Boxes								●							●	●	
B. Improved Mobile Phone Notification								●	●						●	●	
C. Mobile Phone Notification + Surveillance	●							●	●						●	●	
D. Alternative C + VMS + HAR	●			●				●	●						●	●	
E. Alternative D + Automatic Notification	●		●	●		●		●	●						●	●	

fig_b3.wpd

Alternative System Configurations for Centralized Information Management Service

	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
Function / **User Service**	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Improved E-Mail System					●					●					●	●	
B. Improved E-Mail + Fax					●					●					●	●	
C. Improved E-Mail + Message Banner				●	●					●					●	●	
D. Improved E-Mail + General Alert System				●	●			●		●					●	●	
E. Improved E-Mail + Widespread Paging System				●	●			●		●					●	●	

fig_b4.wpd

Alternative System Configurations forPre-Trip Travel Information Service

	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
Function / User Service	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Enhanced Telephone Information									●	●					●		
B. Interjurisdictional Telephone Information System	●								●	●					●	●	
C. Alternative B + Individual Interface	●				●				●	●					●	●	
D. Alternative C + Traffic Prediction	●				●				●	●			●		●	●	
E. Alternative D + Navigation + Routing	●				●	●	●		●	●			●		●	●	

fig_b5.wpd

Alternative System Configurations for Traffic Control Service

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Signal Control	●									●	●			●	●		
B. Signal Control + VMS	●			●						●	●			●	●		

fig_b6.wpd

Alternative System Configurations for Commercial Vehicle Administrative Processes Service

	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
Function / User Service	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Provide Supplemental Credential Information Only															●		
B. Electronic Filing of Credentials					●					●					●		●
C. Alternative B + HAZMAT Permit Information on Transponder		●			●				●	●					●		●

fig_b7.wpd

Alternative System Configurations for Freight Mobility Service

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Provide Staging Areas for Commercial Trucks																	
B. Add Credit Card Phones to Select Areas									●	●							●
C. Real-Time Access to Toll REcords					●					●					●		●
D. Alternative B+ Alternative C					●				●	●					●		●

fig_b8.wpd

Alternative System Configurations for Hazmat Incident Response Service

	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
Function / **User Service**	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Provide Hazmat Database Access									●						●	●	
B. Automatic “MAYDAY” to Communications Center			●			●		●							●	●	
C. Automatic “MAYDAY” and Remote Monitoring of Load Contents		●	●			●		●	●						●	●	

fig_b9.wpd

Alternative System Configurations for Demand Management & Operations Service

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. HOV Lane in Major Urban Areas			●							●		●			●		
B. Off-Peak Toll Discounts	●		●							●		●			●		●
C. HOV Lane with SOV Premium	●	●	●						●	●		●			●		●

fig_b10.wpd

Alternative System Configurations for Ride Matching & Reservation Service

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A. Basic Ride Matching System										●					●	●	
B. Ride Matching System with Real-Time Call-In									●	●					●	●	
C. Advanced Ride Matching System					●				●	●					●	●	●

fig_b11.wpd

Alternative System Configurations for Ride Matching & Reservation Service

Function / User Service	Surveillance			Traveler Interface		Navigation & Guidance		Communications			Traffic Control		Date Processing			Coordination & Payment	
	Traffic	Vehicle	In-Vehicle	Variable Displays	Individual Interface	Navigation	Routing	1-Way Mobile	2-Way Mobile	Stationary	Signals	Restrictions	Traffic Prediction	Traffic Control	Database	Inter-Agency	Payment Systems
A Upgrade Travel Boards At Service Plazas				●	●		●			●					●		●
B. Telephone Link to Traveler Services Information							●		●						●		
C. Advanced In-Vehicle System					●	●	●		●						●		●

fig_b12.wpd

Appendix

M

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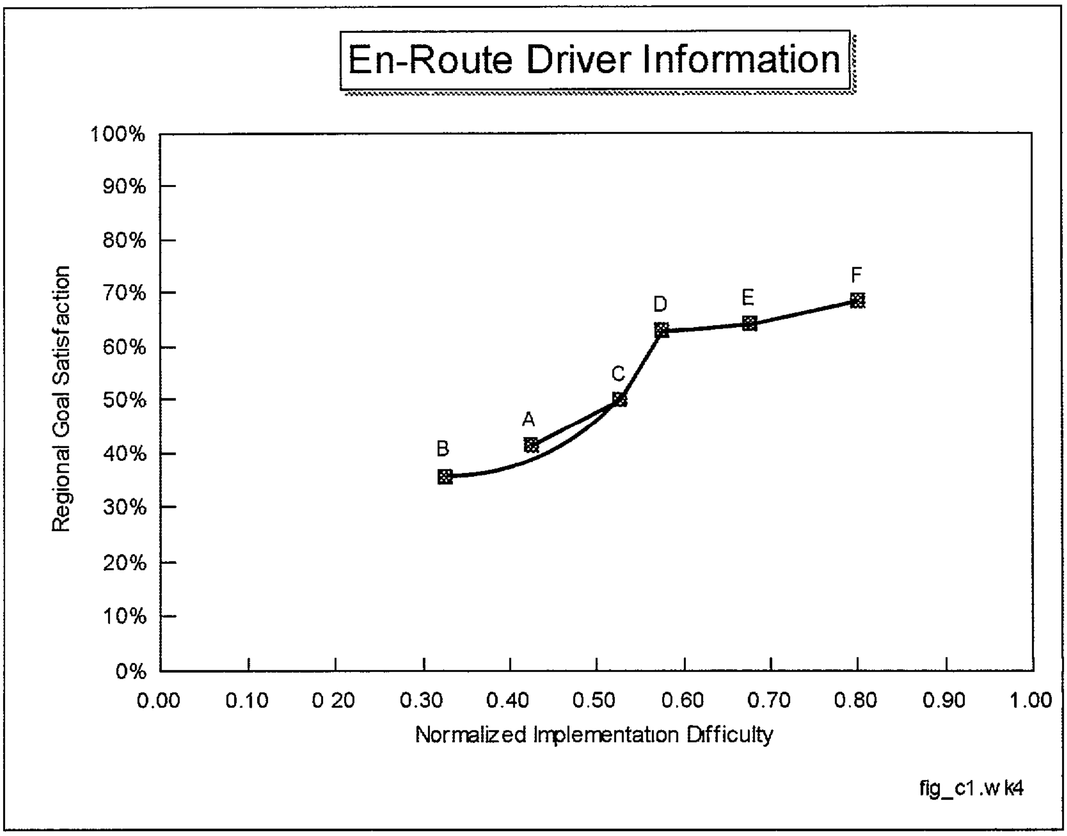
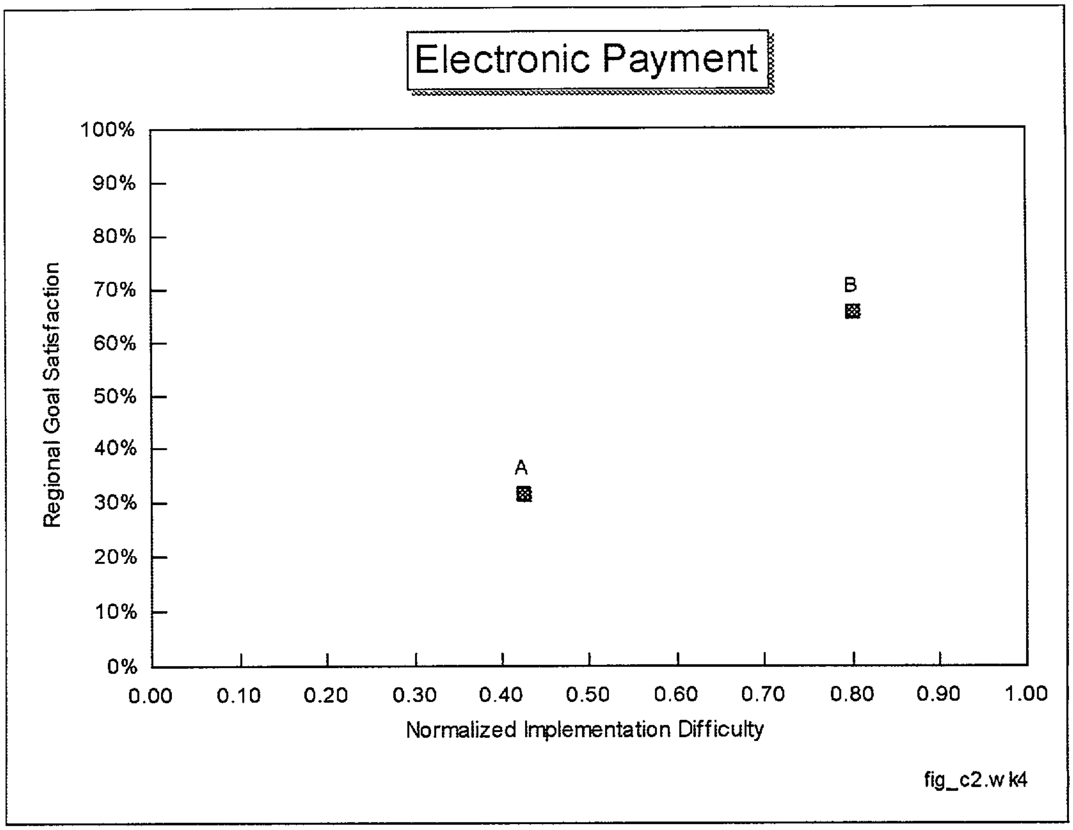
PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX M

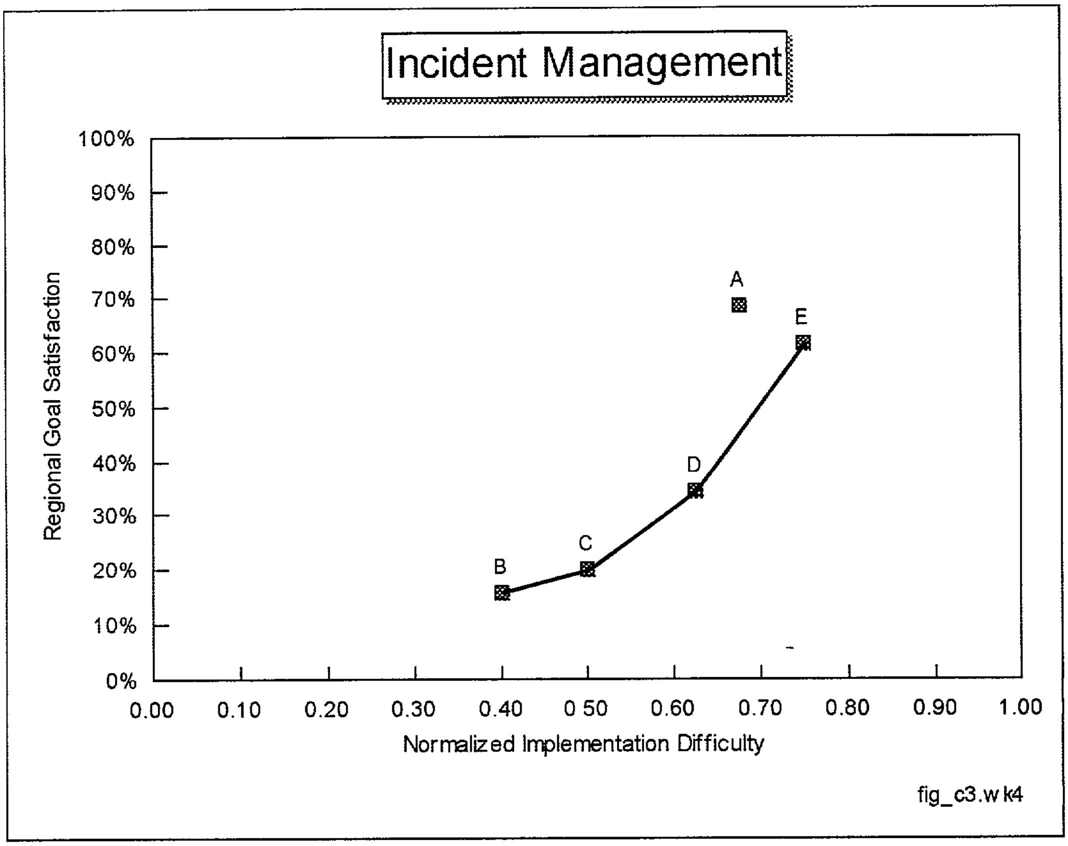
FUNCTIONAL AREA ANALYSIS



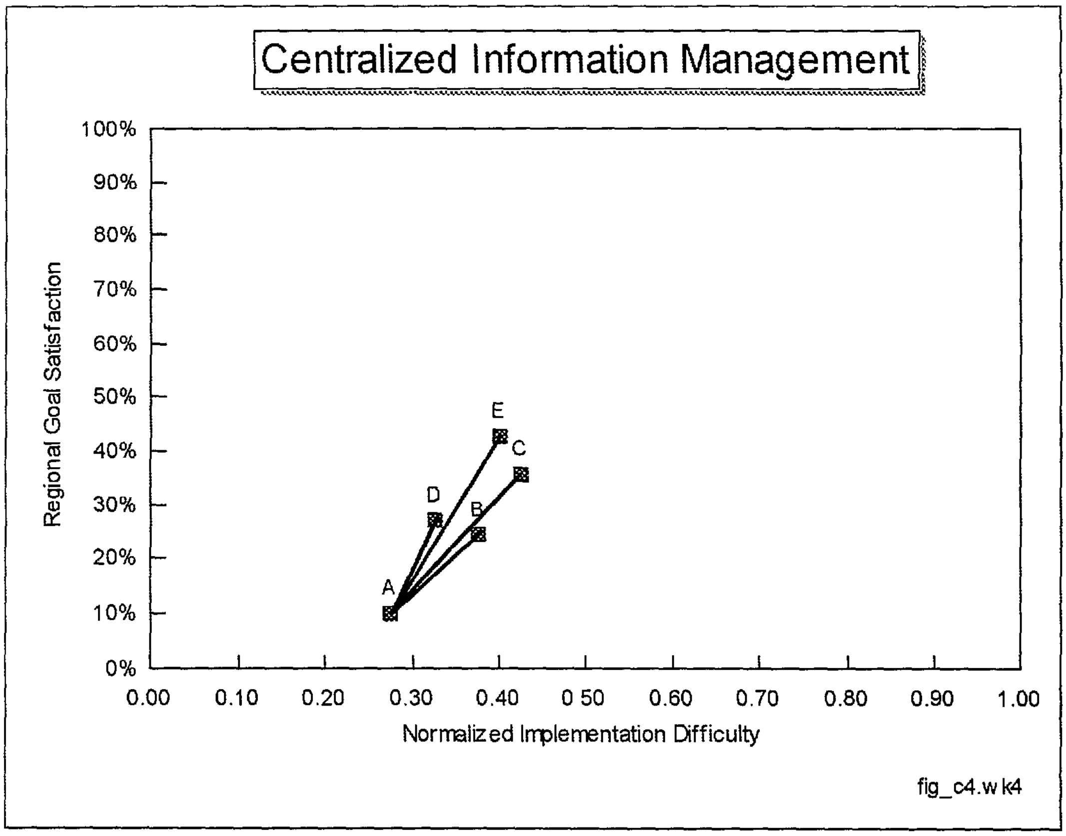
Alternative A: Improved VMS System
Alternative B: Improved HAR System
Alternative C: Improved VMS + HAR System
Alternative D: Alternative C + Telephone Link to En-Route Information
Alternative E: Alternative D + Upgraded Kiosk at Service Plazas
Alternative F: Alternative E + Traffic Prediction Data Processing



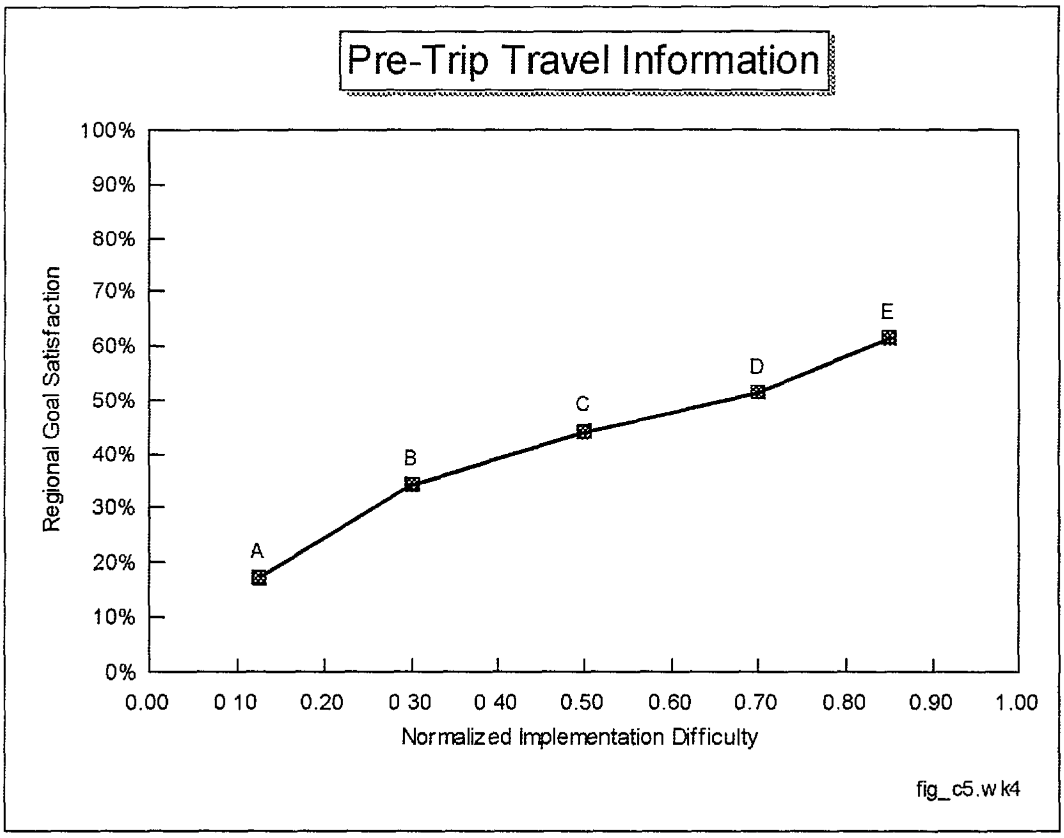
Alternative A: Debit of ATM/Credit Card At End of Day
Alternative B: Electronic Toll & traffic Management (E-ZPass)



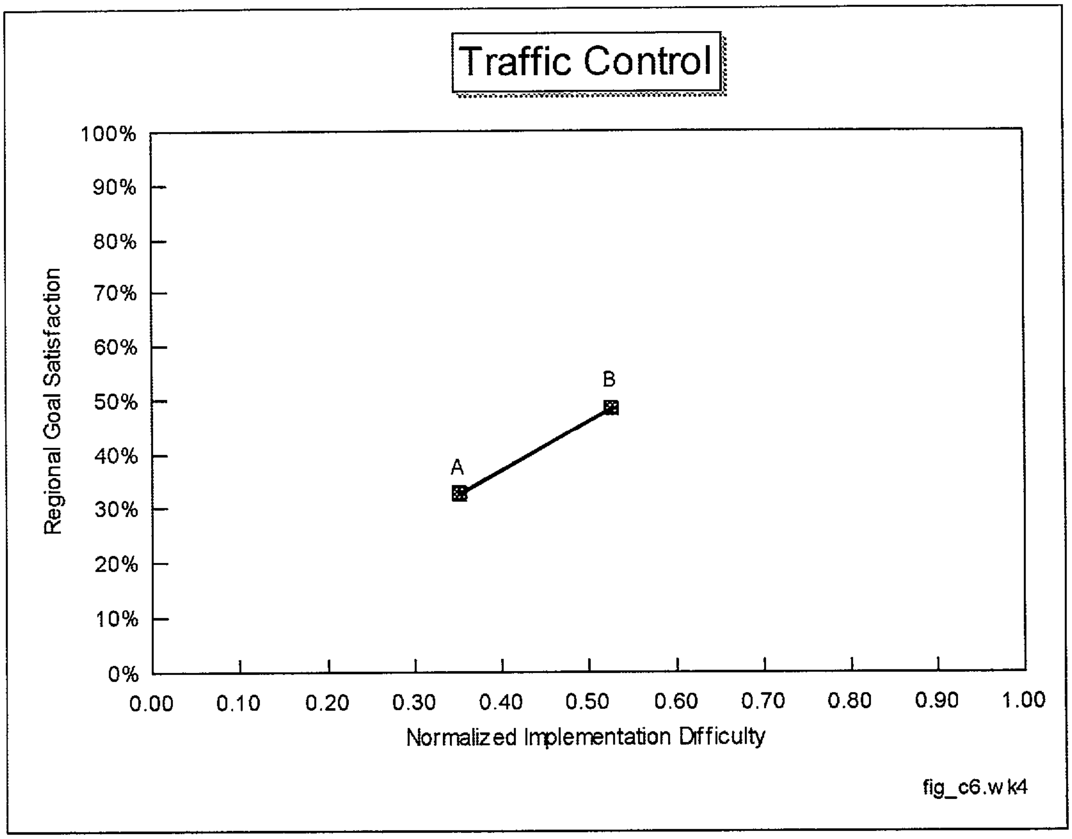
Alternative A: Improved Call Boxes
Alternative B: Improved Mobile Phone Notification
Alternative C: Mobile Phone Notification + Surveillance
Alternative D: Alternative C + VMS + HAR
Alternative E: Alternative D + Automatic Notification



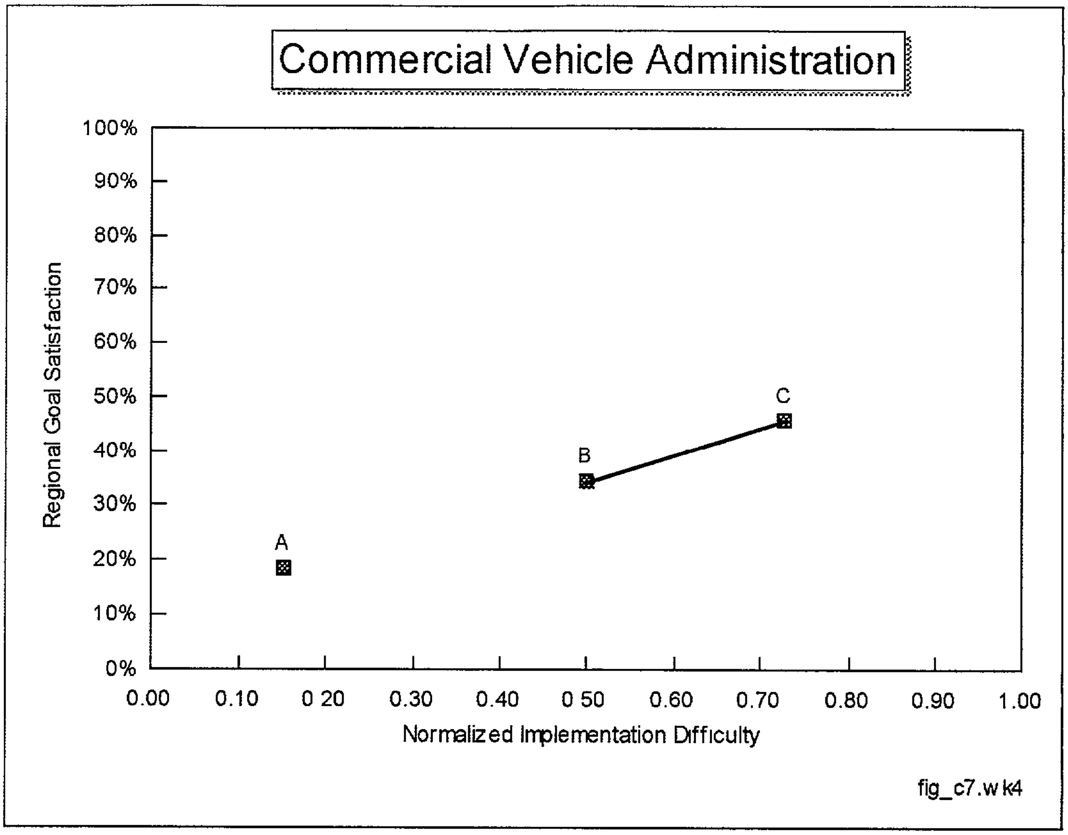
Alternative A: Improved E-Mail System
Alternative B: Improved E-Mail + FAX
Alternative C: Improved E-Mail + Message Banner
Alternative D: Improved E-Mail + General Alert System
Alternative E: Improved E-Mail + Widespread Paging System



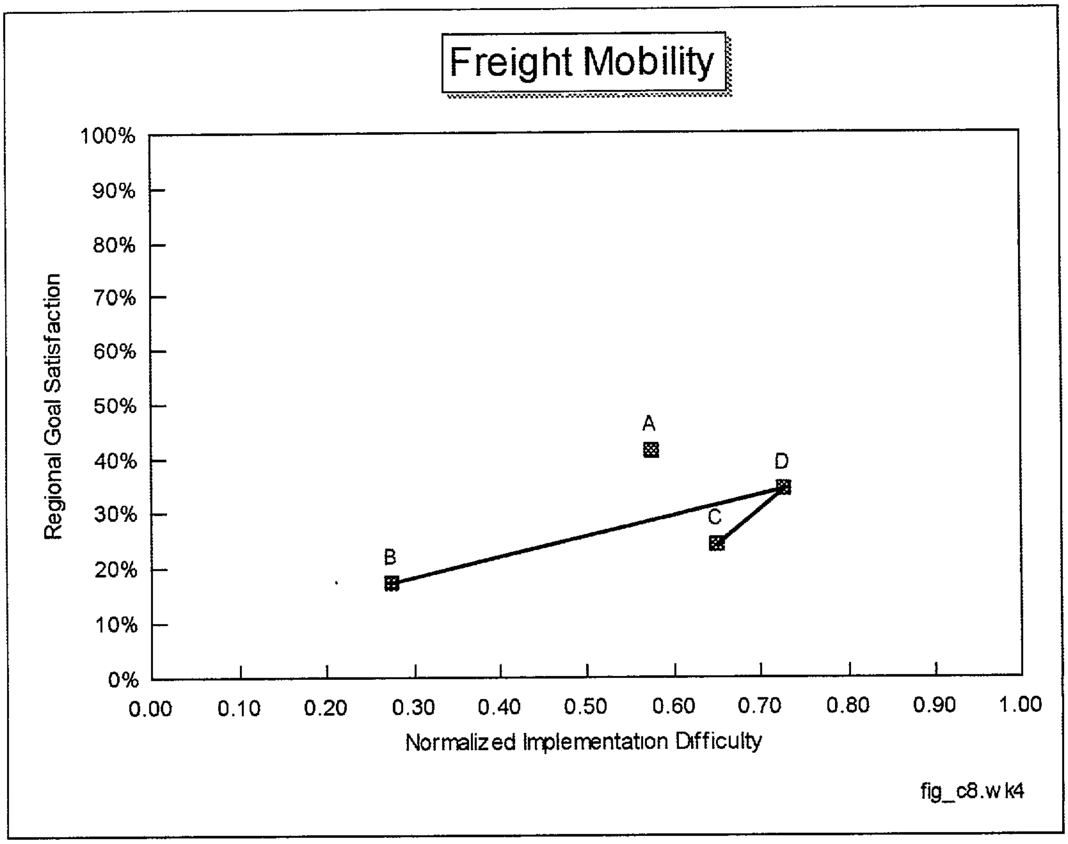
Alternative A: Enhanced Telephone Information
Alternative B: Interjurisdictional Telephone Information System
Alternative C: Alternative B + Individual Interface
Alternative D: Alternative C + Traffic Prediction
Alternative E: Alternative D + Navigation + Routing



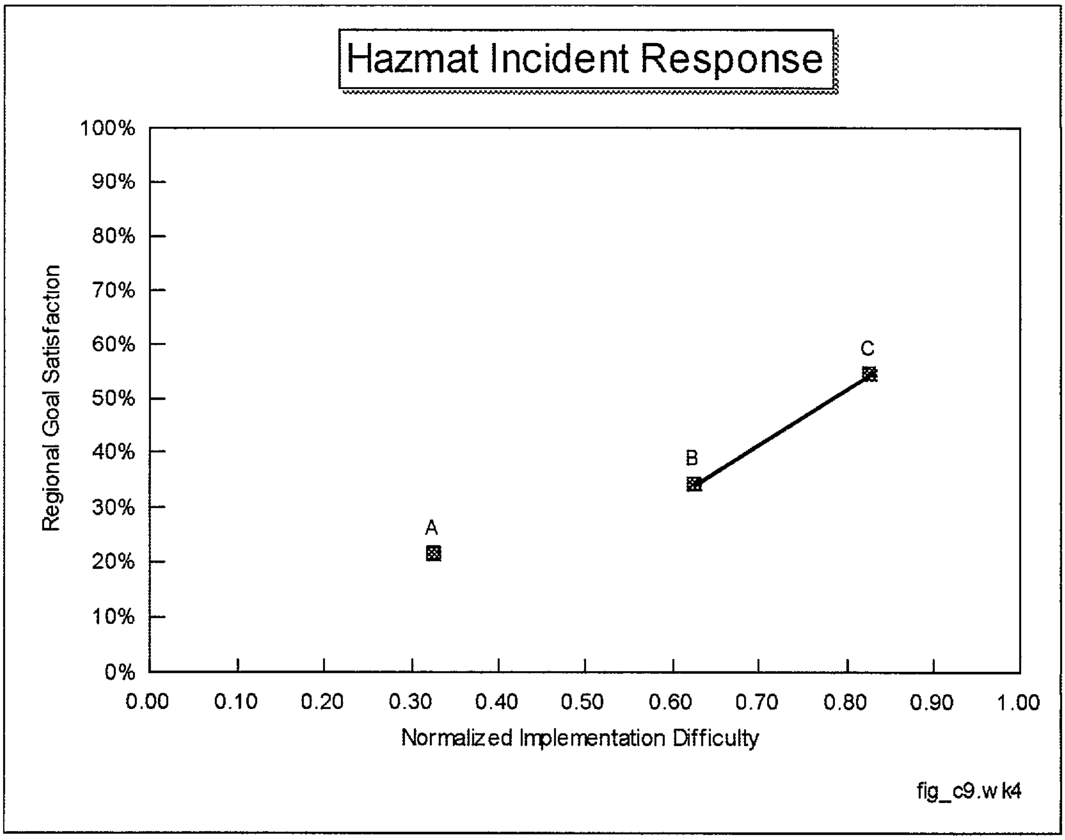
Alternative A: Signal Control
Alternative B: Signal Control + VMS



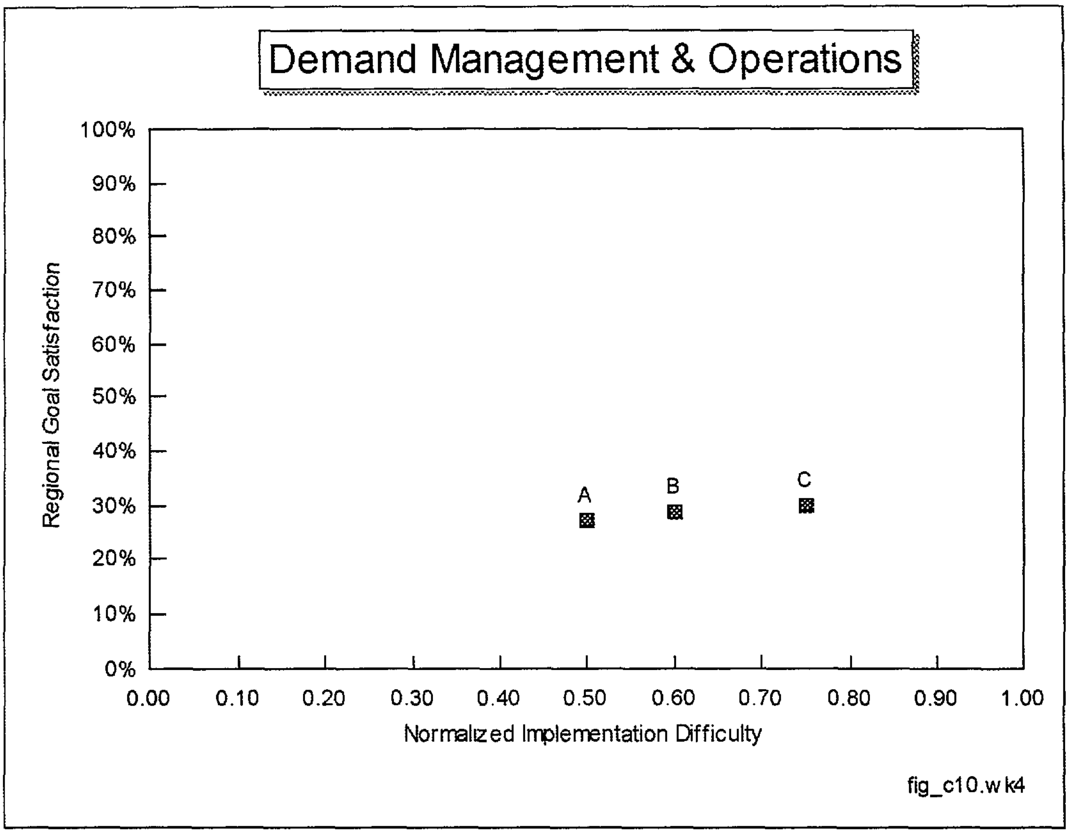
Alternative A: Provide Supplemental Credential Information Only
Alternative B: Electronic Filing of Credentials
Alternative C: Alternative B + HAZMAT Permit Information on Transponder



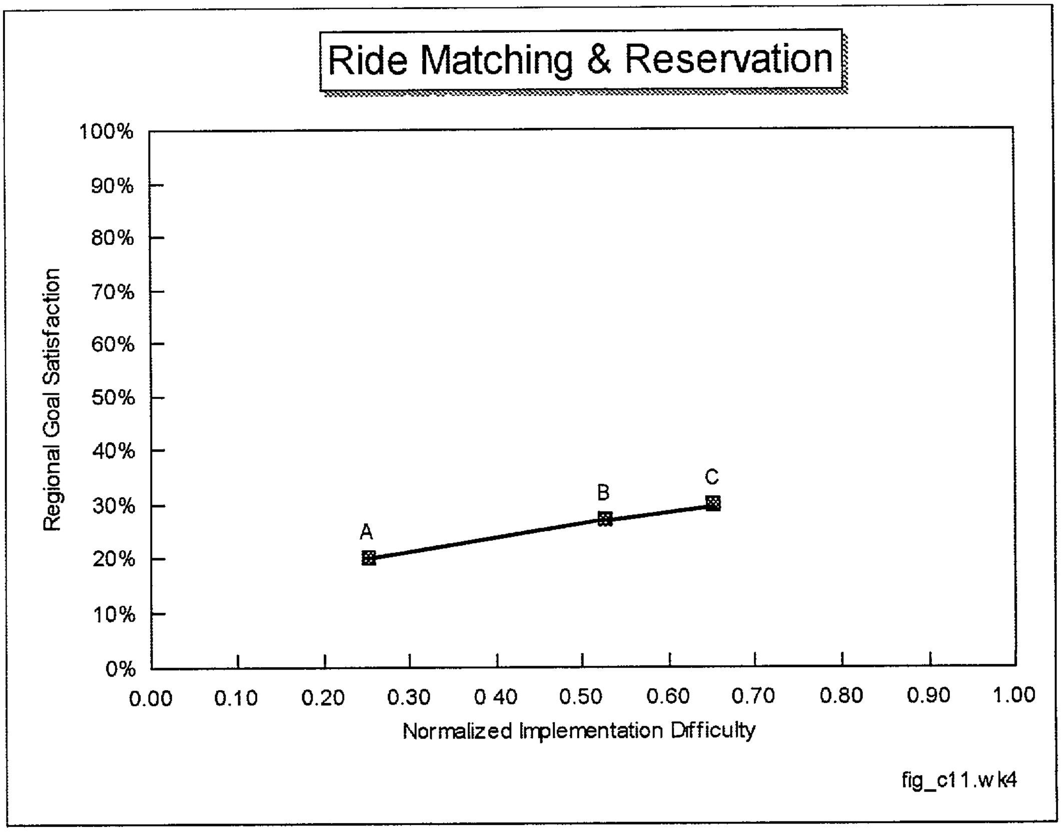
Alternative A: Provide Staging Areas for Commercial Trucks
Alternative B: Add Credit Card Phones to Select Areas
Alternative C: Real-Time Access to Toll Records
Alternative D: Alternative B + Alternative C



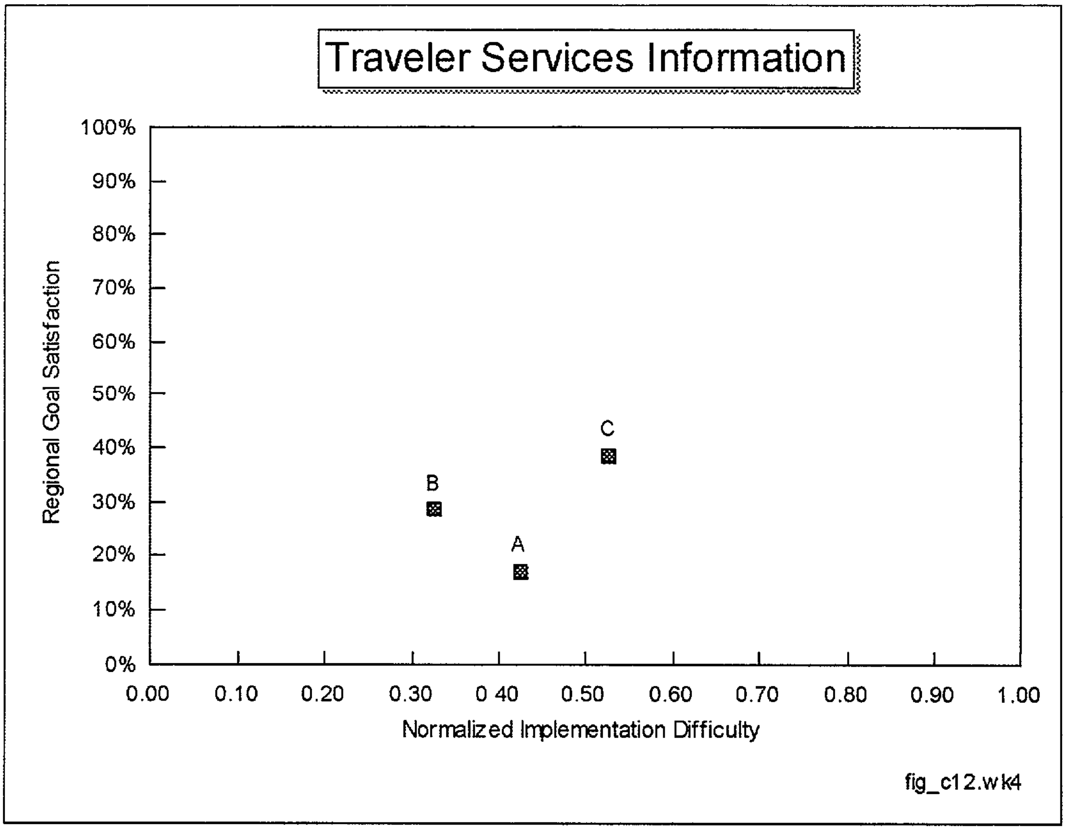
Alternative A: Provide HAZMAT Database Access
Alternative B: Automatic "MAYDAY" to Communications Center
Alternative C: Automatic "MAYDAY" and Remote Monitoring of Load Contents



Alternative A: HOV Lane in Major Urban Areas
Alternative B: Off-Peak Toll Discounts
Alternative C: HOV Lane with SOV Premium



Alternative A: Basic Ride Matching System
Alternative B: Ride Matching System with Real-Time Call-In
Alternative C: Advanced Ride Matching System



Alternative A: Upgraded Travel Boards at Service Plazas
Alternative B: Telephone Link to Traveler Service Information
Alternative C: Advanced In-Vehicle System

Appendix N

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PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX N

EVALUATION TABLES

Evaluation Table for En-Route Driver Information Service

Factor	WTG	Alternative A		Alternative B		Alternative C		Alternative D		Alternative E		Alternative F	
		EVAL	PROD	EVAL	PROD	EVAL	PROD	EVAL	PROD	EVAL	PROD	EVAL	PROD
Implementability Factors *													
stem Cost	100	5	500	2	200	6	600	7	700	7	700	9	900
mpatibility With Existing Infrastructure	100	7	700	5	500	7	700	7	700	7	700	8	800
sk Factors	100	4	400	3	300	5	500	5	500	9	900	10	1000
gree Of Change	100	1	100	3	300	3	300	4	400	4	400	5	500
ubtotal		**17**	**1700**	**13**	**1300**	**21**	**2100**	**23**	**2300**	**27**	**2700**	**32**	**3200**
aximum Product			4000		4000		4000		4000		4000		4000
rmalized Implementation Difficulty **			**0.43**		**0.33**		**0.53**		**0.58**		**0.68**		**0.80**

valuations were scored on a 1=low/10=high scale.

Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	A EVAL	A PROD	B EVAL	B PROD	C EVAL	C PROD	D EVAL	D PROD	E EVAL	E PROD	F EVAL	F PROD
Regional Goal Factors ***													
prove Safety	100	5	500	3	300	6	600	6	600	6	600	6	600
prove Service Level/Reduce Congestion	100	5	500	4	400	6	600	7	700	7	700	8	800
duce Environmental Impact	100	5	500	4	400	6	600	7	700	7	700	8	800
hance Goods Movement	100	1	100	1	100	1	100	5	500	5	500	6	600
sist In Management & Maintenance of Infrastructure	100	5	500	4	400	6	600	6	600	6	600	6	600
prove Mobility	100	5	500	5	500	5	500	7	700	8	800	8	800
pports Off-System ITS Initiatives	100	3	300	4	400	5	500	6	600	6	600	6	600
ubtotal		**29**	**2900**	**25**	**2500**	**35**	**3500**	**44**	**4400**	**45**	**4500**	**48**	**4800**
aximum Product			7000		7000		7000		7000		7000		7000
gional Goal Satisfaction *****			**41%**		**36%**		**50%**		**63%**		**64%**		**69%**

Evaluations were scored on a 1=low/10=high scale.

fig_c1 wk4

* Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

ternative A: Improved VMS System
ternative B: Improved HAR System
ternative C: Improved VMS + HAR System
ternative D: Alternative C + Telephone Link to En-Route Information
ternative E: Alternative D + Upgraded Kiosk at Service Plazas
ternative F: Alternative E + Traffic Prediction Data Processing

Evaluation Table for Electronic Payment Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD
Implementability Factors *					
System Cost	100	5	500	9	900
Compatibility With Existing Infrastructure	100	1	100	9	900
Risk Factors	100	6	600	7	700
Degree Of Change	100	5	500	7	700
Subtotal		**17**	**1700**	**32**	**3200**
Maximum Product			4000		4000
Normalized Implementation Difficulty **			**0.43**		**0.80**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD
Regional Goal Factors ***					
Improve Safety	100	5	500	5	500
Improve Service Level/Reduce Congestion	100	1	100	9	900
Reduce Environmental Impact	100	1	100	9	900
Enhance Goods Movement	100	5	500	8	800
Assist In Management & Maintenance of Infrastructure	100	5	500	6	600
Improve Mobility	100	1	100	1	100
Supports Off-System ITS Initiatives	100	4	400	8	800
Subtotal		**22**	**2200**	**46**	**4600**
Maximum Product			7000		7000
Regional Goal Satisfaction ****			**31%**		**66%**

*** Evaluations were scored on a 1=low/10=high scale. fig_c2.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Debit of ATM / Credit Card at End of Day
Alternative B: Electronic Toll & Traffic Management (E-ZPass)

Evaluation Table for Incident Management Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD	Alternative D EVAL	Alternative D PROD	Alternative E EVAL	Alternative E PROD
Implementability Factors *											
System Cost	100	9	900	5	500	6	600	7	700	8	800
Compatibility With Existing Infrastructure	100	5	500	2	200	4	400	4	400	5	500
Risk Factors	100	4	400	4	400	4	400	7	700	9	900
Degree Of Change	100	9	900	5	500	6	600	7	700	8	800
Subtotal		**27**	**2700**	**16**	**1600**	**20**	**2000**	**25**	**2500**	**30**	**3000**
Maximum Product			4000		4000		4000		4000		4000
Normalized Implementation Difficulty **			**0.68**		**0.40**		**0.50**		**0.63**		**0.75**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD	Alternative D EVAL	Alternative D PROD	Alternative E EVAL	Alternative E PROD
Regional Goal Factors ***											
Improve Safety	100	7	700	1	100	2	200	4	400	6	600
Improve Service Level/Reduce Congestion	100	9	900	3	300	4	400	5	500	8	800
Reduce Environmental Impact	100	6	600	1	100	1	100	2	200	5	500
Enhance Goods Movement	100	7	700	1	100	1	100	4	400	6	600
Assist In Management & Maintenance of Infrastructure	100	6	600	1	100	1	100	3	300	6	600
Improve Mobility	100	8	800	3	300	3	300	4	400	7	700
Supports Off-System ITS Initiatives	100	5	500	1	100	2	200	2	200	5	500
Subtotal		**48**	**4800**	**11**	**1100**	**14**	**1400**	**24**	**2400**	**43**	**4300**
Maximum Product			7000		7000		7000		7000		7000
Regional Goal Satisfaction *****			**69%**		**16%**		**20%**		**34%**		**61%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c3.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Improved Call Boxes
Alternative B: Improved Mobile Phone Notification
Alternative C: Mobile Phone Notification + Surveillance
Alternative D: Alternative C + VMS + HAR
Alternative E: Alternative D + Automatic Notification

Evaluation Table for Centralized Information Management Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD	Alternative D EVAL	Alternative D PROD	Alternative E EVAL	Alternative E PROD
Implementability Factors *											
System Cost	100	1	100	2	200	3	300	2	200	3	300
Compatibility With Existing Infrastructure	100	4	400	6	600	4	400	4	400	5	500
Risk Factors	100	5	500	5	500	7	700	5	500	6	600
Degree Of Change	100	1	100	2	200	3	300	2	200	2	200
Subtotal		**11**	**1100**	**15**	**1500**	**17**	**1700**	**13**	**1300**	**16**	**1600**
Maximum Product			4000		4000		4000		4000		4000
Normalized Implementation Difficulty **			**0.28**		**0.38**		**0.43**		**0.33**		**0.40**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD	Alternative D EVAL	Alternative D PROD	Alternative E EVAL	Alternative E PROD
Regional Goal Factors ***											
Improve Safety	100	1	100	1	100	1	100	1	100	1	100
Improve Service Level/Reduce Congestion	100	1	100	3	300	3	300	2	200	5	500
Reduce Environmental Impact	100	1	100	1	100	2	200	1	100	4	400
Enhance Goods Movement	100	1	100	2	200	3	300	3	300	3	300
Assist In Management & Maintenance of Infrastructure	100	1	100	4	400	6	600	4	400	6	600
Improve Mobility	100	1	100	3	300	7	700	5	500	7	700
Supports Off-System ITS Initiatives	100	1	100	3	300	3	300	3	300	4	400
Subtotal		**7**	**700**	**17**	**1700**	**25**	**2500**	**19**	**1900**	**30**	**3000**
Maximum Product			7000		7000		7000		7000		7000
Regional Goal Satisfaction *****			**10%**		**24%**		**36%**		**27%**		**43%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c4.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Improved E-Mail System
Alternative B: Improved E-Mail + Fax
Alternative C: Improved E-Mail + Message Banner
Alternative D: Improved E-Mail + General Alert System
Alternative E: Improved E-Mail + Widespread Paging System

Evaluation Table for Pre-Trip Travel Information Service

Factor	WTG	Alternative A EVAL	PROD	Alternative B EVAL	PROD	Alternative C EVAL	PROD	Alternative D EVAL	PROD	Alternative E EVAL	PROD
Implementability Factors *											
System Cost	100	1	100	4	400	6	600	7	700	8	800
Compatibility With Existing Infrastructure	100	1	100	3	300	4	400	8	800	9	900
Risk Factors	100	2	200	3	300	5	500	6	600	8	800
Degree Of Change	100	1	100	2	200	5	500	7	700	9	900
Subtotal		**5**	**500**	**12**	**1200**	**20**	**2000**	**28**	**2800**	**34**	**3400**
Maximum Product			4000		4000		4000		4000		4000
Normalized Implementation Difficulty **			**0.13**		**0.30**		**0.50**		**0.70**		**0.85**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	PROD	Alternative B EVAL	PROD	Alternative C EVAL	PROD	Alternative D EVAL	PROD	Alternative E EVAL	PROD
Regional Goal Factors ***											
Improve Safety	100	1	100	2	200	2	200	2	200	2	200
Improve Service Level/Reduce Congestion	100	1	100	3	300	4	400	4	400	5	500
Reduce Environmental Impact	100	1	100	2	200	3	300	4	400	5	500
Enhance Goods Movement	100	1	100	3	300	5	500	6	600	7	700
Assist In Management & Maintenance of Infrastructure	100	4	400	5	500	6	600	7	700	8	800
Improve Mobility	100	3	300	5	500	6	600	7	700	9	900
Supports Off-System ITS Initiatives	100	1	100	4	400	5	500	6	600	7	700
Subtotal		**12**	**1200**	**24**	**2400**	**31**	**3100**	**36**	**3600**	**43**	**4300**
Maximum Product			7000		7000		7000		7000		7000
Regional Goal Satisfaction *****			**17%**		**34%**		**44%**		**51%**		**61%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c5.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Enhanced 800 Information
Alternative B: Interjurisdictional 800 Information System
Alternative C: System B + Individual Interface
Alternative D: System C + Traffic Prediction
Alternative E: System D + Navigation + Routing

Evaluation Table for Traffic Control Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD
Implementability Factors *					
System Cost	100	3	300	7	700
Compatibility With Existing Infrastructure	100	4	400	4	400
Risk Factors	100	5	500	7	700
Degree Of Change	100	2	200	3	300
Subtotal		**14**	**1400**	**21**	**2100**
Maximum Product			4000		4000
Normalized Implementation Difficulty **			**0.35**		**0.53**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD
Regional Goal Factors ***					
Improve Safety	100	4	400	6	600
Improve Service Level/Reduce Congestion	100	4	400	4	400
Reduce Environmental Impact	100	4	400	4	400
Enhance Goods Movement	100	4	400	6	600
Assist In Management & Maintenance of Infrastructure	100	4	400	7	700
Improve Mobility	100	2	200	6	600
Supports Off-System ITS Initiatives	100	1	100	1	100
Subtotal		**23**	**2300**	**34**	**3400**
Maximum Product			7000		7000
Regional Goal Satisfaction ****			**33%**		**49%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c6.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Signal Control
Alternative B: Signal Control + VMS

Evaluation Table for Commercial Vehicle Administrative Processes Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD
Implementability Factors *							
System Cost	100	1	100	4	400	8	800
Compatibility With Existing Infrastructure	100	1	100	3	300	4	400
Risk Factors	100	2	200	7	700	9	900
Degree Of Change	100	2	200	6	600	8	800
Subtotal		**6**	**600**	**20**	**2000**	**29**	**2900**
Maximum Product			4000		4000		4000
Normalized Implementation Difficulty **			**0.15**		**0.50**		**0.73**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD
Regional Goal Factors ***							
Improve Safety	100	1	100	1	100	3	300
Improve Service Level/Reduce Congestion	100	4	400	7	700	9	900
Reduce Environmental Impact	100	1	100	1	100	1	100
Enhance Goods Movement	100	4	400	8	800	10	1000
Assist In Management & Maintenance of Infrastructure	100	1	100	1	100	1	100
Improve Mobility	100	1	100	1	100	1	100
Supports Off-System ITS Initiatives	100	1	100	5	500	7	700
Subtotal		**13**	**1300**	**24**	**2400**	**32**	**3200**
Maximum Product			7000		7000		7000
Regional Goal Satisfaction *****			**19%**		**34%**		**46%**

*** Evaluations were scored on a 1=low/10=high scale. fig_c7.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Provide Supplemental Credential Information Only
Alternative B: Electronic Filing of Credentials
Alternative C: Alternative B + HAZMAT Permit Information on Transponder

Evaluation Table for Freight Mobility Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD	Alternative D EVAL	Alternative D PROD
Implementability Factors *									
System Cost	100	5	500	1	100	9	900	9	900
Compatibility With Existing Infrastructure	100	9	900	1	100	3	300	3	300
Risk Factors	100	0	0	4	400	7	700	8	800
Degree Of Change	100	9	900	5	500	7	700	9	900
Subtotal		**23**	**2300**	**11**	**1100**	**26**	**2600**	**29**	**2900**
Maximum Product			4000		4000		4000		4000
Normalized Implementation Difficulty **			**0.58**		**0.28**		**0.65**		**0.73**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Regional Goal Factors ***	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD	Alternative D EVAL	Alternative D PROD
Improve Safety	100	3	300	1	100	1	100	1	100
Improve Service Level/Reduce Congestion	100	7	700	2	200	5	500	7	700
Reduce Environmental Impact	100	7	700	2	200	1	100	2	200
Enhance Goods Movement	100	9	900	2	200	5	500	7	700
Assist In Management & Maintenance of Infrastructure	100	1	100	1	100	1	100	1	100
Improve Mobility	100	1	100	3	300	1	100	3	300
Supports Off-System ITS Initiatives	100	1	100	1	100	3	300	3	300
Subtotal		**29**	**2900**	**12**	**1200**	**17**	**1700**	**24**	**2400**
Maximum Product			7000		7000		7000		7000
Regional Goal Satisfaction *****			**41%**		**17%**		**24%**		**34%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c8.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Provide Staging Areas for Commercial Trucks
Alternative B: Add Credit Card Phones at Select Areas
Alternative C: Real-Time Access to Toll Records
Alternative D: Alternative B + Alternative C

Evaluation Table for Hazmat Incident Response Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD
Implementability Factors *							
System Cost	100	3	300	7	700	9	900
Compatibility With Existing Infrastructure	100	3	300	5	500	5	500
Risk Factors	100	4	400	6	600	10	1000
Degree Of Change	100	3	300	7	700	9	900
Subtotal		**13**	**1300**	**25**	**2500**	**33**	**3300**
Maximum Product			4000		4000		4000
Normalized Implementation Difficulty **			**0.33**		**0.63**		**0.83**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Regional Goal Factors ***	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD
Improve Safety	100	3	300	5	500	8	800
Improve Service Level/Reduce Congestion	100	1	100	1	100	1	100
Reduce Environmental Impact	100	3	300	5	500	8	800
Enhance Goods Movement	100	3	300	5	500	7	700
Assist In Management & Maintenance of Infrastructure	100	3	300	4	400	8	800
Improve Mobility	100	1	100	1	100	1	100
Supports Off-System ITS Initiatives	100	1	100	3	300	5	500
Subtotal		**15**	**1500**	**24**	**2400**	**38**	**3800**
Maximum Product			7000		7000		7000
Regional Goal Satisfaction *****			**21%**		**34%**		**54%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c9.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Provide Hazmat Database Access
Alternative B: Automatic "MAYDAY" to Communications Center
Alternative C: Automatic "MAYDAY" with Remote Monitoring of Load Contents

Evaluation Table for Demand Management & Operations Service

Factor	WTG	Alternative A EVAL	PROD	Alternative B EVAL	PROD	Alternative C EVAL	PROD
Implementability Factors *							
System Cost	100	5	500	7	700	2	200
Compatibility With Existing Infrastructure	100	1	100	1	100	9	900
Risk Factors	100	5	500	7	700	10	1000
Degree Of Change	100	9	900	9	900	9	900
Subtotal		**20**	**2000**	**24**	**2400**	**30**	**3000**
Maximum Product			4000		4000		4000
Normalized Implementation Difficulty **			**0.50**		**0.60**		**0.75**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	PROD	Alternative B EVAL	PROD	Alternative C EVAL	PROD
Regional Goal Factors ***							
Improve Safety	100	1	100	1	100	1	100
Improve Service Level/Reduce Congestion	100	5	500	7	700	9	900
Reduce Environmental Impact	100	5	500	3	300	3	300
Enhance Goods Movement	100	1	100	4	400	1	100
Assist In Management & Maintenance of Infrastructure	100	1	100	1	100	1	100
Improve Mobility	100	1	100	1	100	1	100
Supports Off-System ITS Initiatives	100	5	500	3	300	5	500
Subtotal		**19**	**1900**	**20**	**2000**	**21**	**2100**
Maximum Product			7000		7000		7000
Regional Goal Satisfaction ****			**27%**		**29%**		**30%**

*** Evaluations were scored on a 1=low/10=high scale. fig_c10.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: HOV Lane in Major Urban Areas
Alternative B: Off-Peak Toll Discounts
Alternative C: HOV Lane with SOV Premium

Evaluation Table for Ride Matching & Reservation Service

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD
Implementability Factors *							
System Cost	100	3	300	7	700	5	500
Compatibility With Existing Infrastructure	100	1	100	5	500	6	600
Risk Factors	100	3	300	4	400	9	900
Degree Of Change	100	3	300	5	500	6	600
Subtotal		**10**	**1000**	**21**	**2100**	**26**	**2600**
Maximum Product			4000		4000		4000
Normalized Implementation Difficulty **			**0.25**		**0.53**		**0.65**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	Alternative A PROD	Alternative B EVAL	Alternative B PROD	Alternative C EVAL	Alternative C PROD
Regional Goal Factors ***							
Improve Safety	100	1	100	1	100	1	100
Improve Service Level/Reduce Congestion	100	2	200	4	400	4	400
Reduce Environmental Impact	100	3	300	4	400	4	400
Enhance Goods Movement	100	1	100	1	100	1	100
Assist In Management & Maintenance of Infrastructure	100	1	100	1	100	1	100
Improve Mobility	100	1	100	5	500	3	300
Supports Off-System ITS Initiatives	100	5	500	3	300	7	700
Subtotal		**14**	**1400**	**19**	**1900**	**21**	**2100**
Maximum Product			7000		7000		7000
Regional Goal Satisfaction ******			**20%**		**27%**		**30%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c11.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Basic Ride Matching System
Alternative B: Ride Matching System with Real-Time Call-In
Alternative C: Advanced Ride Matching System

Evaluation Table for Traveler Services Information Service

Factor	WTG	Alternative A EVAL	PROD	Alternative B EVAL	PROD	Alternative C EVAL	PROD
Implementability Factors *							
System Cost	100	3	300	4	400	7	700
Compatibility With Existing Infrastructure	100	2	200	2	200	1	100
Risk Factors	100	10	1000	4	400	9	900
Degree Of Change	100	2	200	3	300	4	400
Subtotal		**17**	**1700**	**13**	**1300**	**21**	**2100**
Maximum Product			4000		4000		4000
Normalized Implementation Difficulty **			**0.43**		**0.33**		**0.53**

* Evaluations were scored on a 1=low/10=high scale.

** Note: Higher numbers represent more difficulty in implementation.

Factor	WTG	Alternative A EVAL	PROD	Alternative B EVAL	PROD	Alternative C EVAL	PROD
Regional Goal Factors ***							
Improve Safety	100	1	100	2	200	4	400
Improve Service Level/Reduce Congestion	100	4	400	4	400	5	500
Reduce Environmental Impact	100	1	100	1	100	1	100
Enhance Goods Movement	100	2	200	3	300	4	400
Assist In Management & Maintenance of Infrastructure	100	1	100	2	200	4	400
Improve Mobility	100	2	200	3	300	4	400
Supports Off-System ITS Initiatives	100	1	100	5	500	5	500
Subtotal		**12**	**1200**	**20**	**2000**	**27**	**2700**
Maximum Product			7000		7000		7000
Regional Goal Satisfaction *****			**17%**		**29%**		**39%**

*** Evaluations were scored on a 1=low/10=high scale.

fig_c12.wk4

**** Note: Higher percentages represent a greater satisfaction of Regional Goals (i.e. higher benefits).

Alternative A: Upgraded Travel Boards at Service Plazas
Alternative B:Telephone Link to Traveler Services Information
Alternative C: Advanced In-Vehicle System

Appendix

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HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX 0

SUBSYTEM DESCRIE'TIONS

SUBSYSTEM DESCRIPTIONS

This appendix discusses each of the recommended subsystems in turn. For each subsystem, we present the equipment involved, the proposed operation, and the communication requirements.

1.0 Highway Advisory Radio Subsystem

Equipment At each HAR transmitter site, there is a broadcast antenna, an AM radio transmitter, an HAR controller, a digital recorder that stores and plays the message to be broadcast, a silence sensor to detect malfunctions and, in a separate cabinet, a radio receiver tuned to the transmitter's frequency.

At sites near the edge of the area covered by the transmitter, but within that area, are signs with remotely controlled flashers. The flashers are on when the transmitter is broadcasting an urgent message that applies to motorists who can read the sign.

The central equipment consists of the HAR subsystem and a computer-controlled digital switch. The switch is to enable the HAR software to communicate with any selected HAR station.

Operation. An operator can record a message segment using a microphone that feeds into the HAR subsystem. That subsystem digitizes the message segment and stores it on its hard disk. The operator can then send the digitized message to one or more recorders at the transmitter site. The recorder can have several message segments stored in its memory, and play them sequentially. If a HAR station is broadcasting a three-segment message warning motorists about three separate problems, and if one of the problems clears up, the message segment about the cleared problem can be dropped, leaving a two-segment message playing. If a new problem arises that is covered by a message segment already on the HAR computer's hard disk, that message can be transferred to the HAR station's recorder and added to the segments already playing. Thus, an operator does not have to make a new recording every time he or she changes a transmitter's broadcast message; a new recording is required only when a situation arises that is not covered by a message segment already recorded.

The operator should be able to record or listen to a recorded message segment at his or her workstation. This enables the operator to play a prerecorded segment and decide whether it fits a particular situation, or whether it is necessary to record a different message segment.

As was described in previous subsections, the traffic management subsystem assists the operators when weather hazards, incidents, or unusual congestion occur. With regard to HAR, it identifies the HAR stations upstream of the problem (with the distance upstream depending on the seriousness of the problem) and determines (by consulting a database) whether there is a prerecorded message appropriate for that problem type at that location. If the database says there is an appropriate prerecorded message segment, the traffic management subsystem provides the title of the message and gives the operator the opportunity to listen to it. The operator also has the opportnnity to record a new message. Then the operator can pick from a list of HAR stations which ones should play the message. The traffic management subsystem relays appropriate instructions to the HAR subsystem to carry out the operator's wishes.

Every message segment is classified either as urgent or not. Urgent messages are to be accompanied by flashing lights on the HAR signs, so that motorists know to tune in. There may be several signs with flashers associated with a given HAR transmitter so that both directions on the Turnpike and all approach roads are covered. Each sign is controlled separately, so that motorists only see flashing lights when the message is relevant to them. When an operator directs the HAR transmitter to play an urgent message segment, the HAR subsystem presents the operator with a list of the signs for that station, and the operator must indicate which ones should flash for that particular segment. As urgent segments are dropped from a transmitter's message and new urgent segments are added, the HAR subsystem ensures that the proper flashers are on and that no flashers are on unless the message contains an urgent segment.

The HAR subsystem does not communicate directly with the flashers at the signs, but rather sends instructions to the HAR transmitter which broadcasts DTMF tones to control the flashers. The signs will be equipped with radio receivers tuned to a HAR transmitter's frequency and the receiver's audio output will be fed to a DTMF tone-controlled switch.

The audio output of each receiver goes to a silence sensor at the Communication Center. If the silence sensor detects the absence of an audio signal, it closes an electrical contact to notify the HAR subsystem of the failure. The HAR subsystem then notifies the traffic management subsystem, which issues an alarm to the operator workstations requesting confirmation of the condition. The operator responding to the alarm may listen to the audio output himself and/or contact Turnpike staff near the transmitter to confirm that it is not working. Upon receiving confirmation the traffic management subsystem notifies all workstations and the HAR subsystem that the transmitter is dead. A similar process occurs when a dead transmitter returns to operation.

The workstations' map displays have symbols for the HAR transmitters. The transmitter's symbol takes on a distinctive appearance when its message includes an urgent segment. When the user double-clicks on the symbol a pop-up window appears giving the transmitter's status (working or failed), a list of message segments currently being broadcast with urgent messages highlighted, and a list of the associated signs with the flashing ones highlighted. The user can also request to hear the audio from the associated monitoring receiver.

Communication. The digital recorders at the transmitter sites communicate with the central equipment via the Turnpike's forthcoming digital backbone. Audio signals are sent in digital form for maximum clarity. A separate point-to-point communication channel is used for each transmitter. The Turnpike's HAR plans call for all transmitters to be at interchanges, where they can directly access the backbone. The audio output of the monitoring receiver will be sent to the silence sensor and digital recorder via copper or fiber optic cable, depending on how far the receiver is from the transmitter. The communication link between the digital recorder and signs is the HAR broadcast itself.

Communication between the HAR subsystem, traffic management subsystem, cabinet telemetry subsystem, and workstations is carried over the LAN and WAN. The HAR subsystem communicates with the digital switch via a cable.

The radio receiver near the HAR transmitter is also tuned to the transmitter's frequency, but serves a different purpose than the receivers at the sign. It's audio output is fed to a device in the transmitter's cabinet called a "silence sensor" that closes a contact when no audio is received. No audio from the receiver could indicate a transmitter failure or antenna damage. When the silence sensor closes its contacts, the recorder at the transmitter site automatically notifies the HAR subsystem so that repairs can be made. The recorder can also digitize the audio from the monitoring radio receiver and send it to the Communication Center so that Turnpike staff can hear the same audio that motorists are hearing.

2.0 Incident and Work Zone Subsystem

Equipment. The only equipment in this subsystem is a processor and database that keeps track of incident and work zone information.

Operation. The subsystem keeps a record of each current work zone and incident likely to be of interest to Turnpike users. It also has information about scheduled future work zones. Most of these work zones will be on the Turnpike, but information describing work zones on other facilities may also be included. Information that would be stored includes the exact location, which lanes are closed, the expected time of reopening, and the identity of the people supplying or changing the information. Workstation software shows the location of each incident and work zone on a digital map and presents the details in a pop-up box when the user double-clicks his mouse while pointing to the map symbol. The workstation can be programmed to alert the operator each time an incident or work zone is added to or deleted from the map.

Information about work zones and incidents is entered by a user at a workstation, which relays it to the incident and work zone subsystem. The incident and work zone subsystem then broadcasts the information over the network to all workstations and the traffic management subsystem. The traffic management subsystem then determines which tools are candidates for disseminating the information. If the information is that an incident or work zone has been cleared, the traffic management subsystem identifies the devices that were displaying messages about the incident and requests permission from the operator to remove the messages.

Communication. Communication for the incident and work zone subsystem is entirely over the local and wide area networks.

3.0 Video Control Subsystem

The detailed system diagram for the video control subsystem is shown in Figure 9-3.

Equipment. At selected mainline and toll plaza locations we recommend color video cameras in pressurized enclosures. The cameras should be equipped with motorized zoom lenses and automatic iris control. The enclosures should be equipped with window defoggers. For cameras not in tunnels, the enclosures should be equipped with window wipers and sunshields.

Tunnel cameras are fixed, but each camera that is not in a tunnel should have a motorized pan-tilt drive and a camera controller that communicates with the video subsystem at Turnpike headquarters. The controller should be able to move the camera and adjust the pan, tilt, zoom and focus in response to user commands, and should be able to automatically adjust the pan, tilt, zoom, and focus to display preset views. It should also be able to sense and report the camera azimuth.

Most non-tunnel cameras will be mounted on poles (typically 40 feet high), although consideration should be given to mounting cameras atop tall buildings or the microwave towers adjacent to the Turnpike if the view would be better than that provided by a pole.

At locations where cameras are in close proximity, such as at the tunnels, the camera's video output is connected (via coaxial or fiber optic cable) to a remotely controlled video matrix switch. The switch is used to select which video is sent to Turnpike headquarters.

At headquarters, there is another video matrix switch controlled by the video subsystem. The subsystem controls the central and remote switches to route the video from selected cameras to the users' monitors or workstations. Each workstation except the operator workstations will have the capability to display a video image in a window on the screen. The operator workstations at the Communications Center will not be equipped for this; instead, each operator will have a 19" diagonal color video monitor next to his or her workstation for viewing camera pictures.

As shown in the subsystem diagram, between the switch and the monitors or workstations are titlers, which superimpose a title dictated by the video subsystem onto the video image. Between the titler and each operator's monitor is a screen splitter that permits the operator to simultaneously show pictures from four cameras, each in a different quadrant of the screen. (The screen splitter permits the operator to display a single picture full screen when desired.)

Operation. Users will select cameras to be displayed and will control pan, tilt, zoom, and focus via a control panel window on their workstations. They will be able to select preset views from a list on their screens. Users will also be able to select "tours", sequences of preset views that are displayed automatically on their workstation or monitor in an endless loop.

When preset views are displayed, the video subsystem causes the titler to display the view's title on the screen. When the picture is not a preset view, the subsystem causes the title to be the camera location and azimuth.

The video control subsystem also ensures that if a user has moved a camera, there is a delay (perhaps one minute) before another user can move the camera, so that the first user can see what he needed to see. Operators will have the capability to prevent all other users from controlling the camera when they feel they need to keep a particular scene constantly in view.

The camera controllers, video switches, and titlers all get their instructions from the video subsystem. The screen splitter is manually controlled.

Communication. The video control subsystem will communicate with the camera controllers and remote video switches using the Turnpike's forthcoming digital backbone. One multipoint RS-232 communication channel can link the video subsystem to all the camera controllers. Depending on the equipment manufacturer, it may be necessary to have a separate point-to-point RS-232 channel between the video control subsystem and each switch.

The Turnpike's digital communications backbone also carries video from remote switches or individual cameras to the Turnpike headquarters, and from the headquarters to remote workstations. Codecs are used at each end of these links to convert between analog video and a digital format suitable for transmission over the Turnpike communications backbone. If a camera or remote workstation is not at an access point to the Turnpike backbone, then microwave, cable, or leased circuits will be used to bridge the gap.

Within the Turnpike headquarters, video will be carried over dedicated coaxial cables, separate from the cables used for the local area networks. Data exchanged between workstations and the video subsystem, such as camera control commands, will flow over the local and wide area networks.

4.0 Traffic Management Subsystem

Equipment. The equipment for the traffic management subsystem consists of a processor, database, display, and software.

Operation. The role of this subsystem is to draw the operators' attention to information from the field equipment or other transportation agencies that may require action, and to recommend appropriate action. The traffic management subsystem is notified about potential problems by the weather, traffic flow, or incident and work zone subsystems. It, in turn, notifies an operator. When the operator confii that the problem requires action, the traffic management subsystem consults its database of response plans and proposes, based on the seriousness and location of the problem, how each of the following subsystems should be used: highway advisory radio; variable message signs; Travel Boards; recorded telephone messages; and fax, E-mail, beeper, and web bulletins. For each of these devices there is a library of message segments or an automated process for creating an appropriate message. The traffic management subsystem shows the operator which notification devices it proposes to use and the message that is suggested for each. The operator can approve or modify both the recommended choice of devices and the message. When the operator is satisfied, the traffic management subsystem sends the appropriate commands to the other subsystems to carry out the operator's commands. The traffic management database keeps a record of which messages were posted as a result of the problem and, with operator approval, automatically removes those messages when the problem has cleared up.

Communication. The traffic management subsystem must communicate with the various other subsystems for controlling roadside devices, including both data collection devices and information dissemination devices. Communications with the other subsystems on the same computer occurs via the operating system software. Communications with the subsystems on other computers and with the workstations occurs via the LAN.

5.0 Tunnel Lane Control Signal Monitoring Subsystem

Equipment. The equipment required for this subsystem consists of a monitoring device at each of the tunnels that registers the current indication of the existing subsystem that controls the lane control signals, and a subsystem at the Turnpike's headquarters that communicates with these units and displays the status of these indications on the graphical displays at the workstations.

Operation. The subsystem automatically monitors the status of the lane control signals at the tunnels so that their status is known at the Communication Center. When a lane in a tunnel is closed (or when two-way traffic is operating within the same tube), this information would be displayed on the VMS unit immediately upstream of the tunnel. Appropriate messages could also be displayed on other VMS units and communicated to travelers through other mechanisms, assuming that there was no higher priority message for these units. When the tunnel reverted to normal operation, a message would automatically be sent to the traffic management subsystem at the Turnpike Communication Center and this subsystem would, in turn, request operator approval to remove any messages that indicated that the lane was closed.

An indication that a lane was closed would also be sent to the VMS subsystem computer so that an appropriate message cannot be inadvertently removed from the VMS unit immediately upstream of the tunnel.

Communication. Communication between the tunnel lane control monitoring devices and subsystem would occupy a single multipoint RS-232 circuit on the Turnpike's future digital backbone.

6.0 Weather Subsystem

Equipment. The recommended roadside equipment consists of weather stations equipped with pavement temperature sensors, ice detectors, air temperature sensors, anemometers, barometers, precipitation sensors, and, where dangerous fog is a common problem, fog detectors. Central equipment consists of the weather processor or module.

Operation. The weather subsystem provides general meteorological information that can help Turnpike maintenance managers determine when to mobilize snow and ice removal crews, and where they are most needed. It can also identify specific weather-related hazards -- dense fog, high winds, icy pavement -- so that the Turnpike can warn motorists. For this reason, weather stations are often installed at locations (such as large bridges) that can be particularly dangerous in bad weather.

The workstations' map displays have symbols for the weather stations. The weather subsystem regularly broadcasts the latest data collected by each weather station, and this information appears in a pop-up window when the user double-clicks on the symbol. The weather station symbol takes on a distinctive appearance when an operator has confirmed that hazardous weather conditions exist at that site. The user has the option of having the workstation notify him or her each time a hazardous condition at a weather station begins or ends.

The weather subsystem notifies the traffic management subsystem when it detects what appear to be hazardous conditions, or when a hazardous condition appears to have ended. The traffic management subsystem then issues an alarm to the operator workstations, requesting confirmation of the condition. Upon receiving confirmation, the traffic management subsystem presents the operator with a list of the motorist information devices for which the messages could be changed to reflect the new conditions. It also notifies all workstations and the weather subsystem that a confirmed hazard exists (or has ended).

The weather subsystem also permits users to see the latest weather forecasts from the National Weather Service or Accuweather. The weather subsystem periodically calls the forecast provider and downloads the latest forecasts for locations along the Turnpike. Workstations can then download and display the forecast whenever the user so requests.

Communication. The weather subsystem communicates with the weather stations using the Turnpike's forthcoming digital backbone. One multipoint RS-232 communication channel can link the weather subsystem to all the weather stations. If the weather station is not at an access point to the backbone, then cable, radio, microwave, or leased telephone company circuits can bridge the gap. Communication between the weather subsystem, traffic management subsystem, and workstations is carried over the LAN and WAN.

7.0 Recorded Message Subsystem

Equipment. This subsystem has no field equipment. At the Turnpike headquarters, there is an automated telephone attendant that answers telephone calls from people wanting information about weather and road conditions. The recorded message subsystem at the headquarters controls the content of the messages callers hear.

Operation. By pressing telephone keys in response to prompts from the attendant, a caller indicates the desired portion of the Turnpike and the current or intended direction of travel. The attendant then plays for the user a set of recorded message segments pertaining to the road segment of interest, and then gives the caller a choice of hanging up, hearing the same messages again, or returning to the main menu to select another portion of the Turnpike.

Much like the HAR subsystem, the recorded message subsystem maintains a library of message segments that can be sent to the attendant, but it also enables an operator to record a new message if none of the recorded messages are appropriate. To avoid recording the same message twice, the operator may transfer messages from the HAR subsystem's library to the recorded message subsystem's library, and vice versa. Message segments are identified as urgent or not urgent, and whenever an urgent message is posted, it must be linked to a specific problem in the traffic management subsystem's database of current problems. That way, the traffic management subsystem can take down the messages when the problem ends.

As with the HAR messages, the messages played by the automated telephone attendant can be posted and removed by the traffic management subsystem with operator approval. The operator is given the opportunity to alter the messages or the choice of applicable roadway segments. Unlike the other devices, which normally only inform motorists about current conditions, the automated attendant also provides information about work zones or other planned events that are scheduled to be in place during the next 24 hours. The traffic management subsystem posts the appropriate messages (with operator approval) based on the schedule of future work zones in the incident and work zone database . At the time a work zone is scheduled to be taken down, the traffic management subsystem requests operator approval to remove the associated messages from the automated attendant's play list.

Communication. The automated attendant communicates with callers via telephone company dial-up lines. It communicates with the recorded message subsystem via dedicated cable. The recorded message subsystem communicates with the traffic management subsystem and workstations via the local and wide area networks.

8.0 Traffic Flow Subsystem

Equipment. The roadside equipment consists of pairs of toll tag readers, one reader on each side of the Turnpike. The pairs of readers will be spaced several miles apart, and will be used to determine the representative vehicle speed over the segments between successive tag readers. The central equipment is the traffic flow subsystem.

Operation. Approximately once per minute, the traffic flow subsystem obtains from each toll tag reader the ID numbers of all the tag-equipped vehicles that passed the reader since the last time it was polled. For each vehicle, the subsystem calculates the time since the same vehicle passed the upstream toll reader, then calculates a representative speed for vehicles driving the segment. This speed calculation excludes vehicles that apparently stopped between the tag reader locations.

The traffic flow subsystem regularly broadcasts the speed for each segment to the workstations. This enables the workstation software to produce a digital map of the Turnpike in which the color of the road segments reflect the current speed over that segment. The traffic flow subsystem also compares the speed on each segment to what is normal for that segment, taking into account time of day and speeds on adjacent segments. If the observed speed seems suspiciously low, the traffic flow subsystem notifies the traffic management subsystem. If the segment in question is not irnmediately upstream of a known incident, the traffic management subsystem then issues an alarm to draw the operators' attention to the situation.

Another function performed by this subsystem is monitoring the location of vehicles belonging to fleets that pay the Turnpike for this service. When a tag reader reports that a vehicle belonging to one of these fleets has passed it, the traffic flow subsystem sends a message to the workstation at the fleet owner's facility. The message gives the vehicle ID, tag reader location, and time of passage. Obviously, this requires the fleet owner to be tied to the Turnpike's wide area network.

Communication. The traffic flow subsystem communicates with the toll tag readers using the Turnpike's forthcoming digital backbone. One multipoint RS-232 communication channel can link the traffic flow subsystem to all the tag readers. If a pair of readers is not at an access point to the backbone, then cable, radio, microwave, or leased telephone company circuits can bridge the gap. Communication between the traffic flow subsystem, traffic management subsystem, and workstations is carried over the LAN and WAN.

9.0 Variable Message Sign Subsystem

Equipment. The roadside equipment consists of the variable message signs (VMS) and their controllers. The central equipment consists of the VMS subsystem.

Operation. The VMS subsystem has a set of sign messages stored in a database. An operator can either select one of these or create a new message. As with the HAR messages, the VMS messages must be designated as urgent or not urgent. Once the message is created or selected, the operator can select which signs the message should be posted on by picking the signs from a list. The list shows which signs are already displaying urgent messages. Before sending the messages to the signs, the VMS subsystem checks to be sure that the messages will fit on the signs, and alerts the operator if it finds a mismatch such as a three-line message going to a two-line sign.

When weather hazards, incidents, or unusual congestion occur, the traffic managment subsystem identifies the variable message signs upstream of the problem (with the distance upstream depending on the seriousness of the problem) and determines (by consulting a database) whether there is a stored message appropriate for that problem type at that location. If the database contains an appropriate message, the traffic management subsystem displays the text of that message and gives the operator the opportunity to edit it. The operator also has the opportunity to create a new message from scratch.

The signs and controllers have some self-diagnostic capabilities that enable the controller to report certain malfunctions to the VMS subsystem. The VMS subsystem then notifies the traffic management subsystem, which issues an alarm to the operator. Based on the type of problem reported (and perhaps observations of the sign made by nearby Turnpike staff), the operator responding to the alarm may declare the sign out of service. If that happens, the traffic management subsystem notifies all workstations and the HAR subsystem that the sign is out of service. A similar process occurs when a malfunctioning sign has been repaired and is ready to return to operation.

The workstations' map displays have symbols for the signs that take on a distinctive appearance when an urgent message is being displayed. When the user double-clicks on the symbol a pop-up window appears showing the sign's current message and current malfunctions, if any.

The operator can assign priority status to a message, which precludes another operator from changing the message without first removing the priority status. This precludes subsystems and other operators from replacing a message that should remain up. This feature is particularly relevant to the signs immediately prior to tunnels, where warning messages will automatically be posted when a tube is carrying two-way traffic. The interlock system posts the warning message so that an operator in the Communication Center, perhaps unaware of the tunnel situation, cannot inadvertently replace the message.

Communication. The sign controllers communicate with the VMS subsystem via the Turnpike's forthcoming digital backbone. A single multipoint RS-232 communication channel will suffice for all of the signs. If a sign is not located at an access point on the backbone, then cable, radio, microwave, or leased telephone company circuits can bridge the gap. For signs on other agencies' roads, cable is not likely to be cost-effective, but radio, microwave, and leased circuits are options. Communication between the VMS subsystem, traffic management subsystem, and workstations is carried over the LAN and WAN.

10.0 Fax, E-Mail, Beeper, and Internet Home Page Subsystem

Equipment. The only equipment in this subsystem is a processor module, which is equipped to interface with multiple dial-up telephone lines.

Operation. The operator can prepare a written bulletin and then direct the fax, E-mail, beeper, and Internet home page subsystem to distribute the bulletin to parties selected from a list presented by the subsystem. The subsystem has a database giving the fax number, beeper number, or E-mail address for each person or organization listed, and it tries repeatedly to send messages that do not go through on the first attempt. If a message has not been successfully sent within a predetermined time interval, such as twenty minutes, the subsystem alerts the operator to that fact.

If the operator selects "Web" from the list of bulletin recipients, the subsystem automatically posts the message on the Turnpike's Internet home page for the public to read. The subsystem also purges outdated messages from the home page.

Beepers will be used to alert certain people that an urgent E-mail or fax bulletin has been sent to them. This may require additional editing of the messages. At some locations, it may be more practical to have the beeper signal trigger a stationary alarm, such as a flashing light, rather than to give beepers to all the staff at that location.

As with the other notification subsystems, the traffic management subsystem assists the operator. When a problem occurs or has cleared up, the traffic management subsystem consults its database to see who should be notified for that type of problem in that location, and composes a proposed bulletin. The bulletin is simply an extract of the information reported by the incident and work zone, traffic flow, or weather subsystem about the problem. The operator has the opportunity to modify the bulletin before it is sent, and to revise the subsystem's proposed list of bulletin recipients.

Communication. The subsystem sends faxes, pager alerts, and updates to the Turnpike's Internet home page via telephone company dial-up service. In order to reduce long distance charges, some calls are routed over the Turnpike's digital backbone before being passed to a telephone company. The subsystem sends E-mail messages over the local and wide area networks, and also uses those networks to communicate with the traffic management subsystem and workstations.

11.0 Travel Board Subsystem

Equipment. The equipment at each Turnpike service plaza consists of a controller and Travel Board that includes a lighted map and information panels, variable message display, and a toll free telephone for obtaining reservations and traveler information. The central equipment is the Travel Board subsystem.

Operation. The operation of a Travel Board resembles that of an HAR transmitter, in that an endlessly repeating message can be formed from message segments stored in the Travel Board's controller. The Travel Board subsystem loads the message segments into the sign controller and tells it what sequence they should be displayed in. Messages can be stored on the Travel Board subsystem database or composed by an operator when needed. Messages must be designated as urgent or not urgent. It will also be possible to minimize the operators' work by displaying the same message on the Travel Board that is displayed on a variable message sign.

As with the HAR and VMS messages, Travel Board message segments can be posted and removed by the traffic management subsystem with operator approval. The operator is given the opportunity to alter the messages or the choice of Travel Boards.

As with the HAR transmitters and variable message signs, the workstation map display shows the location of each Travel Board, and the symbol's appearance indicates whether it is currently displaying an urgent message segment. Double-clicking on the symbol lists the titles of the segments currently being displayed, and provides the opportunity to see the full text of a selected message segment.

Communication. The Travel Board controllers communicate with the Travel Board subsystem via the Turnpike's forthcoming digital backbone. A single multipoint RS-422 communication channel will suffice for all of the Travel Boards. Communication between the Travel Board subsystem, traffic management subsystem, and workstations is carried over the LAN and WAN.

12.0 Cabinet Telemetry Subsystem

Equipment. In each cabinet housing ITS equipment will be a small uninterruptible power supply (UPS) and a telemetry unit. Larger UPSs and the same telemetry units will be at each microwave tower and other sites housing equipment essential to the operation of Turnpike's voice and data communication network. The telemetry units will sense and report cabinet temperature, power failures, open cabinet doors, low UPS batteries, and similar indicators of problems. The central equipment consists of the cabinet telemetry subsystem.

Operation. The cabinet telemetry subsystem continuously polls the telemetry units in the roadside cabinets to detect potential problems. When it finds a problem, or finds that an earlier problem is gone, it notifies the traffic management subsystem, which issues an alarm to the operator workstations. An operator can interrogate the telemetry subsystem to see the current status of any cabinet, and can also get reports helpful for troubleshooting, such as a graph of the cabinet temperature over the previous 24 hours.

Communication. The roadside telemetry units communicate with the cabinet telemetry subsystem via the Turnpike's forthcoming digital backbone. A single multipoint RS-232 communication channel will suffice for all of the cabinets. If a cabinet is not at an access point to the backbone, then cable, radio, microwave, or leased telephone company circuits can bridge the gap. Communication between the cabinet telemetry subsystem, traffic management subsystem, and workstations is carried over the LAN and WAN.

13.0 Call Box Subsystem

Equipment. The roadside equipment consists of the call boxes already in place. The central equipment consists of the call box subsystem already in operation.

Operation. Motorists in distress drive or walk to the nearest call box and push a button to summon help. The motorist has a choice of four buttons: police, fire, ambulance, or tow truck.

The call box notifies the call box subsystem of the motorist's request, and the call box's ID. The subsystem uses the ID to look up the box's location, and then immediately sends a message to an operator workstation notifying the operator of the request. When the operator acknowledges the message on his workstation, the call box subsystem notifies the box that initiated the call. The call box then displays a "message received" signal to the motorist.

Only operator workstations interact with the call box subsystem; other users find out about the incidents only when they have been confirmed and found to be affecting traffic. When that happens, the operator enters the situation into the incident and work zone database. That causes the incident to appear on the digital map displays of all workstations, and may trigger use of the notification subsystems.

Communication. The call boxes communicate with the call box subsystem using radio to reach the communication backbone, and then using the backbone to reach the Turnpike Communication Center. Communication between the call box subsystem and the operator workstations is via a local area network.

Appendix

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PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX P

PROJECT DESCRIPTIONS

PROJECT DESCRIPTIONS

INTRODUCTION

The following are a series of descriptions of the projects that are included in the ITS Strategic Deployment Plan. These descriptions are organized under the major headings associated with the functional categories that will be utilized in implementing ITS on the Pennsylvania Turnpike as indicated in the National ITS Program Plan. These are: Traffic Surveillance; Variable Displays; Individual Traveler Interface; One-Way Mobile Communications; Two-Way Mobile Communications; Stationary Communications; Traffic Control Signals; Traffic Control Data Processing; Database Processing; Interagency Coordination; and Payment Systems. Several additional functional categories have also been added as headings for other important projects. These additional categories are: Weather Surveillance; Commercial Vehicle Operations and Complementary Projects.

The descriptions of the individual projects contain the following elements: priority, prerequisites, comments, justification and (wherever possible) funding.

A **priority** of high or medium has been assigned to all of these projects. High priority projects are those that are associated with ITS User Services selected by the Turnpike for implementation in the short-term. Medium priority projects are associated with ITS User Services selected for implementation in the medium-term.

Prerequisites identify other critical projects that must be completed prior to the completion of the project that is being described.

A description of the project or some other critical aspect of the project is presented in the **comments** section.

Justification for the project is presented in qualitative terms with a focus on the user segment that will benefit from the implementation of the project.

Potential **funding** sources are also identified wherever possible.

It will be noted that many of these projects are dependant upon the implementation of a digital communication system on the Turnpike. While upgrades to the microwave system and the installation of a fiberoptic backbone are included as projects on this list, it is recognized that these projects are intended to support a wide range of the Turnpike's needs and are not solely justified on the basis of their need for the ITS projects.

Traffic Surveillance Function

Projects: Probe Vehicle Monitoring (TS10)
Priority: High
Prerequisites: Implementation of E-ZPass System (PS30) and implementation of fiberoptic network or microwave system improvements. (TW10 or SC10)
Comments: Could be tested based on implementation of E-ZPass in New Jersey (1997/98) and staged in the Philadelphia area first using data from New Jersey tags. This is similar to the Transcom's TRANSMIT project which uses New York State Thruway tags to monitor traffic flow on the northern segment of the Garden State Parkway.
Justification: Monitoring traffic flow is an essential part of most Advanced Traffic Management Systems, particularly in urban areas where drivers may have several alternate routes available. This could also be a revenue enhancement when motorists are advised to use interchanges further "downstream" because of delays at the toll plazas.

Project: CCTV Installation (TS20)
Priority: High
Prerequisites: Implementation of fiberoptic network or microwave system improvements. (TW10 or SC10)
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 back-ups 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.

Weather Surveillance Function

Project: Deploy Weather & Roadway Monitoring Sensors (WS10)
Priority: High
Prerequisites: An RS-232 link to the digital communications backbone (TW10 or SC10). Installation of VMS units, HAR or other traveler information systems are required for communicating messages to the public.
Comments: The roadway sensors are commonly installed on bridges subject to icing.
Justification: Better knowledge of weather and pavement conditions has many benefits. In the short-term, this information allows the Turnpike to conduct anti-icing and snow removal operations more efficiently by providing more precise information about when and where snow and icing conditions are expected to occur. In the long-term, snow, ice, fog, and other weather problems can be communicated to travelers before these conditions are encountered, which will reduce the number of weather-related accidents.

Project: Exchange Roadway and Weather Monitoring Information with PennDOT (WS20)
Priority: High
Prerequisites: Would be implemented via the wide area network link to PennDOT (SC10)
Comments: None
Justification: Increases the ability of the Turnpike to provide information on other roadways and may also help forecast roadway and weather conditions on the Turnpike. When snow is forecast, or has fallen, this information can be provided to drivers to help them identify routes that are open.

Variable Displays Function

Project: Provide Traffic Information on Travelboards (VD10)
Priority: High
Prerequisites: Currently implemented with a dial-up service on an interim basis. An RS-232 link to the digital communications backbone is desired in the long-term. (TW10 or SC10)
Comments: Should control both scrolling text and the light emitting diodes (LEDs) on the map which can indicate problem areas. The Travelboard subsystem should allow the display of a message developed purposes (VMS, or fax) as well as messages written specifically for the Travelboard.
Justification: This could be the first step toward implementing the En-Route Driver Information user service with elements that are (for the most part) already in existence. Real-time information on the Travelboards may also encourage drivers to stop at the service plazas more frequently, and increased revenues at the service plazas.
Financing: It may be possible to charge for the display of an event or product as part of the scrolling text. For Example: "Heavy Traffic Anticipated During Carlyle Auto Show (Dates_____) use exit ______."

Project: Variable Message Sign Installation (VD20)
Priority: High
Prerequisites: Private sector funding for ITS Initiatives (CP10) CP10 may effect the design of these units.) Implementation of fiberoptic network or microwave system improvements (TW10 or SC10).
Comments: Look for opportunities to incorporate VMS into roadway construction projects currently in design. Priorities should be: high accident locations, proximity to tunnels, and major detour routes.
Justification: Although HAR units can give extended messages, the motorist must tune into the station to receive the information. VMS units can provide a short message that will make all drivers aware of the problem.
Financing: If the results of CP10 are positive and the FHWA, PennDOT, and the Turnpike can reach a suitable agreement on the design and operational parameters, it may be possible to defray the cost of these signs by using them for both advertising and traffic messages.

Individual Traveler Interface

Project: Enhance Telephone Information System (IT10)
Priority: High
Prerequisites: None
Comments: These calls currently come in on the existing 800 exchange. This project would enhance the ability of the Turnpike Staff to handle telephone enquiries on a variety of topics by providing callers with a touch-tone selected menu for selecting the area of interest. Pre-trip and en-route information that would be provided includes: traffic, weather, work zones, routing, points of interest, restaurants and lodging, etc. Certain aspects could be implemented prior to others as funding, capabilities, sponsors, or payment mechanisms become available.
Future enhancements to the system could also include operator-assisted responses to verbal route guidance requests, and expansion of the area from which a call to this toll-free subsystem can be made.
Justification: The existing 800 information number becomes extremely busy when bad weather or accidents occur. This system would relieve the burden on the operators and would allow them to focus on callers with unique problems or requests.
Financing : In order to defray costs, the messages could include sections that were "...brought to you by..." This would be particularly appropriate for requests on hotel information and major attractions in certain areas.

Project: Establish an Internet Home Page (IT20)
Priority: High
Prerequisites: None
Comments: This home page would provide a variety of pre-trip travel information. This could include real-time information on incidents, weather, future lane closures for construction or maintenance, toll rates, information on establishing commercial accounts, Hazmat permit information and procedures, etc. When the probe vehicle subsystem is operational, real-time information on traffic flow should also be incorporated into this home page.
Justification: Provides current information to the auto clubs, businesses, traffic reporters and individual travelers. This may be particularly important to trucking companies in the winter who want to know what routes are open between New England and points west.
Funding: It may be possible to get a business that is operating on the Turnpike, or a major trip generator along the Turnpike to subsidize this project in return for an advertisement like "McDonalds's restaurants are located at Eastbound Milepost 75 and 352 and westbound milepost 328 and 78" somewhere on the page.

One-Way Mobile Communications

Project: Implement HAR System (OW10)
Priority: High
Prerequisites: Implementation of the fiberoptic communications system (SC10) or improvements to the microwave communication system (TW 10).
Comments: This system will be implemented in stages as funding becomes available. It should include appropriate signs with flashing beacons at locations on the Turnpike as well as locations on major roads leading to the Turnpike. The system could include information on PennDOT roadways as information on these facilities becomes available and a suitable agreement is negotiated.
Justification: This is one of the easiest ways to provide members of the motoring public with advanced information on travel and weather conditions on the Turnpike. The Turnpike already has some elements of the HAR system in place.
Funding: Although the Federal Communications Commission (FCC) prohibits the use of advertising on HAR broadcasts, it may be possible to appeal to major traffic generators for funds that would help defray the additional operations costs that are associated with advising travelers of alternate routes to major events at these facilities.

Two-Way Mobile Communications

Project: Digital Microwave Communications System (TW 10)
Priority: High
Prerequisites: Investigate sharing of communications system upgrades with PennDOT (IC330)
Comments: This would serve not only ITS applications but, perhaps more importantly, the two-way land mobile radio systems used by the State Police and Turnpike maintenance personnel who may be anywhere on the roadway. This system could also be used to carry digital communications between the ITS units along the roadside and the communications center. A microwave link may also be the most effective communications link for exchanging data with PennDOT, State Police and other facilities that are not on the Turnpike right-of-way. The microwave towers also offer an excellent antenna mounting location for spread-spectrum and other wireless communications to VMS that are not located along the right-of-way, and for CCTV coverage of selected areas of the roadway. The microwave system would provide a back-up communications for the fiberoptic system and vice-versa.
Justification: Many major components of the existing analog system are more than 15 years old, and are becoming increasingly difficult to maintain because replacement parts are not readily available.
Funding: It may be possible to have PennDOT participate in the funding of this system (as part of their need for statewide communications) if they can be given a performance guarantee for their portion of the communications traffic.

Project: Upgrade Communications Center with Additional Operators (TW20)
Priority: High
Prerequisites: None
Comments: Providing additional manpower with appropriate skills is an essential part of the centralized information management user service. Lack of available manpower has resulted in significant overtime expenditures for the existing personnel. More trained call-takers and dispatchers are needed. It is suggested that all new staff receive certification from an acceptable dispatcher training program. If adding new staff lines to the Turnpike's employee roster is not an option, it may be possible to add additional personnel through an agreement with the State Police.
Funding: It may be possible to lower costs by hiring additional personnel and reducing overtime hours which are paid at 50% more than the base salary.

Project: Upgrade Computer Center with a CAD/AVL System for Police and Maintenance Personnel
Priority: High
Prerequisites: Digital Microwave Communications System (TW 10)
Comments: An automated vehicle location (AVL) system automatically identifies the location of an appropriately equipped vehicle. A computer aided dispatch (CAD) system automatically identifies the units (police, maintenance, etc) that are available to respond to a call for assistance and records the activities associated with that incident.
Justification: A CAD/AVL system would allow Turnpike management personnel to know where their forces are during construction, maintenance, and snow clearing operations. It would quickly allow the communications center dispatchers to identify the police or maintenance units that are nearest the calls coming in from the call boxes. It would also simplify the dispatcher's tasks by creating an automated record of all of the events associated with a particular incident. It would provide additional security for State Police troopers by automatically giving their supervisors the location of their vehicle when traffic stops are made.

Project; Upgrade Communications to Troopers and Maintenance Personnel (TW40)
Priority: High
Prerequisites: Improvements to microwave communications system (TW10)
Comments: This project would take advantage of improvements in technology to enhance the clarity, security and privacy of communications with the State Troopers and Turnpike maintenance forces in the field. It includes the provision of additional devices for enhanced data and voice communications with these units.
Justification: The lack of available channels and the "party line" nature of the existing channels for communications with State Troopers and maintenance personnel can cause situations in which urgent messages cannot be clearly received until they are repeated several times. There are also no secure communications channels for law enforcement emergencies.

Stationary Communications

Project: Implement Fiberoptic Communications System (SC10)
Priority: High
Prerequisites: None
Comments: An agreement with the private sector for the installation of a fiberoptic backbone is currently being negotiated. It is anticipated that this system will become a reality in the near future.
Justification: In addition to the non-ITS uses of the fiberoptic network, this system will be useful for many recommended ITS initiatives. The fiberoptic network provides a convenient way of establishing a communication link with ITS devices that are deployed along the roadway, and is especially valuable for bringing back CCTV images and communicating these images with other agencies.

Project; Upgrade Local Area Network (LAN) at Turnpike Headquarters (SC20)
Priority: High
Prerequisites: None
Comments: This project forms the nucleus of the system architecture and the communications center equipment supporting the LAN at Turnpike Headquarters.
Justification: This LAN will facilitate the posting of the incident status bulletins on the existing E-mail system, which, in turn, will keep senior management and administrative personnel at headquarters better informed about the status of incidents.

Project: Upgrade Wide Area Network (WAN) (SC30)
Priority: High
Prerequisites: LAN at Headquarters (SC20), and communications upgrades (TW10 or SC10)
Comments: This project will provide the software and hardware improvements that are required to upgrade the existing WAN so that it can support the remote workstations envisioned in the system architecture.
Justification: This WAN and the remote user workstations will provide the managers of the facilities along the Turnpike with real-time information on the status of activities in their areas, as well as activities in other areas that may effect them.

Traffic Control Signals

Project: Tunnel Lane Control Signal Monitoring at the Communications Center (TC10)
Priority: Medium
Prerequisites: Digital Communications (via fiber or microwave) between the Tunnels and the Communications Center (SC10 or (TW10).
Comments: This project would provide Communication Center operators with real-time information on the operating status of the tunnels.
Justification: Real-time information on the status of the tunnel operations allows appropriate messages to be posted on VMS and HAR units upstream of the tunnel, and allows close supervision of the actual duration of these closures by local and central office supervisors.

Project: Install VMS Units Upstream of Crossovers for Tunnels (TC20)
Priority: High
Prerequisites: None (The initial implementation of these signs would be under the direct control of the tunnel operators .)
Comments: These VMS units would be located upstream of the point where vehicles are crossed over from one side of highway to the other. The objective is to provide an eye catching advance warning to drivers who may be entering this crossover area at excessive speeds, and thus improve the safety of this crossover operation.
Justification: The Turnpike has reported that there have been several head-on collisions in the areas where these crossovers take place. This could be due to a driver entering the crossover at an excessive speed. It is likely that the number of accidents in the future will increase because of the raising of the posted speed limit. Thus, some countermeasures to reduce speed in these areas appears to be warranted.

Project: Provide Automatic Truck Rollover Warning Signs at Selected Locations (TC30)
Priority: High
Prerequisites: None
Comments: This system consists of five major components: A pair of speed, weight and truck classification stations upstream of the curve; a height detector; a computer with software that calculates the truck's estimated speed at the curve, and the estimated rollover speed; and a fiberoptic sign with the message "TRUCKS REDUCE SPEED" that is activated by the computer .
Justification: The Turnpike has reported that the number of truck rollover accidents has increased markedly following the change in the posted speed limit. Some countermeasures to reduce speeds in rollover prone areas appears to be warranted.
Funding: FHWA has recently undertaken an evaluation of this system at three sites in the Washington, D.C. area. They may be willing to subsidize an additional series of test sites along the Turnpike.

Traffic Control Data Processing

Project: Install Lane Control Signal/ VMS Interconnect for Two-Way Operation (TD10)
Priority: High
Prerequisites: VMS installation at Tunnels (TC20)
Comments: Suitable software would provide "interconnect" capabilities so that appropriate warning messages would always be displayed on a nearby VMS when one tube in a tunnel is operating with two-way traffic flow.
Justification: When these VMS units are linked to the communications center, the interconnect will prevent a "Two-way traffic ahead" or "Crossover ahead" message from being inadvertently changed from the communications center.

Database Processing

Project: Imnlement Automated Coordination and Broadcast of Information on Bulletin Board, Fax, Paper, and Travel Board: etc. (DP10)
Priority: High
Prerequisites: The VMS, bulletin board, fax, pager, and Travelboard will be installed individually. The specific projects that coordinate their messages depends upon the order in which these systems are implemented.
Comments: This project would coordinate the formation of messages that are presented in a written format.
Justification: The objective is to reduce the amount of work required to create text in the various formats required by the devices that will be utilized by the communications center staff.

Project: Implement Automated Coordination of HAR and Telephone Information Messages (DP20)
Priority: High
Prerequisites: HAR (OW10) and the Telephone Information System (IT10)
Comments: This project coordinates the formation of audio messages in a manner comparable to the coordination of text messages.
Justification: This project reduces the workload for the communications center staff by eliminating the need for the separate recording of messages for the HAR and the toll-free information telephone subsystem.

Project: Establish a Hazmat Carrier Database (DP30)
Priority: Medium
Prerequisites: Although this project could proceed independently, it may be desirable to coordinate this with the improvements to the hazmat permit processing project (CV30).
Comments: This project will create a database of important information for vehicles with hazardous materials placards. This information might include the owner, exact nature of the material being shipped, 24-hour telephone numbers, existing service contracts, etc.
Justification: The objective is to gain 24-hour access to information that may be needed to expedite the safe handling of incidents involving hazardous materials. This information might be used to identify the proper response when these cargos are leaking or on fire, and preexisting arrangements by the shipper with wrecker/recovery and hazmat clean-up firms.

Interagency Coordination

Project; Check/Update Existing Broadcast Fax System (IC10)
Priority: High
Prerequisites: None
Comments: This project would check and verify the names and telephone numbers, and sort parameters used by the existing broadcast fax system to ensure that the correct telephone numbers are being called, the sort parameters that are used to select who gets the messages, etc. This should be coordinated with the commercial accounts office to make sure that every commercial account has the opportunity to get on the fax list. The project also includes a verification of the phone numbers for public agencies.
Justification: Access to the Turnpike's fax system may be of interest to firms that are considering the option of opening a commercial account. However, the phone numbers within any growing organization change periodically, and appropriate information must be incorporated into the Turnpike fax system.
Funding: This project has no capital costs, but will require a moderate level of activity by administrative support staff.

Project: Investigate Sharing of Operations Center Facilities and Personnel with PennDOT (IC20)
Priority: High
Prerequisites: None
Comments: PennDOT does not provide the continuous 24-hour operational staff coverage that is needed for the operation of ITS traveler services. It may be more cost-effective for PennDOT to subcontract the operation of selected devices and systems to the Turnpike than to staff and fund this operation independently.
Justification: It is assumed that if PennDOT gave the Turnpike the authority to operate ITS devices on PennDOT roadways it would also provide suitable funding for the operation of those devices.
Funding: This coordination project has no capital costs and nominal staff costs.

Project: Investigate Sharing of Communication Systems Upgrades with PennDOT (IC30)
Priority: High
Prerequisites: None
Comments: PennDOT is in the process of considering its needs and implementation alternatives for a statewide communication system linking all of the PennDOT districts. The Turnpike passes through almost all of these districts and the Turnpike's communication system could form a part of PennDOT's statewide system.
Justification: Compensation from PennDOT would help defray the implementation and operational costs of the fiber and microwave communications systems. Initial discussions of the costs to PennDOT for this service could be based on the rates that would be charged by private sector carriers for this service.
Funding: This interagency coordination project has no capital costs, but will require nominal activity by the engineering staff.

Project; Obtain CCTV Pictures from PennDOT Cameras (IC40)
Priority: High
Prerequisites: Implementation of the fiberoptic communications system (SC10) or improvements to the microwave communication system (TW 10).
Comments: PennDOT will have CCTV units in the vicinity of the Turnpike's Mid-County Interchange.
Justification: This interchange is near one of the high-accident locations and the images from these CCTV units may assist the Turnpike in determining the response to an incident in this vicinity and the proper message to be provided on the HAR and VMS units.

Project; Exchange Traffic Flow and Lane Closure Information with PennDOT, ODOT and N. J. Turnpike (IC50)
Priority: High
Prerequisites: None
Comments: Preliminary aspects of this project are already being pursued and implemented as part of the Information Exchange Network (IEN) that is being developed by the I-95 Corridor Coalition. However, because of the multi-State nature of the coalition, initial indications are that this network may be oriented toward interstate and other major roadways.
Justification: A system that will include data on all PennDOT roadways that serve the Turnpike's interchanges is needed. If these routes are not included in the IEN, then a supplementary system of exchanging data will be required.

Payment Systems

Project: Legislation Enabling Photobased Toll Violation Ticketing (PS10)
Priority: High
Prerequisites: None
Comments: This project would provide suitable support for the passage of legislation enabling the ticketing of automobile tag holders whose vehicles are in violation of the electronic toll collection system.
Justification: This is a prerequisite for the implementation of the E-ZPass System.

Project: Investigate and Change Restrictions on the Placement of Transponders on Windshields (PS20)
Priority: High
Prerequisites: None
Comments: This project would support appropriate changes in the laws restricting the placement of transponders on windshields.
Justification: This is a prerequisite for the implementation of the E-ZPass System.

Project: Implement E-ZPass (PS30)
Priority: High
Prerequisites: Legislation enabling photobased toll violation ticketing (PS10), and eliminating any restrictions to the placement of transponders on windshields (PS20) must be completed prior to the operation of the E-ZPass system.
Comments: This initial installation of exclusive E-ZPass toll lanes would take place on the eastern end of the Turnpike where the number of vehicles using these lanes would be augmented by vehicles carrying E-ZPass tags for use on toll facilities in New Jersey.

Commercial Vehicle Operations

Project: Make Account Information Available to CVOs (CVlO)
Priority: Medium
Prerequisites: None
Comments: A fleet operator with hundreds of Turnpike transactions every month cannot easily analyze or allocate the costs associated with individual shipments. This project would make the commercial account records electronically available to the account holders. This information could then be downloaded by the account holders and analyzed and presented in the manner that best served their needs. This type of electronic transaction information is now available from some of the major fuel suppliers indicating the date, location, and truck number that incurred the charges.
Justification: The availability of easy-to-use cost information may provide an additional incentive

for opening a commercial account for truck fleets that are considering this alternative.

Funding: The cost of implementing and operating this system should be offset by the reduced costs associated with toll payments by new commercial account holders.

Project: Make Location Information Available to CVOs (CV20)

Priority: Medium

Prerequisites: Implementation of E-ZPass (PS30)

Comments: Initially, this system would operate using the E-ZPass transponder tags that are carried by commercial vehicles. It would allow the commercial account holder to access the toll transaction records to identify when a vehicle paid a toll and exited the Turnpike. In the future, the commercial account holder could access the system to determine the most recent time that one of its vehicles passed a probe vehicle monitoring station.

Justification: Several commercial fleet operators have paid for the installation of a transponder and reader system on the Ohio Turnpike to identify when vehicles are approaching their distribution terminal.

Funding: It may be possible to incorporate a nominal transaction charge when records are accessed to help defray the costs of this system.

Project: Improve and Simplify Hazmat permit Processing

Priority: Medium

Prerequisites: None

Comments: This project would streamline the Hazmat permit process by having the truck operator or owner submit a copy of their PennDOT Hazmat permit along with any supplementary information and indemnification material that is required by the Turnpike.

Justification: The objective of the project is to reduce the amount of paperwork that must be completed by the owner and reviewed by the Turnpike. It is anticipated that the time and costs associated with the Turnpike's processing of a Hazmat permit will be decreased by simplifying the form. Simplifying the form may also encourage the purchase of hazmat permits by additional truck operators. This is also in keeping with the national desire to move toward a "paperless" record system.

Project: Identifv Private Sector Partner to Provide Truck Staging Areas Near Interchanges (CV40)
Priority: Medium
Prerequisites: None
Comments: The commercial vehicle operators and drivers expressed a desire for staging areas to help facilitate truck operations. These could range from simple parking areas where trailers and drivers could be dropped off or switched, to more elaborate truck stops offering a variety of maintenance and repair services, and amenities for the truck drivers.
Justification: Commercial vehicles are a major component of the Turnpike's customer base, and the Turnpike has exhibited a desire to satisfy the needs of these customers and provide services that are competitive with alternative east-west routes.
There is inadequate room within the existing right-of-way for constructing facilities that would serve the truck operator's needs. In addition, the changing of trailers would violate the operational control requirements of the Turnpike. It is therefore best to provide these services outside of the Turnpike, but conveniently close to the Turnpike interchanges. It should be possible for the Turnpike to identify parcels of land near these interchanges that could be purchased and/or developed with the aid of a private sector firm that would operate these facilities much the same as the service plaza operators.
Funding: The costs of purchasing these properties should be offset by the long-term revenue stream provided by these facility operators.

Project: Add Additional Pay Telephones at Selected Locations (CV50)
Priority: Medium
Prerequisites: None
Comments: The truck owners and operators commented on the need for additional pay telephones. Although a number of pay-telephones are installed near the toll plazas, these units are not popular because of their location. It is suggested that additional phones be installed in the parking lots of the service plazas, and that these units accept no coins to reduce potential vandalism.
Justification: This is another service that is desired by the Turnpike's commercial vehicle customers.
Funding: A portion of the fees collected by the phone company will be paid to the Turnpike.

Project: Incorporate Hazmat Permit Information onto E-ZPass Tag (CV60)
Priority: Medium
Prerequisites: E-ZPass Implementation (PS30)
Comments: When a Hazmat permit is issued for a particular vehicle this information would be stored in the appropriate database and the vehicle owner would be notified. When this vehicle subsequently passes through a toll plaza the appropriate information would automatically be written on to the transponder. The database would also

prompt the permit section to contact the owner when the permit was due to be renewed, and could also inform the driver by sending a coded message to the toll taker indicating that he should tell the driver that the permit is due to be renewed.

Justification: Facilitating CVO operations by eliminating the forms to be carried by the driver should be welcomed by the industry. If a majority of vehicles have their permit information encoded on the tags the toll takers will have more opportunities to ask to see the paperwork of any placarded vehicle that does not have a tag. This should increase safety, reduce the violation rate, increase compliance with the Turnpike requirements, and increase the revenues to the Turnpike.

Complementary Projects

Project: Identify Private Sector Funding Opportunities for ITS Initiatives (CP10)
Priority: High
Prerequisites: None
Comments: Opportunities for private sector funding of various ITS initiates have been discussed in each of the relevant project descriptions. These include: the "sale" of CCTV pictures to the Media (TS20); the placement of advertisements in the scrolling text of the message on the Travelboards (VD10), VMS units (VD20), the enhanced telephone information system (IT10), the Internet Home Page (IT20); and fees to major trip generators that want alternate access routes displayed (OW10).

In addition to these private sector funds, it may also be possible to obtain funds from PennDOT for use of the Turnpike's communication system (TW10) or for the operation of ITS devices on PennDOT roadways (IC20); and funds from FHWA for the truck rollover system (TC30). on the VMS units (VD20).
It must be noted that funding alternatives associated with advertising on Variable Message Signs should be discussed with PennDOT, FHWA and the private sector to make sure that the final result is acceptable to all parties.

Project: Install Incident Alert Flashers at Turnpike Facilities (CP20)
Priority: High
Prerequisites: Coordination and Broadcast of Information on Bulletin Board, Fax, Pager, and Travel Board, etc. (DP10)
Comments: This system would activate some form of flasher that could be seen from many areas within a facility to notify the Turnpike's personnel that an incident has occurred and that appropriate information is available on the local area network.
Justification: The existence of an incident may not be known by managers and administrators whose responsibilities include some element of response or interface with the public, or whose operations may be affected by the existence of the incident. The Incident Alert Flasher is a low-cost method of alerting all of these individuals of the event.

Project: Provide Additional Location Markers Between Mile Markers (CP30)
Priority: High
Prerequisites: None
Comments: This project would provide additional location markers between the existing mile markers. These may be attached to existing bridge or sign support columns, the call-boxes, or may be mounted in the same way as the mile markers. It is also important to provide these location markers on the ramps at major interchanges.
Justification: An increasing number of incidents are reported by cellular phones. However, a Good Samaritan reporting the incident may not be aware of the exact location of the incident. Misinformation about the location of the incident may lead to a delayed arrival of emergency vehicles or an error in the number of incidents that are underway in the same general area.

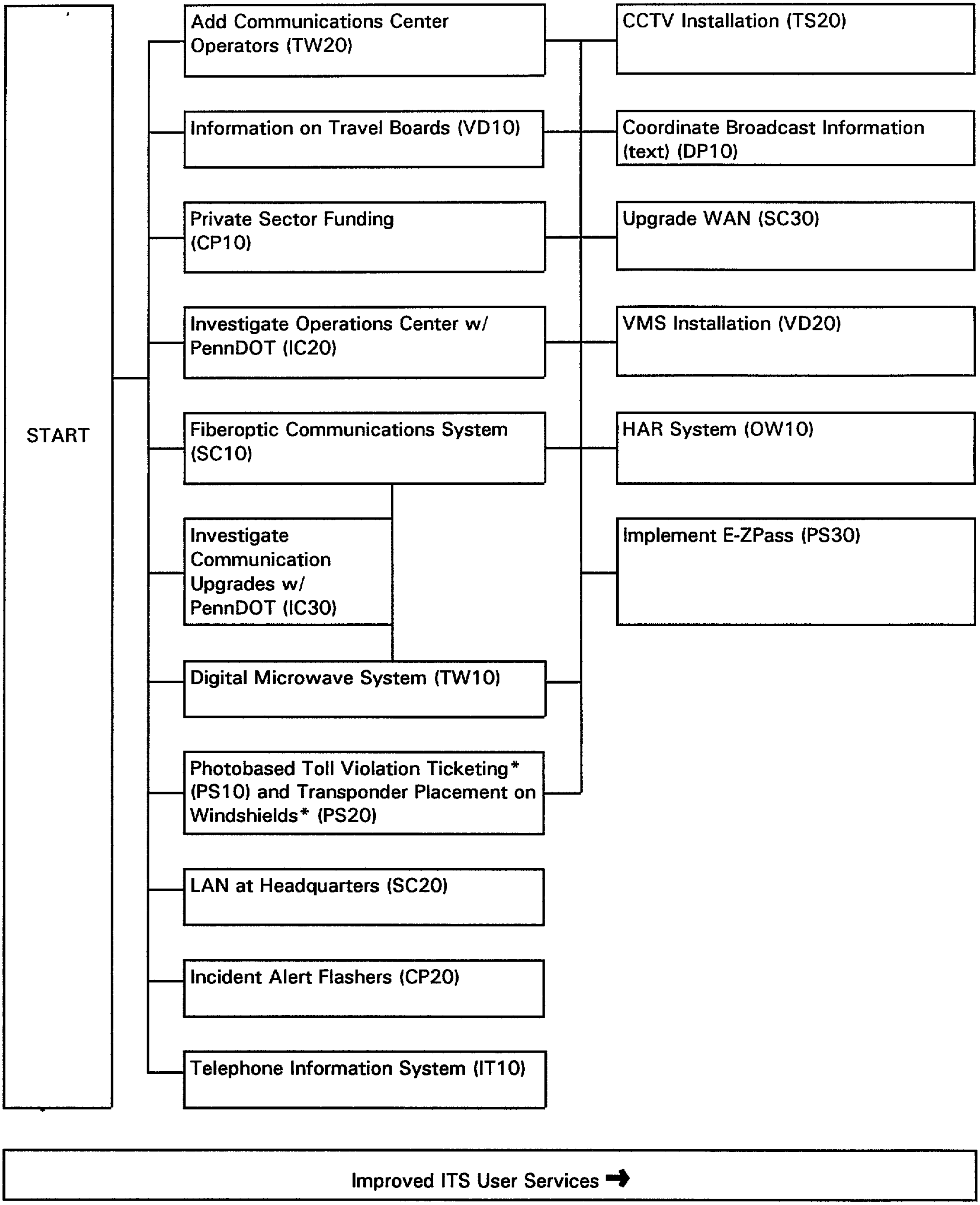
Project: Upgrade Larse Telemetry System (CP40)
Priority: High
Prerequisites: Microwave Communication System Upgrades (TW10)
Comments: Upgrades to the Larse telemetry system are necessary as an adjunct to the monitoring of field devices located near the microwave system.
Justification: faster, more cost-effective maintenance of field equipment due to better information about equipment failures.

Project; Obtain Authorization to ObtainSurcharges for Peak-Period or Short Trips (CP50)
Priority: Medium
Prerequisites: None
Comments: Increasing the capacity of the Turnpike in urban areas is prohibitively expensive. Eventually, the Turnpike may wish to implement some congestion pricing controls in order to encourage the shifting of discretionary trips to the off-peak.
In addition, since the Turnpike's costs of collecting an individual toll is relatively insensitive to the amount of the toll, the cost per mile of collecting this toll is greater for short trips than for long trips. Therefore, there is some reason to charge travelers disproportionately more per mile for short trips than for long trips.
Justification: The objective of this project is to create mechanisms that the Turnpike can use to achieve maximum utilization of the facility on a 24-hour basis and preserve capacity for long distance travel. This would be achieved by establishing surcharges and rates which would discouraging some peak period and short trips which may consume all of the available capacity in small segments of the Turnpike.

Project; Encourage Ride-Matching Activity by Others(CP60)
Priority: Medium
Prereauisites: None
Comments: The existing ride matching programs within the state eliminate the need for the Turnpike to establish its own ride matching program. However, the Turnpike can support these ride matching programs through signage programs and through appropriate recorded information on the Telephone Information System.
Funding: The costs of signage programs should be defrayed through the sponsoring agency.

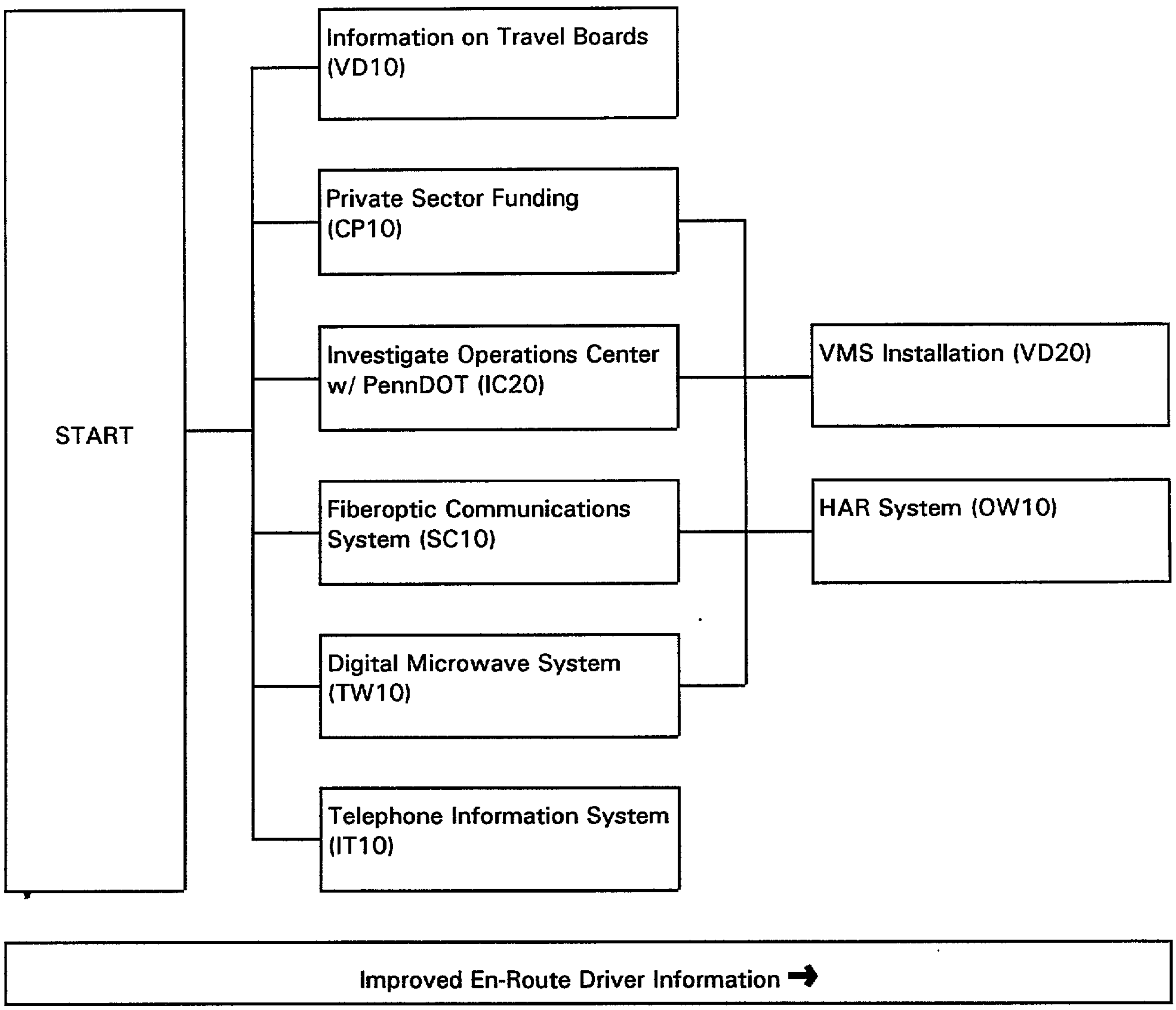
Project: Develop Automated Systems for Collecting Performance Measures (CP70)
Priority: High
Prerequisites: These measures should be considered as an element of all projects.
Comments: The ITS Early Deployment Project developed performance measures for all of the ITS User Services that are important to the Turnpike. The collection of these performance measures enables improvements in these user services to be documented. Where possible these mechanisms should be incorporated into the individual ITS projects. Elsewhere they may need to be collected separately. To the greatest extent possible these performance measures should be collected automatically.

COMPOSITE IMPLEMENTATION DIAGRAM FOR THE PREFERRED SYSTEM CONFIGURATION FOR IDENTIFIED SHORT-TERM / HIGH PRIORITY USER SERVICES

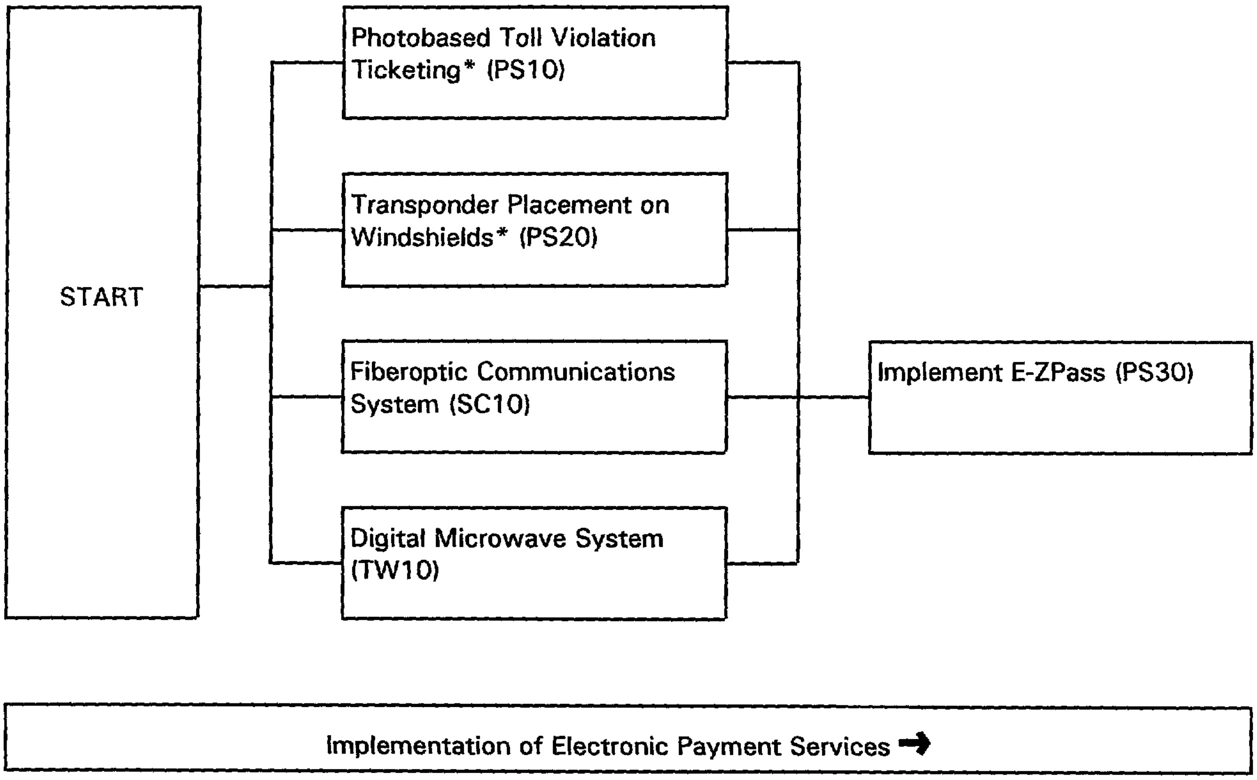


* Note Although these two projects were not identified as part of the preferred system configuration, the electronic toll collection user service cannot be implemented without them.

IMPLEMENTATION FLOWCHART FOR THE PREFERRED SYSTEM CONFIGURATION OF THE EN-ROUTE DRIVER INFORMATION USER SERVICE

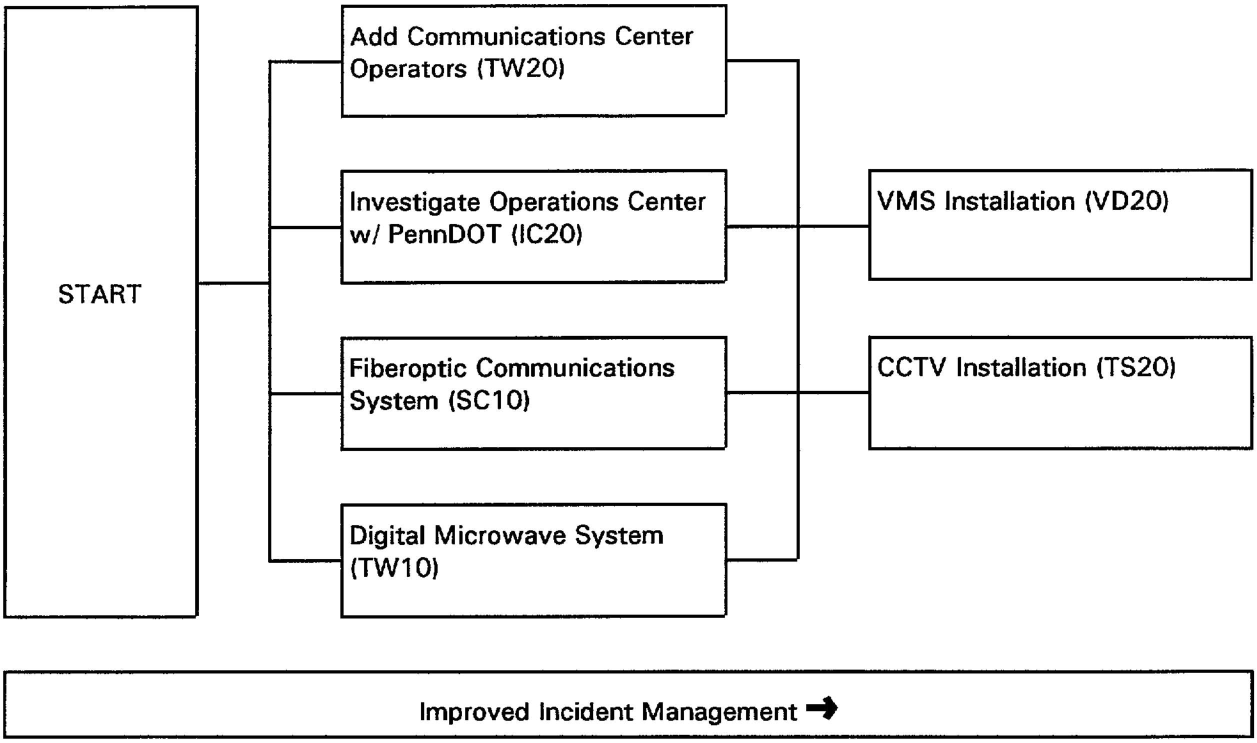


IMPLEMENTATION FLOWCHART FOR THE PREFERRED SYSTEM CONFIGURATION OF THE ELECTRONIC PAYMENT SERVICES USER SERVICE

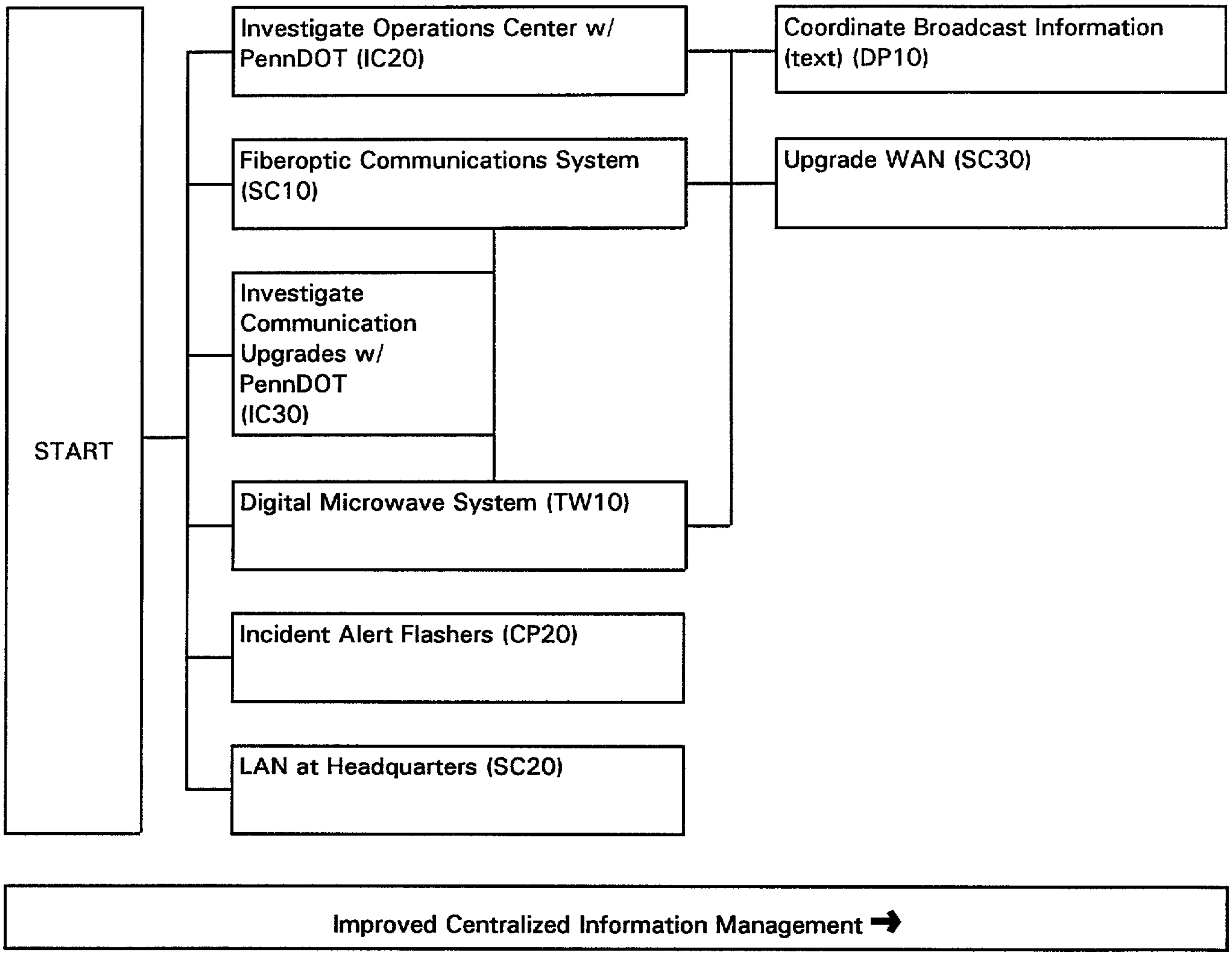


* Note: Although these two projects were not identified as part of the preferred system configuration for this user service, this service cannot be implemented without them.

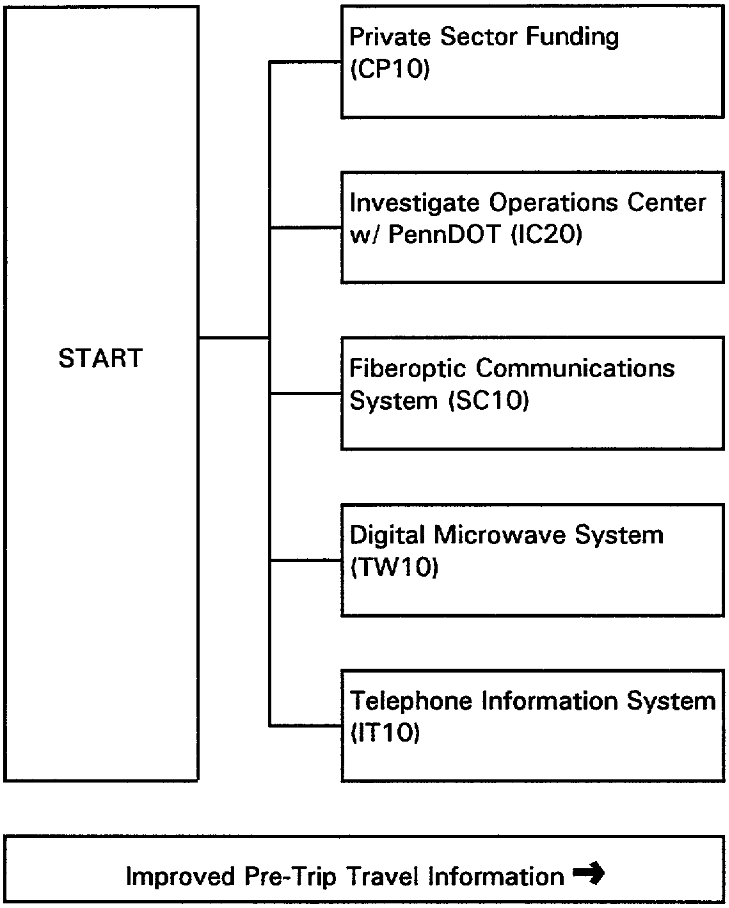
IMPLEMENTATION FLOWCHART FOR THE PREFERRED SYSTEM CONFIGURATION OF THE INCIDENT MANAGEMENT USER SERVICE



IMPLEMENTATION FLOWCHART FOR THE PREFERRED SYSTEM CONFIGURATION FOR THE CENTRALIZED INFORMATION MANAGEMENT USER SERVICE



IMPLEMENTATION FLOWCHART FOR THE PREFERRED SYSTEM CONFIGURATION OF THE PRE-TRIP TRAVEL INFORMATION USER SERVICE



Appendix

Q

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX Q

OPERATIONS PLAN CONSIDERATIONS

OPERATIONS PLAN CONSIDERATIONS

This appendix contains a series of comments on the preliminary operations plan for the ITS User Services identified in the project. This operations plan differs from others that are commonly prepared for Traffic Management Systems because of the fact that the Pennsylvania Turnpike has an existing 24-hour Management System in place as part of its incident management and fare collection activities. In addition, because of the sophisticated nature of the equipment utilized in the communications and fare collection systems, the Turnpike has already established in-house and contract maintenance procedures for these systems.

The following sections and paragraphs address operations aspects which may change because of the additional ITS related systems. Because of the presence of the existing system and the staged implementation of improvements, these changes are evolutionary in nature, and not the revolutionary changes that are commonly associated with the start-up of new traffic management systems.

1. Operations

Hours of Operation - The Turnpike already operates its communication center on a 24-hour basis.

Number of Personnel Required - The communications center has estimated that two additional people will be needed in the communications center at all times to cover the expanded operation of the HAR and improve the operation of the existing information systems. Since most people only work an eight-hour day five days a week and must also be given time off for sick leave and vacations, it will take approximately nine additional people to fill two more operational chairs in the communication center on a 24-hour basis. This request from the communications center does not appear to be unreasonable and should also accommodate the implementation of other high-priority ITS systems.

Operations Staff Skills - In order to avoid the boredom that can occur when task assignments are unchanged for extended time periods, and to provide maximum flexibility in the assignments given to the communications center staff it is recommended that all staff members be cross-trained in a variety of assignments and skills. These skills include: dispatching; call-taker procedures; and operation of the HAR VMS, CCTV units, facsimile transmissions, and other ITS equipment and systems as they become operational. In addition, since these personnel are involved with law enforcement communications and have access to confidential materials, it is further recommended they receive certification from an acceptable dispatcher training program and receive a security clearance appropriate for this mission.

Contract Operations Alternatives - Some public agencies find themselves unable to hire additional personnel because of policy or legislative restrictions upon the total number of personnel that can be employed by the agency. **Even** when this is not the case, an agency must carefully consider the alternatives of adding staff positions or obtaining this staffthrough a contract with another organization. The Turnpike's alternatives include directly hiring additional staff, obtaining dispatchers and other commum'cations center personnel through the State Police, or through a private sector firm The INFORM system on Long Island and the I-64 Traffic Management System in Virginia Beach are examples of two centers which utilize traffic engineering consultants to operate their systems.

The disadvantages of this type of contract with the private sector are:

Procurement must follow procedures - These contracts must follow the procurement guidelines and procedures of the agency, and will require administrative efforts during the procurement process.

The potential liabilitv of the parties must be addressed - The liability for actions taken by the contract staff must be resolved prior to their participation in the operation of the system

The authoritv of the contract staff must be established - Depending upon the nature of the support activities, situations may arise in which contract staff at the communications center are directing the activities of Turnpike personnel in the field. The authority of the contracted staff to direct these activities must be clearly identified, along with procedures for resolving disagreements between contractor and Turnpike personnel.

The advantages of this type of contract include:

Known costs - The contract specifies the number of staff and the hours of operation. Although some cost provisions for overtime are included, these are included in the cost estimate. There is no commitment to a pension or retirement fund, or other long-term financial obligation.

Consistent staffing levels - The contract can require that the contractor provide suitable trained staff to cover periods when a regular staff member is on extended leave because of vacation or illness, or during periods of transition after a regular staff member has resigned or been terminated.

Performance motivation - Contracts are procured periodically for a fixed term and prior performance can be a major factor in the selection process. During the contract replacements can be requested for regular staffmembers whose performance is not acceptable.

Availability of on-call expertise - The contract can also contain provisions for obtaining additional expertise on short-notice to support the operation of the communications center and its related systems.

2. Maintenance

Maintenance activities of the Turnpike's existing systems are currently divided between Turnpike personnel and outside contractors. This division of responsibilities has worked well for the Turnpike and has enabled them to keep their systems working at a high performance level. It is anticipated that this division of maintenance responsibilities will continue to exist in the future as additional ITS elements are incorporated into the Turnpike's operations.

3. Office and Maintenance Facility Space

The communications center is already operating in cramped quarters in the basement of the Turnpike's Admin.&ration building. This lack of available space will be felt even more acutely as additional ITS systems and devices are installed in the field. Discussions concerning new and expanded quarters for the commum'cations center were underway at the beginning of this ITS Deployment Study and are currently being studied. The critical element is the realization of the inadequacy of the current space by all levels of the Turnpike's management structure.

The control center that is currently being planned for the Penn Lincoln Parkway near Pittsburgh will be approximately 4,900 square feet in size. Although this center is not exactly the same as the expanded communications and control center that would be needed for the Pennsylvania Turnpike, it does provide a yardstick for comparisons. This estimate for the Penn Lincoln's control center includes a lobby and reception area, hmch room, rest rooms, and other areas that duplicate area needs that are served by other space in the existing Turnpike building. In general, approximately 1/3 of the space requirements are served by these other spaces within the Turnpike's Headquarters.

It is strongly recommended that discussions with PennDOT and Troop H of the State Police take place regarding the potential of joint use of any new facility before the design of any new Turnpike commum'cation center is finalized

4. Annual Budget Elements

A recent survey of Transportation Management Centers conducted by the "Urban Transportation Monitor" revealed that the average operating and maintenance budget was on the order of 2.1 million dollars. The individual values ranged from a low of $250,000 for a small part time operations center serving a single interchange in south Florida, to a high of $10 million for the Los Angeles Traffic Management Center which operates on a full time basis.

Because of the variability in the size of the area encompassed by these management centers, the number and extent of the monitoring systems utilized by the staff, the operational responsibilities of the staff, and the number of hours that these systems are operated at full and reduced staffing levels, it is not possible to directly associate the operational costs of these systems with their capital costs.

Operations Personnel - The communications center has estimated that the additional personnel cost of the nine additional positions that have been requested is in the order of $360,000. This will allow two additional people to be in the communications center around the clock. The number of personnel assigned to the communications center has remained constant over many years in spite of the increase in activity that has occurred. Data from the communications center indicates that this increased workload is accomplished through the provision of a significant amount of overtime by the existing personnel. The amount of overtime hours logged by the current staff is estimated at the equivalent of three or four additional full time positions.

Personnel Maintaining ITS Hardware - Maintenance activities by Turnpike personnel should also be expected to increase when ITS elements are deployed. It is reasonable to assume that maintenance of most of the electronics systems may be performed by a private contractor. Routine cleaning and maintenance of the hardware, mechanical, and electrical elements of the ITS units are consistent with the capabilities of the existing Turnpike personnel. These maintenance activities are many and varied, but would include items such as: cleaning of transparent front panels and lamp replacement in VMS units; cleaning the glass on CCTV enclosures, lubrication of their pan-tilt units, and replacement of CCTV units damaged by lightning; replacement of flashing bulbs on HAR alert signs; etc.

Software Maintenance - Software systems are never truly complete and periodically require maintenance. This maintenance might include modifications to correct for: bugs in the existing software, the incorporation of new capabilities into the software, and the integration of the software from two separate systems. Whether this maintenance is performed by Turnpike personnel or contracted out to the private sector, there is no doubt as to the need to perform this maintenance activity.

Contract Maintenance - As indicated in the previous paragraphs, the maintenance of electronic systems is likely to be performed by a private sector contractor and the system software may also be performed by a private contractor. The extent and expense of these efforts cannot be determined until the exact systems that will be deployed are determined. The Turnpike has already established contract maintenance agreements and is familiar with the benefits of performing this work through an outside contractor.

Computers and Networks- Most of the proposed subsystems that were identified in the system architecture were identified as elements that would be operating on a multi-tasking computer systemlinked together through a network server. It is anticipated that these units will be considerably less expensive to operate and maintain than a traditional mainframe computer, but monthly budgets for their maintenance must also be established.

Communications - The Turnpike has considerable experience maintaining their existing microwave equipment and can reasonably estimate the expenses associated with these systems. Maintenance costs for the fiber optic communications system is heavily dependant upon the nature of the agreement with the private sector organization that is providing this service. The agreement may be for "dark fiber" in which case the Turnpike must maintain all of the electronics equipment associated with the communication system, or the agreement may provide guarantees for a particular quantity of "bandwidth" between designated points. In this latter case the private sector firm would be responsible for maintaining all of the electronic equipment between these points.

Replacement - Most electronic systems become obsolete within a period of seven to ten years. After this time the technologies that were used are one or two generations out of date, and parts and equipment required for maintenance become hard to find and unreasonably expensive. On the positive side, electronic equipment is one of the few items that decrease in cost over time, and the cost of an equivalent replacement is likely to be substantially less than the price of the original equipment. An account for the replacement of major systems should be established and money should be allocated to this account on an annual basis.

5. Alternative Procurement Techniques

There are a multitude of contracting procedures that could be used to implement the Turnpike's ITS initiatives. These include:

Sole-Source Procurement - where an item is selected for purchase on the basis of prior experience with that particular manufacturer This is often the case when the procurement is an extension of an existing system or must closely interface with existing equipment that was previously obtained from that provider. Because of the additional expenses that are often incurred when material from different providers must be made to work together, this is often referred to as the "best buy" approach.

Low-Bid Against a Detailed Design - is the most common form of procurement. From the agency's viewpoint, the design and technical specifications govern the minimum acceptable form of the item to be procured. However, from the provider's perspective these materials can be perceived as dictating the maximum acceptable form of the product.

Two-Step Procurement - is useful when items from several vendors may be used and the agency is looking for competitive bids from the best of the alternative providers. The first step in this process is to obtain references and qualifications from all of the providers. The field is then narrowed to the preferred providers who participate in the second step of this process, which is a Low-Bid Against a Detailed Design.

System Manager - is an approach that is often used on complex projects where items from different providers must be integrated together into a cohesive working unit. A firm is selected to performthe design and after this design has been approved by the public agency, that firm procures the equipment and systems from the vendors and makes sure that these systems are properly integrated together. However, physical construction activities are undertaken by a firm (who may be selected on a low-bid basis) that has a separate contract with the public agency.

Design/Build - is similar to the system manager approach but in this case all purchase and contractual activities, including the construction contract, are handled by one private sector firm This approach gives total responsibility to that firm.

The factors that govern the selection of a procurement approach on the Pennsylvania Turnpike are: the requirement for phased construction - different ITS items will be added to the system as funding becomes available; and the presence of existing systems in the communications center that must be integrated into an "evolving" system In addition, the staff of the Turnpike includes many sophisticated professionals who have detailed knowledge of their existing systems and the alternatives that are available. These factors make the system manager and the design/build procurement approaches inappropriate.

The recommended approach is a mix of the two-step procurement for new systems, and a sole-source procurement for expansions and enhancements of the existing systems.