Northern Virginia
Intelligent Transportation System (ITS)
Early Deployment Study

Final Report:
Strategic Deployment Plan

May 1996

prepared by
De Leuw, Cather & Company of Virginia

in association with
Allied Signal Technical Services Corporation
George Mason University
A/E Group, Inc.

ACKNOWLEDGEMENT

This document has been prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration, and the Virginia Department of Transportation.

In addition, the Consultant wishes to acknowledge the prior efforts of transportation agencies and organizations having a role in transportation in the Northern Virginia Region. The findings of the Consultant, through the performance of project tasks relating to transportation inventory and documentation review, indicates that substantial documentation exists specifically pertaining to the region's infrastructure improvement policy goals and objectives and current problems that these goals and objectives have been established to address.

Portions of the region's documents have been used in this plan. A reference list of these documents is provided in Appendix A.

DISTRIBUTION OF REPORT

This final report is the strategic deployment plan for the Northern Virginia Region and is a supplement to the Interim Report: *User Service Plan* distributed in January 1996 and a complement to the Final Report: *ATMS Implementation Plan* of April 1996. This plan's primary purpose is to provide the region with a strategy for the implementation of ITS, and a "road map" for the integration of the ITS components, in order for the full potential of ITS to be realized.

Distribution of this report is being made to the Federal Highway Administration and the Virginia Department of Transportation. Any subsequent distribution of the this report will be at the discretion of the Virginia Department of Transportation.

EXECUTIVE SUMMARY

PURPOSE OF PLAN

The development of an Intelligent Transportation System (ITS) Strategic Deployment Plan is intended to provide the foundation for the integration of ITS applications within the transportation infrastructure and enhance the potential for effective system improvements through evaluation of the key transportation issues facing the region. For this study, ITS is defined by the following:

> "Strategy to assess the potential for advanced technology applications to address transportation system needs and improvement opportunities . . including applications not directly linked to the transportation infrastructure."

Simply stated, the purpose of the Northern Virginia ITS Strategic Deployment Plan is to apply the stated strategy.

NEED FOR COORDINATION

Many governing transportation policies for the Northern Virginia Region have yet to fully consider and formally incorporate the applications of advanced technologies – known as ITS – into the regional transportation policy structure. In addition, there is a growing recognition of the interdependencies of transportation improvement financing, land use and transportation relationships, congestion and air quality, coordination of transportation modes, and the place of strategies to manage the overall demand for travel, not only within the Northern Virginia Region, but on an interregional basis, as well. The evaluation structure used under this study is formulated to enhance transportation improvement coordination and cooperation, based on the integration of the ***adopted*** regional transportation policy goals and objectives with potential ITS opportunities in the region's multi-jurisdictional and multi-modal environment.

DEPLOYMENT VISION

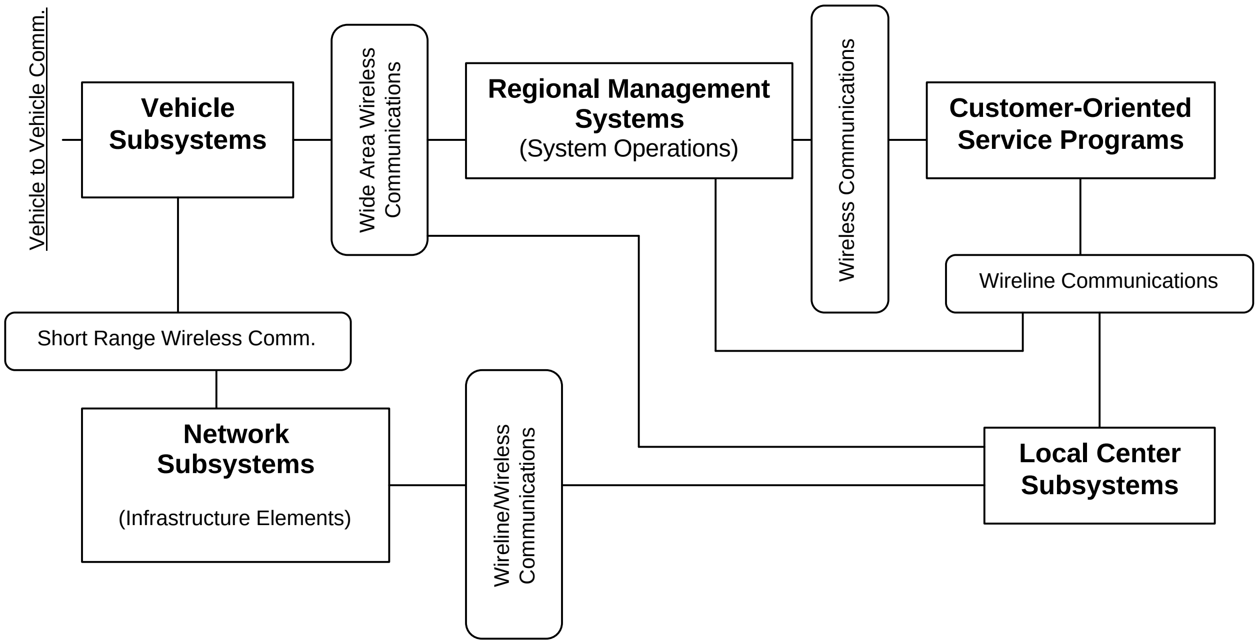
Simply stated, the vision for regional ITS deployment is total transportation management capability. The vision is multi-modal in appearance with respect to information processing requirements, including process integration for traffic management, emergency services, public transportation management, and traveler information services. Interface requirements with programmed commercial vehicle operations initiatives are also included. The analysis of the communication system requirements identified a need to establish a wide-area-network (WAN) interconnecting the existing operations centers in the region for peer to peer information exchange. This study concludes that a network-level management function is required for a successful, long-term program and is recommended to provide centralized coordination through a regional Transportation Management Coordination Center (TMCC). The term “center” relates only to the functionality of the total transportation management system. The architecture recommended for the regional ITS infrastructure provides for distributed data processing and control, therefore, management responsibilities can be similarly distributed on the WAN to any number of operating entities. The vision also maximizes the utilization of the existing and available communication infrastructure for the backbone interagency communications system, maintaining each individual agency’s current level of autonomy, unless otherwise agreed upon for a particular need or circumstance.

The vision offers opportunity for each agency to maximize its benefit in actively participating through economies of scale. Privatization, government decentralization, and general downsizing trends in the public sector will further influence future decisions regarding agency coordination and collaboration. As ITS evolves with the economic environment and business culture of the region, numerous co-location and resource sharing opportunities are anticipated with respect to traffic control and public transportation management services. This trend is currently being experienced in the region and activities in this area are expected to accelerate over the near-term (1-3 year) time frame. The implementation strategy, systems architecture, and supporting elements are configured to address these trends. Most importantly, it provides a resource to the individual agency and will present opportunities to reduce annual operating expenses while providing enhanced transportation services to the users in their jurisdiction.

PROGRAM STRUCTURE

Overcoming credibility problems with existing operations and improving public image of the primary transportation service providers through improved service reliability are noted as key factors to a successful regional ITS deployment in Northern Virginia. Accordingly, the near- and mid-term projection for ITS user services deployment is envisioned to integrate the primary service providers, both public and private, for transportation in the region.

The ITS deployment windows of opportunity adopted by this report are: near-term (present-1999); mid-term (2000-2005); and long-range (2006-2012). A phased implementation plan is recommended, integrating the ITS user service deployment recommendations with a logical sequence of improving the operational efficiency of the transportation system. The cornerstone of the improvement recommendations is the establishment of a communications architecture that identifies the basic functional, deployment, and institutional characteristics for the Northern Virginia system. The illustration below identifies the major subsystems envisioned for the region. A more detailed evaluation of this recommendation is presented in Section 5.0 of this report.



Communications Architecture

BENEFITS AND COSTS

While the total picture remains unclear regarding how ITS user services deployment will relate to all transportation needs, partial results are available from early ITS projects and related deployments. Significant benefits have been recorded in areas such as accident reduction, time savings, transit customer service, roadway capacity, emission reduction, fuel consumption, vehicle stops, etc. Analysis and simulation based on limited tests have predicted even greater potential for benefits with more extensive deployment of more mature products and total transportation management approaches, such as recommended for the Northern Virginia Region.

Based on available data with respect to benefits and costs, minimum estimated annual benefits for the region total $161,092,560 while the estimated annual costs over a service-life cycle of 15 years is $41,645,000. These estimates yield a minimum system-wide Benefit/Cost Ratio of approximately 4:1 for region-wide, integrated ITS deployments. Utilizing the evaluation methodologies described in this report, the actual measured benefits/cost ratio is anticipated to
be significantly higher when more comprehensive datas is available for use in the analysis.

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

TABLE OF CONTENTS

Page

PART II -- STRATEGIC DEPLOYMENT PLAN

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF FIGURES

LIST OF FIGURES

Page

LIST OF TABLES

Page

SECTION 1.O INTRODUCTION

1.1 PURPOSE OF PLAN

The Northern Virginia Region, Figure 1.1, is one of the most vital urban areas adjacent to Washington, D.C. The economy has experienced dramatic growth the past two decades with the future holding more of the same, continued growth in economy and accompanying congestion. Significant resources have been invested in the transportation infrastructure and services that have been regarded as among the best in the country, however, congestion and related problems have become progressively worse with the growth of traffic and demand for improved public transportation services outpacing the programmed expansion of the transportation network.

The development of an Intelligent Transportation System (ITS) Strategic Deployment Plan is intended to provide the foundation for the integration of ITS applications within the infrastructure and enhance the potential for effective transportation infrastructure improvements through evaluation of the key transportation issues facing the region. To accomplish this, first and foremost, ITS must be defined in a context that has specific relevance to the Northern Virginia Region. For the purpose of this study, ITS is defined by the following:

> "Strategy to assess the potential for advanced technology applications to address transportation system needs and improvement opportunities . . . including applications not directly linked to the transportation infrastructure."

Simply stated, the purpose of the Northern Virginia ITS Strategic Deployment Plan is to define the stated strategy. This plan highlights the principal topics that are more fully developed and supported in the body of the Interim Report: User Service Plan and Final Report: ATMS Implementation Plan.

1.2 POLICY COMPLIANCE

Current national legislation mandates that existing transportation infrastructure expansion and enhancement conform to the national policy of the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA). The Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 set out national transportation goals and compliance guidelines, at both the state and regional levels.

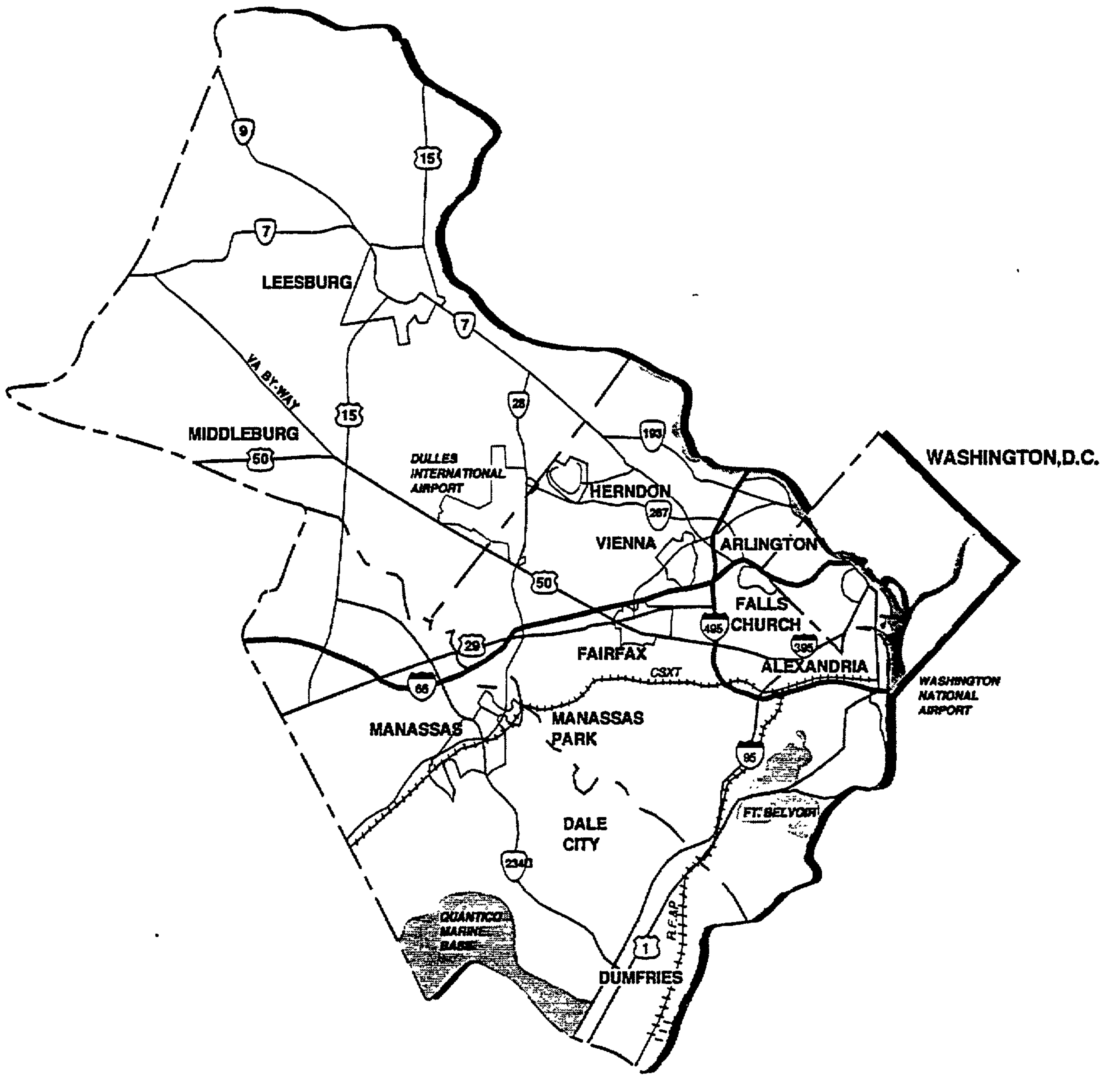


Figure 1.1 - Northern Virginia ITS Early Deployment Study Area

A key to meeting these goals is the formulation of long-term management programs and deployment measures for ITS. In comparison to the ultimate vision of ITS on a national level, most deployment initiatives remain in their developmental stages. In this dynamic state, many governing transportation policies for the Northern Virginia Region have yet to fully consider and formally incorporate the applications of advanced technologies – known as ITS – into the regional transportation policy structure. For this reason, a multi-agency analysis is required to more reasonably identify the extent to which existing policy compliance is achieved by the findings of this study and the extent to which the findings of this study may impact or have significant influence on future transportation policy in the region. For Northern Virginia and the purposes of developing this Strategic Deployment Plan for the region, the adopted transportation policies contained in the referenced documentation represent four policy levels for evaluation of the applicability of ITS technologies and subsequent user services. The correspondinglevels are national, state, regional, and local. [ref: Northern Virginia ITS Early Deployment Plan Interim Report: *User Service Plan*]

1.3 NEED FOR COORDINATION

Given the complexity of the region's existing transportation facilities and services, significant institutional and technical issues are driven by the increasing interdependence on interregional coordination of transportation improvement financing, land use and transportation relationships, congestion and air quality, coordination of transportation modes, and the place of strategies to manage the overall demand for travel, not only within the Northern Virginia Region, but on an interregional basis, as well. For the purpose of this study, interregional is defined as the relationship between the Northern Virginia Region, otherwise known as the Northern Virginia District of the Virginia Department of Transportation, and the remaining sub-regions of the National Capital Region, namely: the District of Columbia; and Montgomery, Prince Georges, and Frederick Counties of suburban Maryland. The geographical relationship to the Northern Virginia Region to these sub-regions is shown in **Figure 1.2.**

The key to success in addressing the complex transportation issues facing the Northern Virginia Region is the fundamental recognition that strategic planning for ITS deployment requires a multi-faceted approach to transportation management. A number of key transportation challenges for the National Capital Region are identified in **Table 1-1.**

With the provisions of the current long-range plan, most of the transportation revenues during the next 25 years are anticipated to be devoted to operating and maintaining the current roadway system and transit services. Fewer construction projects are in the long-range plan than previous years, and most of them involve improving existing facilities rather than building new ones.

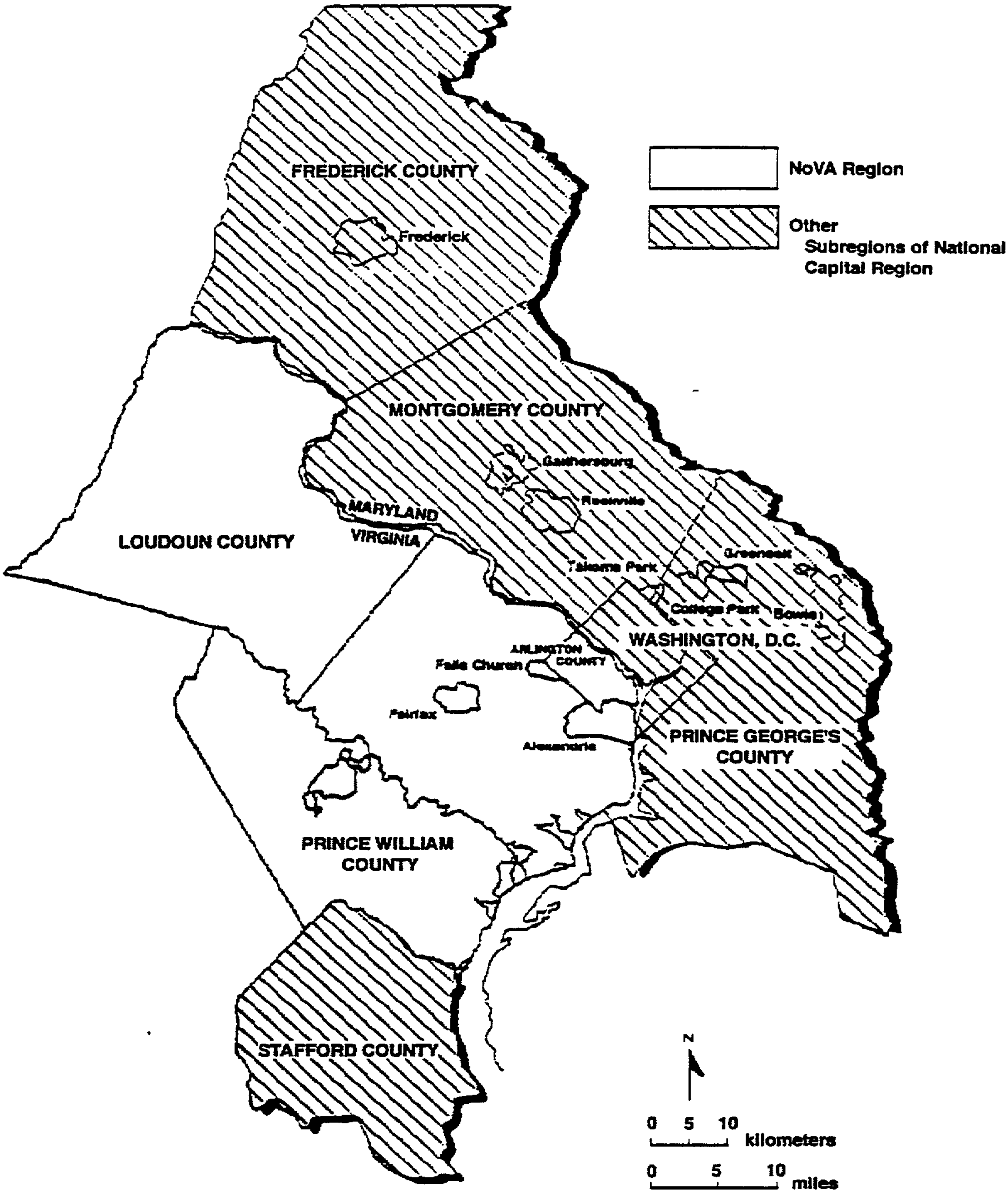


Figure 1.2 - Geographic Relationship of Northern Virginia Region to the National Capital Region

In consideration of this projection, the Northern Virginia ITS Early Deployment Study is a critical link in the development of an effective methodology to identify and assess the potential regional surface transportation priorities that can be addressed by the application of ITS technologies.

TABLE 1-1
FUTURE TRANSPORTATION CHALLENGES
FOR THE NATIONAL CAPITAL REGION

- Increasing public awareness about transportation issues and alternatives.
- Finding new ways to integrate land development and transportation investments and to achieve both large-scale development patterns and individual site designs that support walking, bicycling, and transit use;
- Developing transportation facilities and services that will serve existing dispersed development patterns without encouraging growth in solo commuting;
- Developing new strategies for managing traffic, including considering the role for disincentives to auto use, such as road pricing and parking pricing;
- Increasing coordination among different travel modes, such as highway, rail, bus, HOV, and bicycle/pedestrian options;
- Considering the opportunities offered by new technologies, including those that may become available early in the 21st century;
- Developing transportation services that will meet the needs of the region's increasing diverse population, including low-income households, children, and the elderly;
- Addressing the special issues and needs of freight transportation;
- Achieving consensus on funding levels and priorities for the region's bicycle facilities;and
- Identifying additional transportation revenues to address these challenges and to build, operated, and maintain the new facilities that will be included in future plans.

Source: *Long-Range Transportation Plan for the National Capital Region,* September 1994

To emphasize the growing need for enhanced coordination, **Table 1-2** summarizes the recommended objectives for continuing interagency coordination. The success of the development and implementation of a program for early deployment of ITS, and ultimate integration with the national ITS Program for the region, will rest on the degree to which these coordination objectives are met.

TABLE 1-2
COORDINATION OBJECTIVES

- Reach a consensus on regional ITS program goals and objectives;
- Define stakeholders, their roles, and key areas of contribution;
- Accurately evaluate customer-interface options in an ultimate, services-based business environment;
- Achieve universal recognition of the aggregate benefit of a “coalition approach” to addressing regional transportation issues;
- Reach a consensus that both the transportation (service) provider and the customer are the user...and that benefits accrue to both;
- Develop an effective, continuing regional information exchange program to perpetuate coordination efforts in the region.

1.4 APPROACH AND METHODOLOGY

The initial approach to the comprehensive understanding of the context of this strategic deployment plan is to present some background and conceptual information to the reader. Many of the concepts, briefly presented here and in more detail in the Interim Report: *User Service Plan* and Final Report: *ATMS Implementation Plan,* are new to the transportation industry of Northern Virginia. Recent technological advances along with the comprehensive national program and the dedication of many expert professionals in the field will ensure the success of the regional ITS Program deployment methodology.

1.4.1 User Services Approach

As development of the National ITS Program Plan progressed, a shift in the program occurred, a shift that emphasized the importance of the dependence of the interrelationship of various transportation modes. The sharing of common system characteristics and features among the core ITS application areas became even more prevalent in developing an intermodal ITS deployment strategy.

As stated in the *ITS User Services Summary* prepared by the FHWA, a user service approach was adopted to more adequately address the interdependencies of each of the primary applications areas identified for emerging ITS technologies. The individual user services are building blocks that may be combined for ITS deployment in a variety of fashions. The combination of service deployment recommendations for any given region then becomes dependent on local priorities, identified infrastructure improvement needs, and local market needs. For example, a single user service will usually require several technology applications for deployment, such as advanced communications, mapping, and surveillance, which may be shared with other user services or primary application areas. The commonality of technological functions is one basis for the suggested bundling of services.

For the purpose of this introduction to the approach and methodology used for the development of this report, the primary function of each individual user service is presented in **Table 1-3.** These are excerpted from the FHWA's summary. [Detailed plans for each user service and supporting technology functions are provided in Volume II of the *National ITS Program Plan.* This document will provide the reader an in depth understanding of the user services approach to ITS planning and deployment.]

TABLE 1-3
PRIMARY FUNCTIONS OF ITS USER SERVICES

1. **En-Route Information**
   Provides driver advisories and in-vehicle signing for convenience and safety.
2. **Route Guidance**
   Provides travelers with simple instructions on how best to reach their destinations.
3. **Traveler Services Information**
   Provides a business directory, or "yellow pages," of service information.
4. **Traffic Control**
   Manages the movement of traffic on streets and highways.
5. **Incident Management**
   Helps public and private organizations quickly identify incidents and implement a response to minimize their effects on traffic.
6. **Emissions Testing and Mitigation**
   Provides information for monitoring air quality and developing air quality improvement strategies.

7. Pre-Trip Travel Information

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

8. Ride Matching and Reservation

Makes ride sharing easier and more convenient.

9. Demand Management and Operations

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

10. Public Transportation Management

Automates operations, planning, and management functions of public transportation systems.

11. En-Route Transit Information

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

12. Personalized Public Transit

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

13. Public Travel Security

Creates a secure environment for public transportation patrons and operators.

14. Electronic Payment Services

Allows travelers to pay for transportation services electronically.

15. Commercial Vehicle Electronic Clearance

Facilitates domestic and international border clearance, minimizing stops.

16. Automated Roadside Safety Inspection

Facilitates roadside inspections.

17. On-Board Safety Monitoring

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

18. Commercial Vehicle Administrative Processes

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

19. Hazardous Material Incident Response

Provides immediate description of hazardous materials to emergency providers.

20. Commercial Fleet Management

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

21. Emergency Notification and Personal Security
Provides immediate notification of an incident and an immediate request for assistance.

22. Emergency Vehicle Management
Reduces the time it takes for emergency vehicles to respond to an incident.

23. Longitudinal Collision Avoidance
Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.

24. Lateral Collision Avoidance
Helps prevent collisions when vehicles leave their, lane of travel.

25. Intersection Collision Avoidance
Helps prevent collisions at intersections.

26. Vision Enhancement for Crash Avoidance
Improves the driver's ability to see the roadway and objects that are on or along the roadway.

27. Safety Readiness
Provides warnings about the condition of the driver, the vehicle, and the roadway.

28. 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.

29. Automated Highway Systems
Provides a fully automated, "hands-off", operating environment.

Source: Adapted from FHWA, *Intelligent Transportation Systems (ITS) User Services Summary,* January 1995, pp. 3-14.

Although it may be possible to deploy a single user service, in many cases there are combinations of user services that can be considered related. The variations in bundling derived for a particular region is dependent on assessing the region's transportation improvement needs, examining the existing institutional framework, identifying institutional issues relating to improving overall system efficiency, and developing a functional transportation system management concept required to implement the groupings of individual user services.

Once the functional transportation management concept is developed for the region, a "road map" for incorporating ITS technologies into future regional transportation planning, operations, and management needs to be developed to perpetuate the strategic and tactical planning process for ITS deployment.

1.4.2 ITS Planning Process

ITS technologies promise to help increase the safety and efficiency of the region's transportation system. However, unless there is a process for which ITS can be systematically implemented, and evaluated as part of integrated transportation systems, the promise of ITS may never be fully realized. There is a need to help the agencies and organizations responsible for the region's transportation system to guard itself against inefficient allocation of limited resources so the aim for a safer and more efficient transportation for the region can be reached.

The ITS Planning and Project Deployment Process has been created to serve as a tool for organizations to systematically plan for, and implement, ITS technologies as part of an integrated transportation system. The process actually encompasses two distinct processes: 1) the ITS Planning Process; and 2) the Project Deployment Process. The objective of the ITS Planning Process, **Figure 1.3**, is the development of an ITS Strategic Deployment Plan.

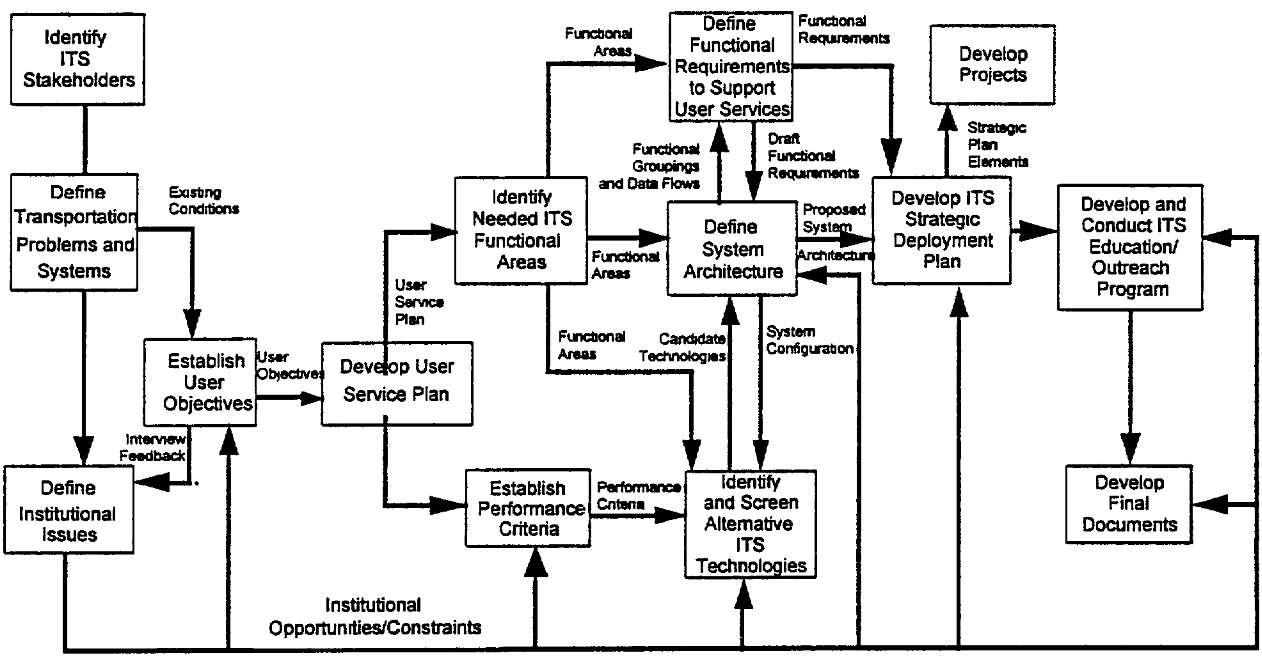


Figure 1.3 ITS Planning Process for the Northern Virginia Region

SECTION 2.0 TRANSPORTATION SYSTEMS IN THE NORTHERN VIRGINIA REGION

2.1 INTRODUCTION

This section presents a brief discussion of the characteristics of the transportation system in the Northern Virginia Region. The system descriptions depicts the existing facilities, services, and technological infrastructure within the region; ongoing implementation projects, tests, research, plans, and programs; as well as the institutional and legislative settings within which transportation policies and programs are planned and implemented. Emphasis is placed on the organizational characteristics of the region, where many improvement opportunities exist.

These system attributes provide the necessary background information to reveal the limitations of the existing transportation system, identify the existing ITS building blocks, translate intra-agency and interagency relationships into meaningful institutional needs, and develop specific objectives that respond to the regional needs. Itemized descriptions of the system considered for regional ITS deployment is further described in the Interim Report: *User Services Plan.*

The Virginia Department of Transportation (VDOT) has been a longtime benefactor from utilizing advanced technology to improve the safety and efficiency of the transportation system in Virginia. VDOT has become increasing active in the development and deployment of advanced systems, and has emerged as a recognized participant in the National ITS Program. VDOTs commitment to ITS includes a variety of local and regional deployments, tests, research, plans, and programs. A summary of these ITS activities, programs, improvement plans, and developments in which Northern Virginia is currently involved in is also discussed in the Interim Report: *User Service Plan.*

2.2 EXISTING SYSTEM CHARACTERISTICS

The Northern Virginia Region encompasses twelve municipalities, supporting a population of over 1,216,000. The transportation system is a multi-modal network of roadways, transit systems, airports, and park & ride facilities; it accommodates local commutes, commercial through-traffic, business and tourism travel, and weekend joy rides. In addition, the Northern Virginia transportation system operates at or near capacity on a daily basis, heavily strained by peak period congestion in combination with high dependency on the single occupant vehicle, insufficient public transportation, and steady regional growth. The key aspects are discussed on the following pages.

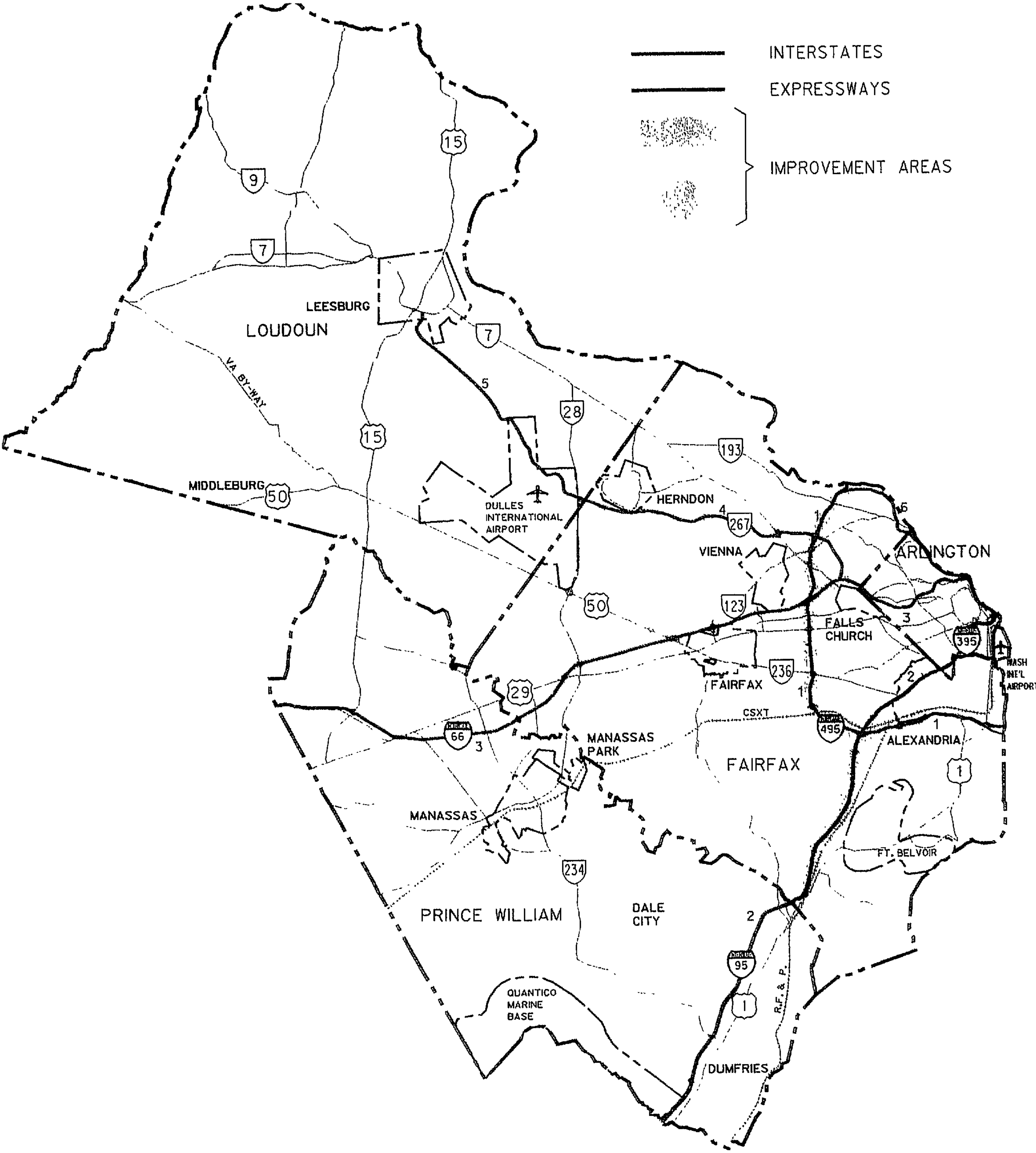


Figure 2.1 - Freeway System in the Northern Virginia Region

2.2.1 Freeways

Northern Virginia's freeways, **Figure 2.1**, are major travel corridors and include interstates, parkways, and toll roads that permit free-flowing traffic across the multiple jurisdictions within the region. Operating speeds on the freeways, with limited access provided by ramps and no traffic signals, are typically higher than on other roadways. The freeways in the study area are:

Capital Beltway Interstate 495 (I-495) and Interstate 95 (I-95) [1]
Interstate 95 (I-95) and Interstate 395 (I-395) [2]
Interstate 66 (I-66) [3]
Washington Dulles Airport Access and Toll Road [4]
Dulles Greenway [5]
George Washington Memorial Parkway [6]

2.2.2 Major Arterials

The major arterial roadways in Northern Virginia carry high volumes of traffic within the region and provide connections to serve freeway traffic and access from minor arterials. The major intersections on major arterials are typically signalized. U.S. routes, primary state highways, and secondary state roadways may be considered major arterials. Segments along 25 roadways in the Northern Virginia Region are considered as major arterials, **Figure 2.2.**

U.S. Route 1 [1]
VA Route 7 [2]
U.S. Route 75 [3]
VA Route 28 [4]
U.S. Route 29 [5]
U.S. Route 50 [6]
VA Route 120 [7]
VA Route 123 [8]
VA Route 234 [9]
VA Route 236 [10]
VA Route 237 [11]
VA Route 243 [12]
VA Route 244 [13]
VA Route 309 [14]
VA Route 401 [15]
VA Route 402 [16]
VA Route 420 [17]
VA Route 667 [18]
VA Route 663 [19]
VA Route 692 [20]
VA Route 776 [21]
Fairfax County Parkway [22]
Franconia-Springfield Parkway [23]
Prince William Parkway [24]
Herndon Parkway [25]

2.2.3 Other Imoortant Corridors

Combinations of certain major arterials and minor arterials in the Northern Virginia Region form travel corridors that are becoming increasingly critical as land use in the region intensifies, and the demand on freeways and major arterials escalates. These makeshift corridors serve as alternates to the principal routes during peak periods, and diversion routes during incidents. The following corridors are additional target corridors for improvements and recommended for consideration of advanced technology applications under the ATMS Implementation Plan, and integral to a region-wide ITS for the Northern Virginia Region. These are also depicted on Figure 2.2.

Ballston-Rosslyn Corridor [1]
Gallows *Road* [2]
Backlick Road/Edsall Toad/Braddock Road [3]
Franconia-Springfield Corridor [4]

2.2.4 Transit Services

There are ten public transit systems operating in Northern Virginia, varying in size from 321 peak-hour Metrobuses (Virginia service only) to the two-bus Tysons Shuttle fleet, as well as a multitude of other regional and local transit providers that serve the region. The transit services are operated by both public agencies and private organizations, however an integrated fare system that would facilitate seamless transfers between systems has not yet been implemented. The transit services that are available in the Northern Virginia Region are discussed in the following subsections.

2.2.4.1 *Heavy Rapid Transit*

The Metrorail system, **Figure 2.3,** is a 103-mile heavy rapid transit system part of which serves Fairfax County and Arlington County in Northern Virginia, Washington, D.C. and suburbs. A significant portion of the system is within heavily developed commercial and residential areas. During an average weekday in 1994,116,000 passengers boarded at Metrorail stations in Northern Virginia, and traveled an average trip length of 7.11 miles.

The Potomac Green station [I] at Potomac Yards in Alexandria is tentatively scheduled to open in 2000. The Franconia/Springfield station [2], scheduled to open **in** the summer of 1997, will serve the Virginia Railway Express (VRE), and may also provide access to the planned Engineering Proving Ground People Mover [10] as well.

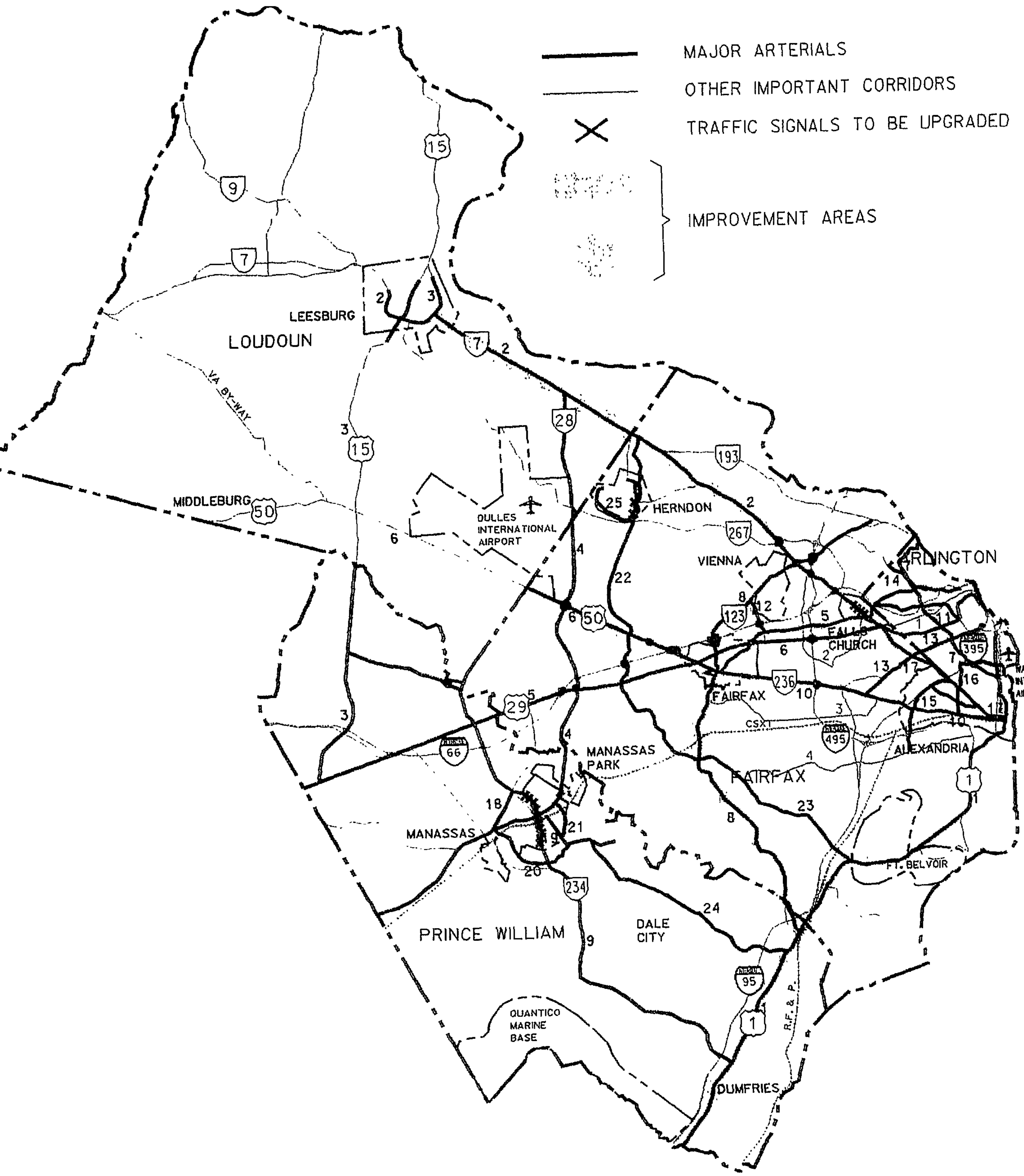


Figure 2.2 - Major Arterials and Important Corridors

Future system enhancements are continually examined by Washington Metropolitan Area Transit Authority. Target areas under analysis for potential extension include the Columbia Pike corridor between the Pentagon and Bailey's Crossroads [5], connections between the Orange Line in the Falls Church/Tysons Corner area and the Red Line in Bethesda, and connections between the Yellow/Blue Lines at the King Street station and the Green Line at Branch Avenue. Other routes under study are from West Falls Church Metro to Dulles Airport [6], Huntington Metro to Tysons Comer via Gallows Road [7], and extension of Orange Line from Vienna Metro to Centreville [8].

2.2.4.2 *Rail*

Interregional commuter rail service is provided in the region, Figure 2.3, through the Northern Virginia Transportation Commission (NVTC) and Amtrak.

Northern Virginia Transportation Commission (NVTC)

Owned and operated by NVTC, the Virginia Railway Express (VRE) is a peak-hour commuter rail service. The VRE is served by Metrorail at the Crystal City station, Union Station, the L'Efant station, the King Street station, and the Franconia Springfield station [2] when the Metrorail portion of the station opens. The Western Fairfax station [4] in Fairfax County and the Cherry Hill [3] station in Prince William County are planned system expansions. A study is underway for an extension from Manassas to Haymarket [9].

Amtrak

Amtrak stations in Alexandria, Woodbridge, and Fredricksburg provide commuter access to intercity rail links that serve areas along the Eastern Seaboard and inland. An arrangement between Amtrak and VRE enables VRE ticket holders to travel aboard scheduled Amtrak intercity trains to VRE transfer locations. This arrangement effectively increases VRE capacity and build ridership through increased flexibility. Approximately 75 VRE trips per day are served by Amtrak.

2.2.4.3 *Bus*

The Northern Virginia Region is served by a number of major bus services, various commuter bus systems, interregional bus services, Vanpools and taxi services. The local transit operator offices

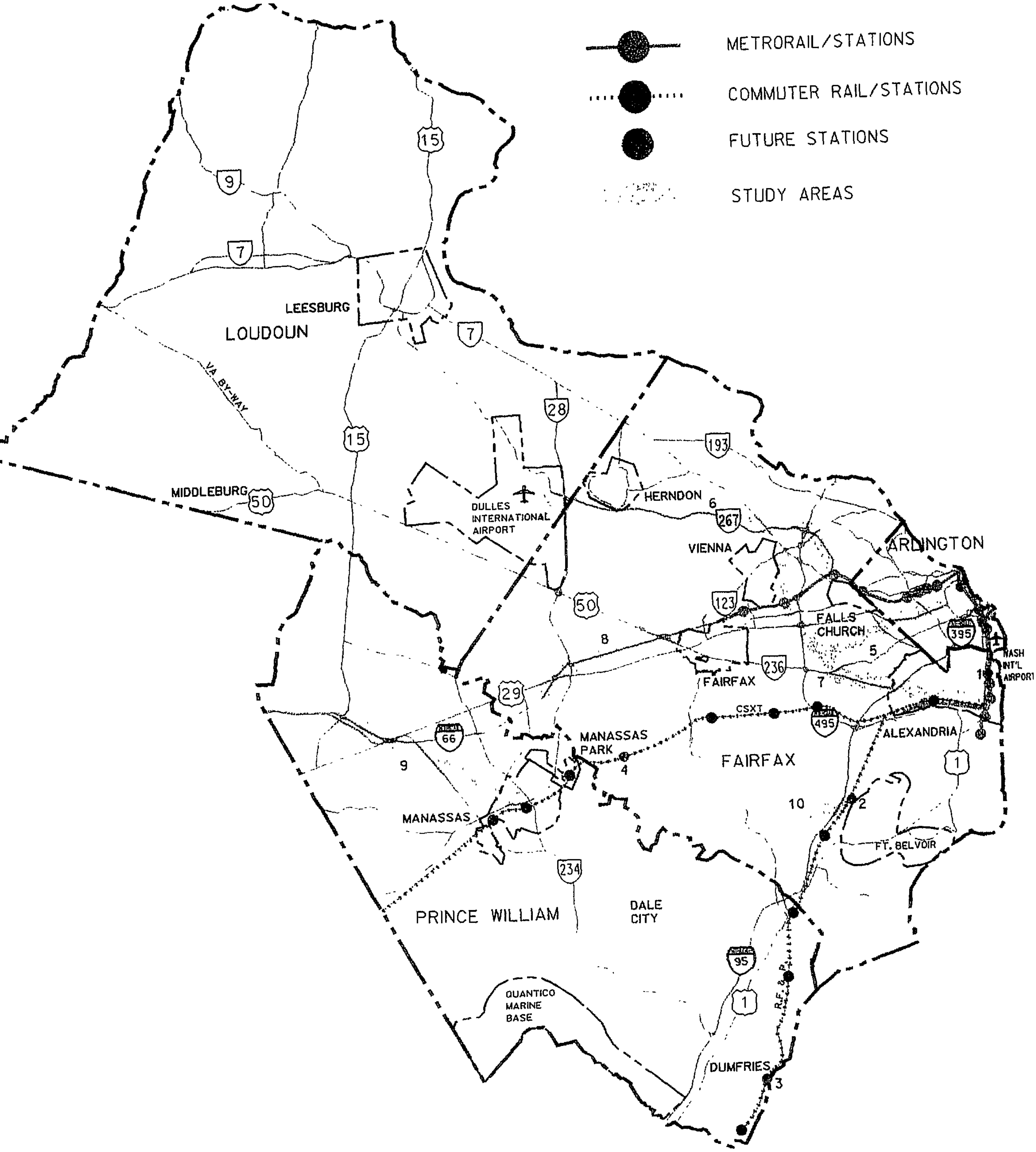


Figure 2.3 - Rapid Transit / Commuter Rail Service

and the bus service's coverage areas are located and outlined on Figure 2.4. Other services not represented on the figure are:

Commuter Bus Systems

Several public and private commuter bus systems offer service for Northern Virginia commuters that live outside the Washington, D.C. metropolitan area. Commuter bus services account for approximately 6500 passenger trips in and out of the metropolitan area daily. The commuter bus services primarily operate out of park and ride lots.

Aries	Quicks Commuter Service
Brooks Transit Services	Greyhound/Trailways
Groome Transportation	Quick-Livic Bus Company
Lee Coaches	Van Pool Service, Inc.
National Coach Works	Transportation Total, Inc.
COMMUTERIDE	Loudoun County Commuter Bus Service

The Loudoun Rideshare bus system, provided by Loudoun County, is the only county-subsidized transit service. Loudoun Rideshare offers one bus that serves Rosslyn and downtown D.C., and another bus that serves the Pentagon.

Interregional Bus Services

In addition to commuter bus service, Greyhound offers intercity bus service between Northern Virginia and other metropolitan areas. Greyhound intercity bus stops currently exist in Arlington, Fairfax City, Springfield, Triangle, and Woodbridge, serving' approximately 108,000 passengers annually. Greyhound, and other intercity bus operators, are investigating the possibility of collocating bus stops with Metrorail stations to facilitate intermodal transfers.

Vanpools

Commercially and privately operated Vanpools account for the transportation means for approximately 423 commuters traveling into Northern Virginia on a typical workday. VanStart is a regional incentive program that encourages the formation

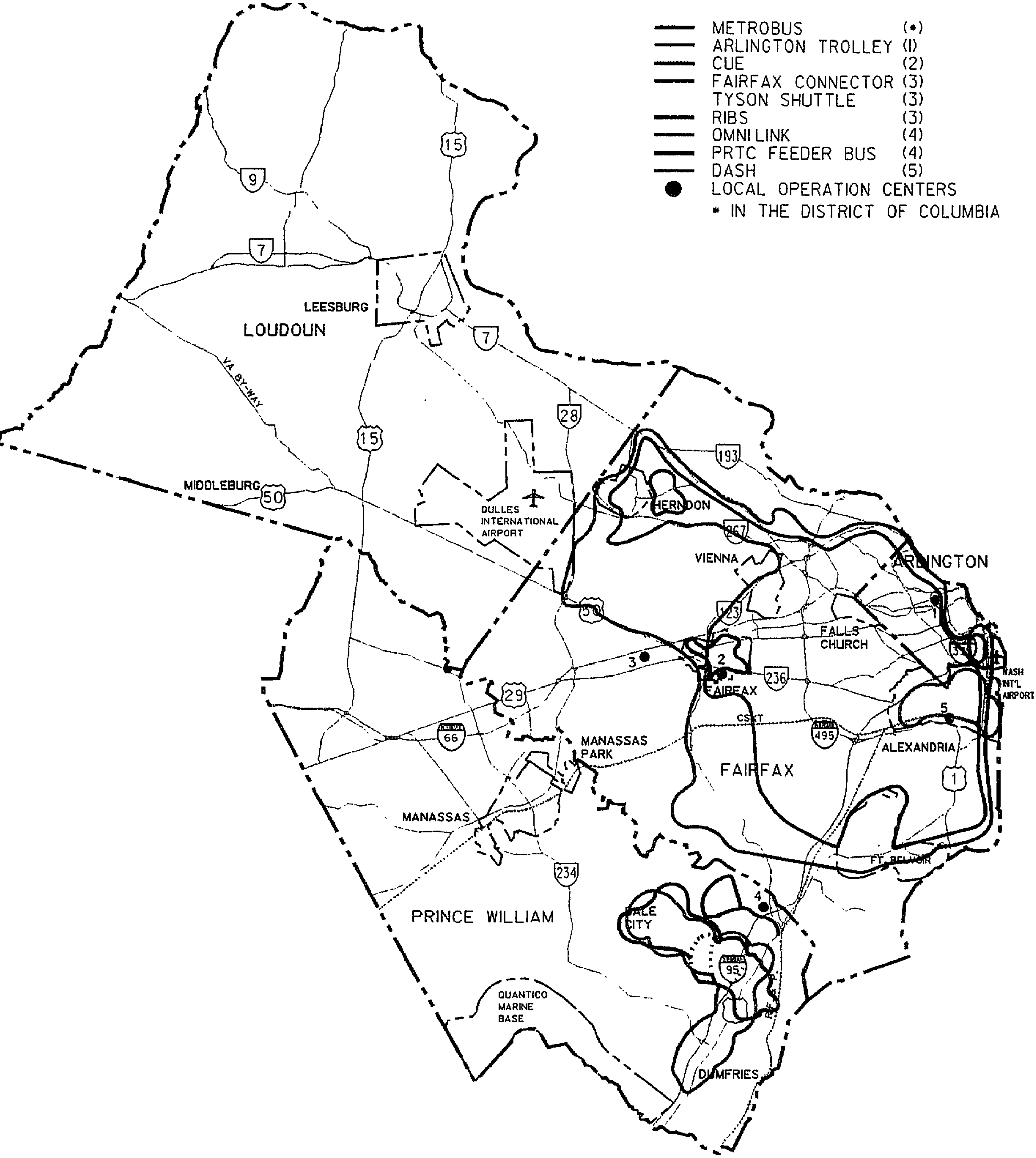


Figure 2.4 - Bus Services

of Vanpools. Through local rideshare programs, eligible Vanpool owners/operators may receive cash assistance equivalent to the average per-passenger cost for between one and four passengers, for up to four months of the vanpool's critical start-up period. While the program is currently funded by the Virginia Department of Rail and Public Transportation, funding may eventually be provided by the jurisdictions.

Taxi

There are 617 licensed taxi cabs in Alexandria, 605 in Arlington, 417 in Falls Church and the City of Fairfax, and 20 in Loudoun County. In addition, the Washington Flyer provides 350 taxis for service to and from the Dulles Airport. A number of Northern Virginia cab companies participate in the VRE Special Delivery Program which ensures VRE passengers of a ride home in the event of midday emergencies, and reimburses them for 90% of the preset cab fares.

2.2.4.4 Paratransit

The deployment of paratransit, or demand-responsive, transit services is gaining momentum in the Northern Virginia Region. A pre-cursor to the demonstration of advanced technology applications to improve mobility and enhance existing public transportation, flexible operating and control systems for transit play a significant role in the development of regional transportation system improvement strategies. At present, there are seven systems in the region operating at various degrees of complexity in a demand-responsive mode. They are:

MetroAccess	Alexandria DOT	Arlington Access
City Wheels	Fare Wheels	FasTrans
Ride On		

2.2.4.5 Commuter Support

At the interregional level, significant efforts have been put forth to respond to enhancing commuter services and provide support with regard to commuting options. These initiatives vary from one-stop-shopping for transit fare media and schedule information to extensive ridesharing programs that has been developed through MWCOG and at the county levels. The Ridefinders Network (1-800-743-RIDE), coordinated by MWCOG, assists commuters in identifying or forming Carpools and Vanpools. The network database can also be accessed by local jurisdictions, many of which provide similar services that assist commuters in identifying transit options as well as available car/vanpools. Transit stores and offices along with the Park & Ride Lots are shown on **Figure 2.5**.

Park and Ride Lots

Park and ride lots are parking facilities where commuters can leave their vehicles and continue traveling via some alternative mode of transportation. Many park and ride lots serve as hubs for car/vanpool assemblage. Park and ride lots located at bus or rail stations accommodate intermodal transfers between vehicular travel and mass transit. In the Northern Virginia Region, there are 70 park and ride lots, providing over 15,000 spaces. Park and ride locations include:

Van Dorn Metrorail	[1]	Jones Point Park	[2]
Ballston Commons Garage	[3]	East Falls Church Metrorail Station	[4]
Four Mile Run Parking Lot	[5]	Washington-Lee Parking Lot	[6]
Clarendon Metered Lot	[7]	Kutner Park	[8]
Municipal Lot	[9]	Ames Dept. Store	[10]
Blackies House of Beef	[11]	Canterbury Woods Park	[12]
Centreville	[13]	Centreville Square	[14]
Centreville United	[15]	Chi-Chi's Restaurant	[16]
Communter Ct./Mason Hirst	[17]	Dunn Loring Metrorail Station	[18]
Fairlanes Bowling Center	[19]	Fair Oaks	[20]
Government Center	[21]	Greenbriar Park	[22]
Hechinger	[23]	Holiday Inn	[24]
Huntington Metrorail Station	[25]	Nottoway Park	[26]
Poplar Tree Park	[27]	Parkwood Baptist Church	[28]
Reston Park and Ride	[29]	Reston South	[30]
Rolling Valley Mall	[31]	South Run District Park	[32]
Springfield Mall	[33]	Springfield Plaza	[34]
Springfield United	[35]	Sully Station Park &Ride Lot	[36]
Vienna Park &Ride	[37]	Wakefield Chapel Recreation Center	[38]
W. Falls Church Metro Stn.	[39]	Worldgate	[40]
Ashburn Farm	[41]	Ashburn Village	[42]
Cascades Park & Ride	[43]	Hamilton	[44]
Innovation Avenue	[45]	Leesburg	[46]
Leesburg Village	[47]	Purcellville	[48]
Sterling Shaw Road	[49]	Sterling Park Shopping Center	[50]
Walmart	[51]	Giant Supermarket	[52]
Brittany Commuter Lot	[53]	Dale City Commuter Lot	[54]
Old Bridge Festival SC	[55]	Hechinger's Lot	[56]

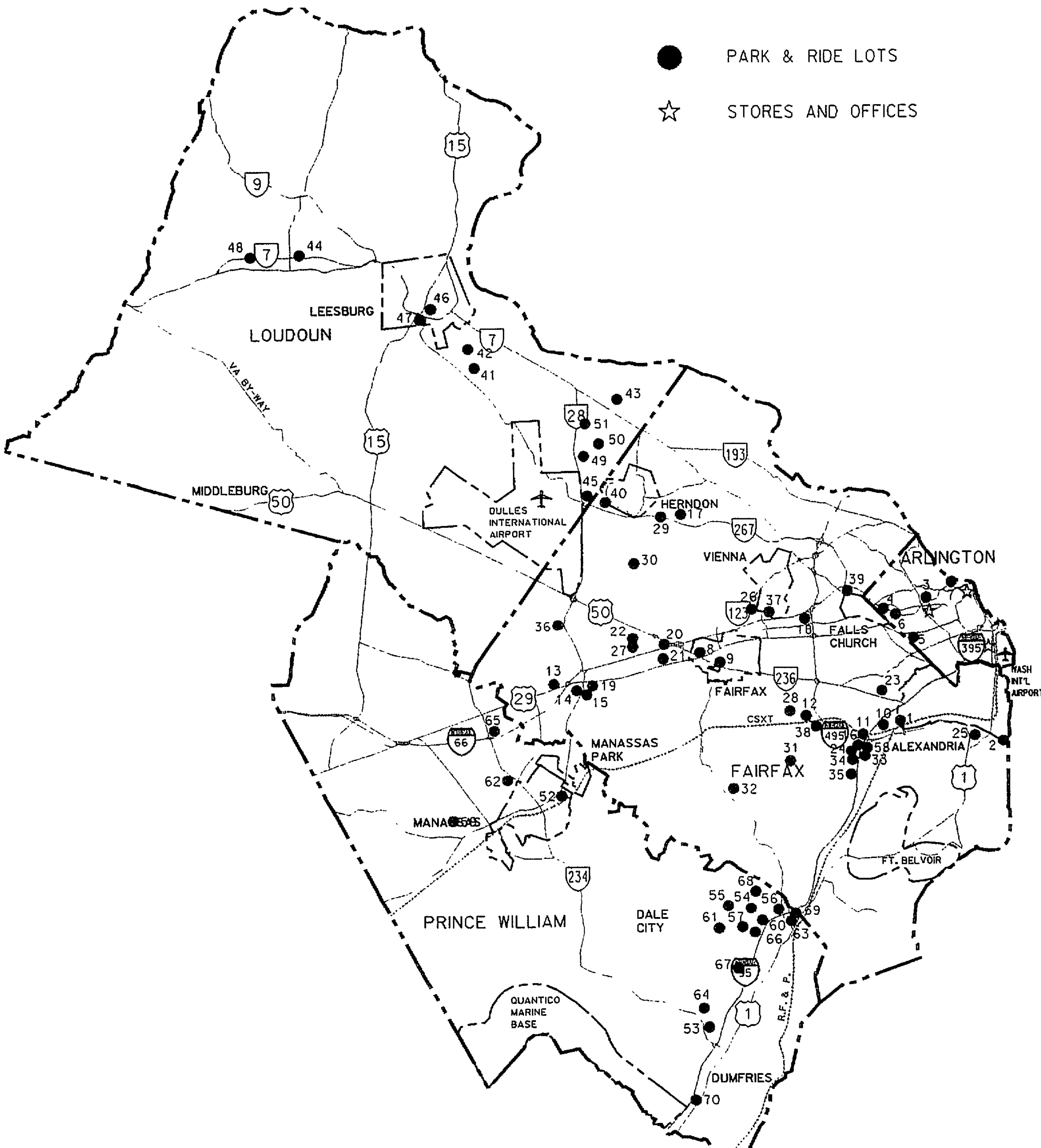


Figure 2.5 - Commuter Support Services

Hillendale	[57]	Horner Road	[58]
K-mart	[59]	Lake Ridge	[60]
Lindendale Lot	[61]	Manassas Mall	[62]
Marumsco Plaza	[63]	Montclair Commuter Lot	[64]
NVCC Commuter Lot	[65]	Potomac Mills	[66]
Prince William Square	[67]	Prince William Stadium	[68]
I-95 & Rt. 123 Commu. Lot	[69]	Triangle Lot	[70]

Alternative Transportation Program

The City of Alexandria initiated an employer outreach program which, among other activities, developed a free-transit benefit program for employees.

2.2.5 Airports

The two Northern Virginia airports, Washington National and Washington Dulles International, shown on the previous figures, are considered to be vital to the economic development of the Northern Virginia Region. It is expected that quality service at these intermodal transportation centers will precipitate commercial/commuter travel, positively influencing regional progress. Strides to improve the accessibility of the airports, as well as mobility within the airport facilities, are critical to realize the potential benefits.

2.3 CURRENT STRATEGIC PLANS

At present, there two major strategic transportation planning initiatives that are considered to have significant impact on the evaluation of future transportation infrastructure improvement and the development of supporting implementation programs for the Northern Virginia Region.

These initiatives are focused at the statewide level through *Virginia Connections,* the current strategic transportation plan for Virginia and at the National Capital Region level through the vision-based planning process recently adopted by the TPB, the MPO for the National Capital Region. The latter is seen to have significant and immediate impact on planning for transportation infrastructure improvements by virtue of the Northern Virginia Region's role as a subregion to the National Capital Region. The vision-based planning process envisioned by TPB and its members is anticipated to align with the underlying strategic planning philosophy of the *ITS Planning and Project Deployment Process* adopted used as a guideline for this study.

Through the preliminary user interviews conducted during the early stages of this study it was observed that, with the exception of the aforementioned strategic planning efforts of VDOT and MWCOG, and NVTC, strategic management practices have not been formally adopted by the other core transportation agencies and organizations in the Northern Virginia Region.

2.3.1 Virginia Connections

Virginia Connections, December 1994, developed a vision for the future direction of transportation in the Commonwealth. Initiated by Virginia Secretary of Transportation, Robert E. Martinez, working groups were established to focus on the principles outlined by the Secretary and members from the private sector, and public and modal agencies. Development of the strategic plan was based on four themes: increase citizens ownership of government; increase the customer-service orientation of transportation services; increase competition in government; and strive to change the culture of the transportation workforce. A key element of the plan is to identify opportunities to enhance strategic intermodal connections.

The significance to the development of an ITS Strategic Deployment Plan for Northern Virginia are the tenets of the plan to promote integrated, total transportation management strategies addressing all modes of transportation at planning, operations, and procurement levels.

2.3.2 Virginia Progress

Developed in March *1993,* the *Virginia PROGRESS* describes the strategic plan for Virginia Department of Transportation's Intelligent Vehicle Highway System (IVHS) *PROGR*am for an Efficient and Safe System. Three major sections included in the document are Strategic Assessment, ITS Functional Area Overview, and a detailed Strategic Plan. It's intent is to guide VDOT activities in ITS (former IVHS) over the next twenty years. This plan was soon preceded by the *Virginia Connection* mentioned above.

2.3.3 MWCOG Regional Vision Plan

From Section 1.2.3 of the *Long-Range Transportation Plan for the National Capital Region,* developed by the TPB with the cooperation of the core jurisdictions and transportation agencies in the Northern Virginia Region, identifies the policy goals and objectives, capital improvements, studies, actions, and strategies the region proposes to carry out by the year 2020. Through the development of the long-range plan, a number of key transportation-related issues challenging the region were addressed (Table1-1). These foreseen challenges are proposed to be explored even further utilizing the vision-based planning process.

As stated in the plan, there is widespread consensus among the TPB membership that a new long-range vision is needed for the area's transportation system. It is anticipated that developing a consensus on a vision for the transportation system of the future will require several years of effort. The TPB has recently embarked on a mission to develop a work plan, schedule, and milestones for the vision-based planning process, which will use the policy goals and objectives presented in this report (Section 3.3). Early efforts in this regard are anticipated to be completed within the next five months, The adopted parameters of the vision plan are summarized in **Table 2-1.**

TABLE 2-1
PARAMETERS FOR THE
NATIONAL CAPITAL REGION VISION PLAN

- It should go beyond the year 2020;
- The continuation of the concept of one central core served by radial transit routes should not be assumed. Multiple centers of activity and circumferential travel also must be addressed;
- It should not be a "needs" plan that simply responds to current trends in travel patterns using current transportation technologies;
- The effects of new technologies on travel patterns must be considered;
- Attention should be given to defining new rail transit corridors since the 103-mile Metrorail system will be completed shortly after the year 2000;
- New transportation corridors also need to be identified, and tights-of-way may need to be designated and preserved in the near future;
- It should not be subject to the strict financial constraints in ISTEA, but it must address funding issues, perhaps with major new approaches to funding of transportation facilities and services;
- It should deal with sustainability of the environment, air quality, infrastructure, economic development, and quality of life.

Source *Long-Range Transportation Plan for the National Capital Region,* 1994, pp. 3-4 - 3-6

2.3.4 NVTC Transportation Service Coordination Plan

The annual plan reviews the institutional and legislative settings within which transportation policies and programs are planned and implemented in Northern Virginia. The region's mobility needs are pulled together by NVTC member agencies and organizations in the region. This plan also assembles performance data for the region's public transit systems, reviews ongoing activities, and discusses the qualities of a good transportation system.

This annual plan also points out the bleak picture to come for the region. Planned investments in road and transit networks will not keep up with the traffic. Some of the recommendations include enhancements to the transit system, increased attention to bicycle and pedestrian access to facilities, and an effort to implement demand management techniques in the region.

2.4 INSTITUTIONAL FRAMEWORK

Presented in this section are the transportation agencies and organizations, both public and private, identified by the study team as having a key role in transportation in the region. In total, seventy-nine (79) agencies and organizations are identified. Through the study team's preliminary analysis, the complexity of resolving region-wide transportation issues is primarily driven by the enormous degree to which efforts are required to effectively and efficiently coordinate the development of strategies, improvement concepts, and resulting impacts on overall transportation system operations among a wide array of agencies and organizations.

2.4.1 Primary Jurisdictions/Agencies

The core agencies and organizations grouped under a number broad categories. Their roles are defined in one or more of the following areas: formation of transportation policy; establishment of transportation improvements at the planning and design levels; responsibility for transportation system operations and maintenance; funding; and procurement. This study has identified the primary tier of jurisdictions and transportation-oriented agencies for potential participation on ITS deployment for the Northern Virginia Region. These are listed in **Table 2-2.**

TABLE 2-2
PRIMARY TIER JURISDICTIONS/AGENCIES

National/Federal	State	Regional
- FHWA-VA Division - Federal Transit Administration (FTA) **Local Emergency** - Arlington Co. Police Dept. - Arlington Co. Fire Dept. - Fairfax Co. Fire Dept. - Loudoun Co. Fire & Rescue Services - Prince William Co. Police Dept. - Prince William Co. Fire Dept. - City of Alexandria Police Department - Department of Emergency Services	- VDOT-Central Offices - Virginia Department of Rail & Public Transportation (VDRPT) - Virginia State Police **Local** - City of Alexandria - City of Fairfax - City of Falls Church - City of Manassas - City of Manassas Park - Arlington County - Fairfax County - Loudoun County - Prince William County - Town of Herndon - Town of Leesburg - Town of Vienna	- Metropolitan Washington Council of Governments (MWCOG) - Northern Virginia Transportation Commission (NVTC) - Potomac and Rappahannock Transportation Commission (PRTC) - Virginia Railway Express (VRE) - Washington Metropolitan Area Transit Authority (WMATA) - Metropolitan Washington Airport Authority (MWAA)

2.4.2 Other Agencies and Organizations

In addition to the key transportation agencies and organizations, there are a number of other private transportation providers operating in the Northern Virginia Region. These entities consist of commuter bus services, taxi services, and other interregional services, such as Greyhound bus, vanpools, etc., and are too numerous to list here. As an example, there are currently twelve (12) private companies that provide commuter bus services and twenty-three (23) taxi companies serving the region.

2.4.3 Regional Coordination

Local transportation policy is defined as those policies endorsed by the Northern Virginia Transportation Coordinating Council (TCC). The purpose of the TCC is to ensure that the cooperative long-range planning process for Northern Capital Region, will continue and that the results of the process will be refined and updated as circumstances require. TCC role is also to continuously monitor the implementation of improvements to the transportation infrastructure, establish improvement priorities, and collectively and actively pursue funding for the established plan. A key element of the TCC's charter, as it relates to the development of this ITS Strategic Deployment Plan for the Northern Virginia Region, is to provide policy guidance for the implementation of the Northern Virginia Transportation Plan through a consensus decision-making process.

Through its membership, the TCC monitors the development of local transportation plans – at the county, city, and town levels – to ensure consistency with the overall plan for the Northern Virginia Region. This is primarily achieved through the efforts of the TCC Technical Committee. Established by the TCC, the Technical Committee provides technical guidance to the TCC on matters relating to the planning processes in the Northern Virginia Region.

The membership of the Technical Committee parallels the core-jurisdictions within the study area and agencies/organizations having a key role in transportation for the region. For the purpose of evaluating compliance of this study's findings to established local transportation policy, the policy goals and objectives at the aforementioned local transportation plan level are considered. The transportation system objectives summary is provided in appendix C of this plan. The current membership listings of the TCC and TCC Technical Committee are summarized as follows.

TCC Membership:

Local Elected Officials

City of Alexandria
Arlington County
Fairfax County
City of Fairfax
City of Falls Church
City of Frederickburg
Town of Herndon
Town of Leesburg
Loudoun County
City of Manassas
City of Manassas Park
Prince William County
Stafford County
Town of Vienna
City of Dumfries

General* Assembly *Members

State Senators and Delegates from Northern Virginia Districts

TCC Citizen Advisory Committee (CAC)

CAC Chairman

VDOT

Northem Virginia District Adminstrator

VDRPT

Director

A key element of the TCC's charter is to provide policy guidance for the implementation of the Northern Virginia Transportation Plan through a consensus decision-making process. Through its membership, the TCC monitors the development of local transportation plans at the county, city, and town levels to ensure consistency with the overall plan for the Northern Virginia Region. To date, the Northern Virginia Transportation Plan – the subregional element of the TPB Long Range Transportation Plan – has not been formally adopted by the TCC, but is used as a guide for regional transportation improvements.

TCC Technical Committee Membership:

Northern Virginia Transportation Commission (NVTC)
Potomac-Rappahanock Transportation Commission (PRTC)
Washington Metropolitan Area Transit Authority (WMATA)
Metropolitan Washington Council of Governments (MWCOG)/ Transportation Planning Board (TPB)
Metropolitan Washington Airports Authority (MWAA)
Northern Virginia Planning District Commission (NVPDC)
RADCO
Federal Highway Administration (FHWA)
Federal Transit Administration (FTA)
Federal Aviation Administration (FAA)
Arlington County
Fairfax County
Loudoun County
Prince William County
Stafford County
City of Fredericksburg
City of Manassas
City of Alexandria
City of Falls Church
Town of Herndon
Town of Leesburg
Town of Vienna

Town of Dumfries
CAC Committee Chair
VDOT - Urban Division
VDOT - Transportation Planning Division
VDOT - Northern Virginia District Planning
VDRPT

Established by the TCC, the Technical Committee provides technical guidance to the TCC on matters relating to the planning processes in the Northern Virginia Region. By comparison to the transportation agencies and organizations, the membership of the Technical Committee includes, in part, those agencies and organizations under categories 1, 2, 3, and 4 representing key federal/national , state, regional/interregional, and local entities, respectively.

2.5 PRIMARY TRANSPORTATION PROBLEMS AND ISSUES

The region has established policy goals and objectives formulated by the Transportation Planning Board to address the primary transportation problems, issues, and challenges for the future. The region's first ITS Coalition Building Workshop, held on August 9, 1995, presented the attendees the study overview, which covered the ITS planning and project deployment processes and other key focus areas. These focus areas are institutional framework, regional ITS strategic deployment planning, and regional ATMS implementation planning. The existing Regional ITS Goals and Objectives are based on the study team's analysis and review of the workshop.

The brainstorming session held at the first coalition building workshop brought forth the transportation problems from the represented agencies. The problems were consolidated into the following primary categories:

- **Common framework** - There is no common framework for interagency communications and coordinated management of transportation network.

- **Credibility** - Current systems are viewed negatively, such as with signal timing and information on VMS. Information processing and dissemination is inadequate or deficient.

- **Utilization**- Available information such as through the police departments is not utilized effectively for current information dissemination. Extent to which expert or predictive system(s) can be utilized to provide decision support in implementing transportation system operation plans needs to be considered.

- **Capability**- There are no comprehensive data capture and exchange to improve the comprehensive planning process. Data collection and analysis is not available to provide the capability of considering the "echo effects" of incidents in network-level analyses. There are no means to collect & disseminate information in different languages, formats, and type & severity of incidents, to automated interjurisdictional information exchange.

- **Information, Static –** There lacks the availability of, and ease of access to, static information relating to public transportation services. Low tech systems such as static signs are not used effectively.

- **Integration –** Independent GIS development activities do not exist but can be integrated to reduce maintenance intensive efforts to continuously update system(s). An integrated, multi-jurisdictional database is not available as a regional resource.

- **Control Plans –** There are no protocols and pre-determined transportation network control plans for specified special events through interjurisdictional agreements. Safeguards have not been implemented to prevent major disruptions to local road/street network in residential areas.

- **Benefits & Cost –** The real benefits and cost of information distribution is not available. Costs to transit operating centers and costs to others resulting from implementing transportation control measures such as adjusting signal timings when buses get behind schedule has not been identified.

The problem list from the workshop specifically supplements this in the context of ITS deployment in the region, of which the essence is integrated transportation system management and the supporting communications network to facilitate information exchange.

The brainstorming session also provided the attendees the opportunity to convey and establish the new regional ITS objectives. The session requested the audience to contribute their thoughts on the region's/agency's primary transportation information issues, needs and how could/should the information be provided? The inputs from the attendees were immediately recorded and then distributed at the end of the workshop.

After the first coalition building workshop, the study team evaluated and summarized the inputs received and divided them into the following Primary Regional ITS Deployment Issues:

- Credibility issues on dynamics of regional transportation policy and approach to operations and maintenance extend to and affect funding issues and mechanisms. Why spend program dollars if it is not going to work?

- institutional constraints exist in that equipment can only be used for certain purposes.

- Are high tech applications really needed? Applications of fairly low tech type systems could be promising, e.g., traveler information systems at park-n-ride lots and other facilities.

- Information dissemination processes need to consider the potential impact on travel demand and trip decisions on the local communities. Mechanisms should be provided to allow local jurisdiction input regarding the economic impact of information dissemination prior to its release.

- Regional deployment initiatives need to consider that limitations exist on how much information can realistically be disseminated in real-time.

- The term "architecture" implies that different agencies communicate at different levels with a focus on being able to add functions without major reconfiguration to the communications system, or architecture. How is this envisioned for the Northern Virginia Region?

- The dependence on region-wide systems needs to addressed through redundant or back-up systems. Fail-safe provisions need to be considered to reduce the vulnerability of having ITS in-place then having it fail in a particular instance.

- Deployment costs need to be addressed at all levels and cost models need to be developed.

- Jurisdictions need to know the money needed to participate in regional deployment programs.

- Regional deployment planning initiatives need to address the resources required to distribute information and to provide this type of service.

- Methodologies need to be established to identify priorities in implementing ITS.

- How will profit motive be shown to the private sector to encourage its involvement?

As noted in the first description above, credibility is a key issue in deploying ITS. The technology/system proposed needs to be highly reliable. And the reliability of a system can be improved in several ways, either by increasing the reliability of certain component(s)/subsystem and/or by providing additional redundant component(s)/subsystems. A credible system will provide affirmative responses in implementing and deploying ITS services.

2.6 IMPROVEMENT NEEDS

The needs for improvement utilizing ITS services were surveyed with the participating agencies identifying the user services of interest for short-term deployment. Results of the survey identified a strong request for ITS deployment in the areas of Traffic Control, Incident Management, Demand Management and Operations, and Public Transportation Management. All of which requires a cooperative effort such as improving communication as well as coordination among the jurisdictions.

Traffic control and incident management are in the travel and transportation management bundle of user services. This user service bundle collects and processes information about the surface transportation system, and provides commands to various traffic devices. These services also provide information to support the Travel Demand Management and the Public Transportation Operations bundles, which were selected as top user services by the participating agencies. The Demand Management and Operations service supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion, by means of generating and communicating management and control strategies that support the implementation of programs to reduce the number of individuals who choose to drive alone, etc.

Public Transportation Management automates operations, planning, and management functions of public transit systems, by means of providing computer analysis of real-time vehicle and facility status to improve transit operations and maintenance. The top user services identified are some of the improvement needs identified for the region and can be implemented or integrated into the current system by applying the functional areas defined in the *Intelligent Transportation Systems User Service Summary,* FHWA, January 1995.

SECTION 3.0 USER SERVICE PLAN

3.1 INTRODUCTION

The critical factor in developing a strategy for region-wide ITS deployment is the establishment of user service objectives for the ultimate attainment of the regional transportation policy goals and objectives – policy goals and objectives that are derived through the consensus of transportation agencies and organizations with a vested interest in the region's transportation network. Once formulated, these objectives serve as the guidelines by which ITS deployment strategies will be generated through the application of the *ITS Strategic Deployment Planning and Project Deployment Process.*

The contents of this section present the summary findings of the mapping of defined system objectives to the user services, provide general deployment recommendations, address issues pertaining to service requirements traceability, and presents the phasing categorization for user service deployment. Interagency coordination requirements in the areas of policy, planning, operations, management, and economics are also presented as they relate to user services deployment on a region-wide basis. These requirements are defined through the evaluation of the existing institutional framework in Section 2.4, and institutional areas identified for further evaluation, based on the study team's evaluation of inputs received during the preliminary interviews conducted with each jurisdiction and the results of the coalition building workshops held on August 9 and November 13, 1995.

3.2 GOALS AND OBJECTIVES STRUCTURE

The development of an integrated, demand-responsive transportation system requires the unified adoption of a strategic management philosophy, focusing on the overall vision of where the region should be heading and the subsequent influences on existing transportation planning and operations through the development of strategies, action plans, and performance monitoring to achieve the desired results.

Recognizing the increasing interdependencies of interregional coordination needs in developing a strategy for ITS deployment, the structure under this study to establish user service objectives is one that seeks to integrate the ***adopted*** transportation objectives in the multi-jurisdictional environment. The user services are then mapped to those objectives, with the criteria of applicability of each user service to assist the region in attainment of those objectives applied.

Using this evaluation structure, the mapping of the user services to policy goals and objectives then represents a tool by which the migration path to integrate existing transportation policy and the operational characteristics of regional transportation system can be initiated.

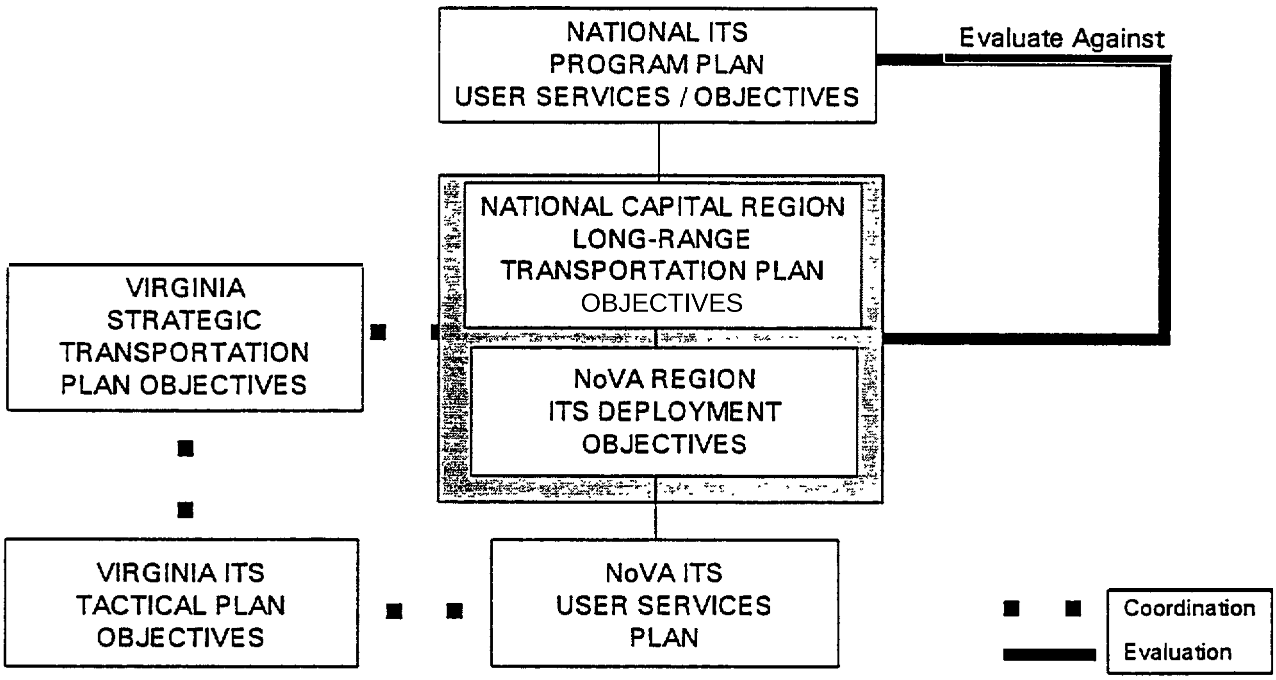


Figure 3.1 - Transportation Objectives Evaluation Process

3.3 TRANSPORTATION SYSTEM OBJECTIVES

The objective categories considered include: national, statewide, interregional, and regional. Key objectives from these categories are summarized in **Table 3-1.** A summary of the primary objectives used in mapping the defined system objectives to the twenty-nine (29) user services is presented in this section of the report. The results of the study team's mapping of these objectives to the user services is presented **in Table 3-2.**

TABLE 3-1
PRIMARY LONG-RANGE TRANSPORTATION PLAN OBJECTIVES

- Consider the likely effect of transportation policy decisions on land use and development and the consistency of trans. plans and programs with the provisions of all applicable short- and long-term land use and development plans.
- Develop and manage the transportation system to meet the requirements of the Clean Air Act Amendments of 1990.
- Promote "clean" travel options by developing a greenway system that includes electric or other non-polluting high occupancy vehicles (HOV), bicycle, and pedestrian facilities.
- Ensure that the region's transportation planning is consistent with federal, state and local energy conservation programs, goals and objectives.
- Manage the operation of the existing transportation system to improve safety and reliability, and to serve the trans. needs identified through the state highway safety management systems.
- Improve the flow of traffic on existing arterial highway facilities by using traffic management and enforcement measures.
- Reduce transit travel time for buses and other high-occupancy vehicles through the use of exclusive lanes or priority treatment.
- Improve and expand regional ridesharing activities by promoting Carpool, Vanpool, and other high-occupancy vehicle programs, including providing preferential treatment for such vehicles.
- Reduce congestion and improve traffic flow on the existing transportation system by developing and implementing complementary demand management strategies, including alternative work hours, telecommuting, and parking pricing.
- Give car and van pools priority in the utilization of long-term parking spaces.
- Implement taxing and pricing policies that favor employer subsidies for transit and other HOV services over employer-subsidized parking.
- Improve transit services to persons with disabilities, including meeting the requirements of the Americans with Disabilities Act of 1990.
- Improve transit services to isolated communities and to other persons without convenient access to automobiles.

- Integrate the airport system with the region's other transportation systems, including maintaining and improving airport access and coordinating with high-speed rail services.
- Expand & enhance transit services and increase the use of such services.
- Provide sufficient revenue to operate, maintain, and expand an efficient public transportation system.
- Provide transit services in the most cost-effective manner possible, including the involvement, where applicable, of private transit providers.
- Develop & implement a coordinated system of transit and HOV facilities, connecting the region's activity centers...radial and circumferential travel.
- Maintain & improve existing roads and bridges, and serve transportation needs identified through the state pavement and bridge management systems.
- Encourage transportation system improvement based on how well they advance the overall development, transportation, and environmental objectives and to encourage HO travel.
- Serve the region's transportation needs identified through the state intermodal facilities and systems management systems.
- Assess the effects of all transportation projects to be undertaken, without regard to whether such projects are publicly funded.
- Improve, where necessary, access to the region's ports, airports, intermodal facilities, major freight distribution routes, national parks, recreation areas, monuments and historic sites, and military installations.
- Implement methods to enhance the efficient movement of freight.
- Consider operating and maintenance costs in analyzing transportation alternatives, and use life-cycle costs in the design and engineering of bridges, tunnels, or pavement.
- Maintain the high level of security in the region's transit systems.
- Serve the region's transportation needs identified through the state public transportation facilities and equipment management systems.

Source: National Capital Region Transportation Planning Board, *Long-Range Transportation Plan for the National Capital Region*, 1993.

3.4 PRELIMINARY DEPLOYMENT RECOMMENDATIONS

A simplified summary listing of user service deployment recommendations is presented in **Table 3-2.** It is important for the reader to understand that the user service rankings indicate a preliminary priority scheme by which ITS user services deployment opportunities will be further evaluated in the planning process (Figure 1.3). The rankings do not necessarily represent the final deployment recommendations for the region. Final recommendations and the extent to which any user service is actually deployed will be dependent on the supporting system architecture and benefit/cost/risk analyses of the project sets identified for deploying the user services.

TABLE 3-2
SUMMARY LISTING OF USER SERVICE DEPLOYMENT RECOMMENDATIONS

Rank	User Service	Eval. Score	Rank	User Service	Eval. Score
1	Public Transportation	65	**16**	Commercial Vehicle	15
2	Traffic Control	65	**17**	En-Route Transit Information	15
3	Demand Management and	41	**18**	Commercial Vehicle Electronic	14
4	Incident Management	35	**19**	Emergency Notification and	14
5	Traveler Services	34	**20**	Public Travel Safety	12
6	Ride Matching and	29	**22**	Automated Highway System	7
7	Pre-Trip Traveler Information	28	**22**	Automated Roadside Safety	6
8	Commercial Fleet	26	**23**	Automated Roadside Safety	6
9	En-Route Driver Information	26	**24**	Intersection Collision	6
10	Route Guidance	25	**25**	Lateral Collision Avoidance	6
11	Electronic Payment Services	21	**26**	Longitudinal Collision	6
12	Hazardous Materials Incident	20	**27**	Vision Enhancement for Crash	6
13	Emergency Vehicle	19	**28**	Safety Readiness	5
14	Personalized Public Transit	16	**29**	Pre-Crash Restraint	3
15	Emissions Testing and	15			

3.5 SERVICE REQUIREMENTS TRACEABILITY

Further development of the ITS user service deployment strategy is dependent on identifying a functional concept to achieve the defined objectives for regional deployment and an assessment of potential migration paths for deployment, considering the expected availability of supporting technologies to each of the user services.

Key traceability issues that need to be addressed include: evaluation of service-provider and customer interface options in a services-based business environment; the creation of a climate that attracts investment in the infrastructure; and development of institutional framework to support long-term investments and secure commitment of the participating parties, i.e., stakeholders.

3.5.1 Functional Concept

While there are overlapping areas of public and private sector roles, the vision for Northern Virginia is driven by the existing and near-future political climate and the adopted regional transportation policy goals and objectives for transportation infrastructure improvements. With respect to service traceability, there are six primary ITS deployment objectives, **Table 3-3,** that can be extrapolated from the objectives analysis previously presented.

TABLE 3-3
REGIONAL ITS FUNCTIONAL DRIVERS

- Provide a common framework for interagency communications and coordinated management of transportation network.
- Enhance credibility of system operations through improved information processing and dissemination to system users.
- Establish automated intejurisdictional information exchange capabilities.
- Examine methods by which independent GIS development activities in the region can be integrated to reduce maintenance intensive efforts to continuously update system(s).
- Provide integrated, multi-jurisdictional database as regional resource.
- Consider the extent to which expert or predictive system(s) can be utilized to provide decision support in implementing transportation system operation plans.

The fundamental element of the functional concept recommended by the study team is one that is based on cooperation and coordination of the operating transportation agencies and organizations in the region, supports continuing investment in the transportation infrastructure, and creates opportunities for private sector involvement. The proposed management coordination concept, **Figure 3.2,** is based on two key nodes: the transportation system operations node is supported by regional management systems and supporting subsystems representing a co-management structure for the primary service providers in their region; and the customer-oriented transportation services node is consisted of various service programs and supporting subprograms established through the secondary service providers and end users in the region.

This concept will require further evaluation against public/private partnering potentials for deployment and prevalent institutional issues in the region as the development of the overall ITS Strategic Deployment Plan progresses.

3.5.2 Transportation System Operations

The results of the study's user interviews and inventories indicate universal preference for initial user service deployments in operations rather than those particularly suited to maximize the benefit of ITS user services to the end user, such as traveler services information. Deployment benefits to the end-user are seen as an element that will inherently result from improved coordination of transportation system operations at an intermodal level.

Overcoming credibility problems with existing operations and improving public image of the primary transportation service providers through improved service reliability were noted as key factors to a successful regional ITS deployment. Accordingly, the near- and mid-term projection for ITS user services deployment is envisioned to integrate the primary service providers for transportation in the region, both public and private.

3.5.3 Customer-Oriented Transportation Services

This element of the functional model is "demand" oriented and primarily serves to function as the information provider to the system end users and secondary service providers, control market demand on transportation system operations, and provide the interface to information support services in areas that are non-transportation oriented.

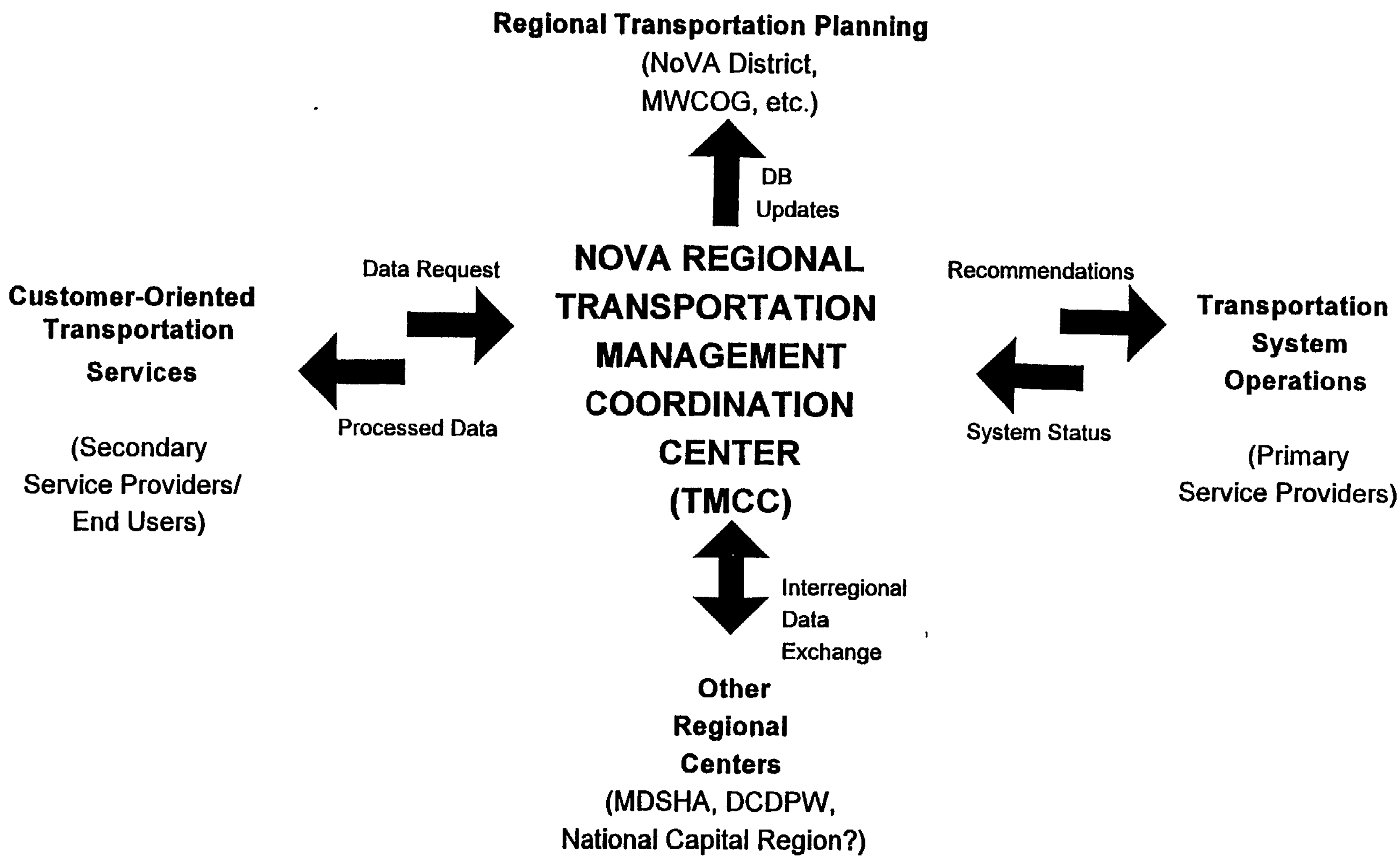


Figure 3.2 - Functional Concept -- Regional Transportation System Management Coordination

With the functional model proposed for regional transportation management coordination, ITS customer-oriented transportation services are recommended to be deployed through various service programs at both the public and private transportation agency levels. The agency level service programs are proposed to be networked with the remaining service programs recommended for the region: traveler information services; emergency services; and public media programs. These service programs are intended to provide an interface for transportation systems management coordination through secondary-service providers and the system end users.

3.6 PHASING CATEGORIZATION

With the functional model for transportation system management coordination defined, the phasing – or staged implementation – plan for user services deployment is achieved by associating supporting ITS technologies with the initial functional management concept. This is derived by matching the supporting technology development timelines to the region-wide deployment opportunity windows. A key derivative of this analysis is the definition of the "deployment limits" of the supporting technologies within each window.

For the purpose of this study and consistent with the deployment planning stages currently adopted by the Virginia Department of Transportation, the ITS deployment windows of opportunity are: **near-term** (present-1999); **mid-term** (2000-2005)**; long-range** (2006-2012). To establish the base reference for deployment recommendations resulting from this study, the near-term window is redefined to 1997-1999, due to this study's current anticipated end date of May, 1996. It is not anticipated that any major region-wide ITS deployment efforts that result from this study's findings will be implementable until early 1997.

3.6.1 Migration Paths for User Services Deployment

For the purpose of evaluating user service deployment recommendations by the aforementioned deployment windows, the migration paths for enabling technologies by user service bundle are presented on the following pages, **Figures 3.3 - 3.9**. Adapted from the technology development timelines defined by the *National ITS Program Plan*, each diagram identifies the migration paths anticipated and recommended for ITS deployment in the Northern Virginia Region. The migration paths are represented by vertical lines with two arrows: one for customer-oriented transportation services; and one for transportation system operations. Each figure is divided horizontally into the three deployment windows. The enabling technologies shown along the migration paths represent the logical sequence of technology deployment and/or system functions recommended.

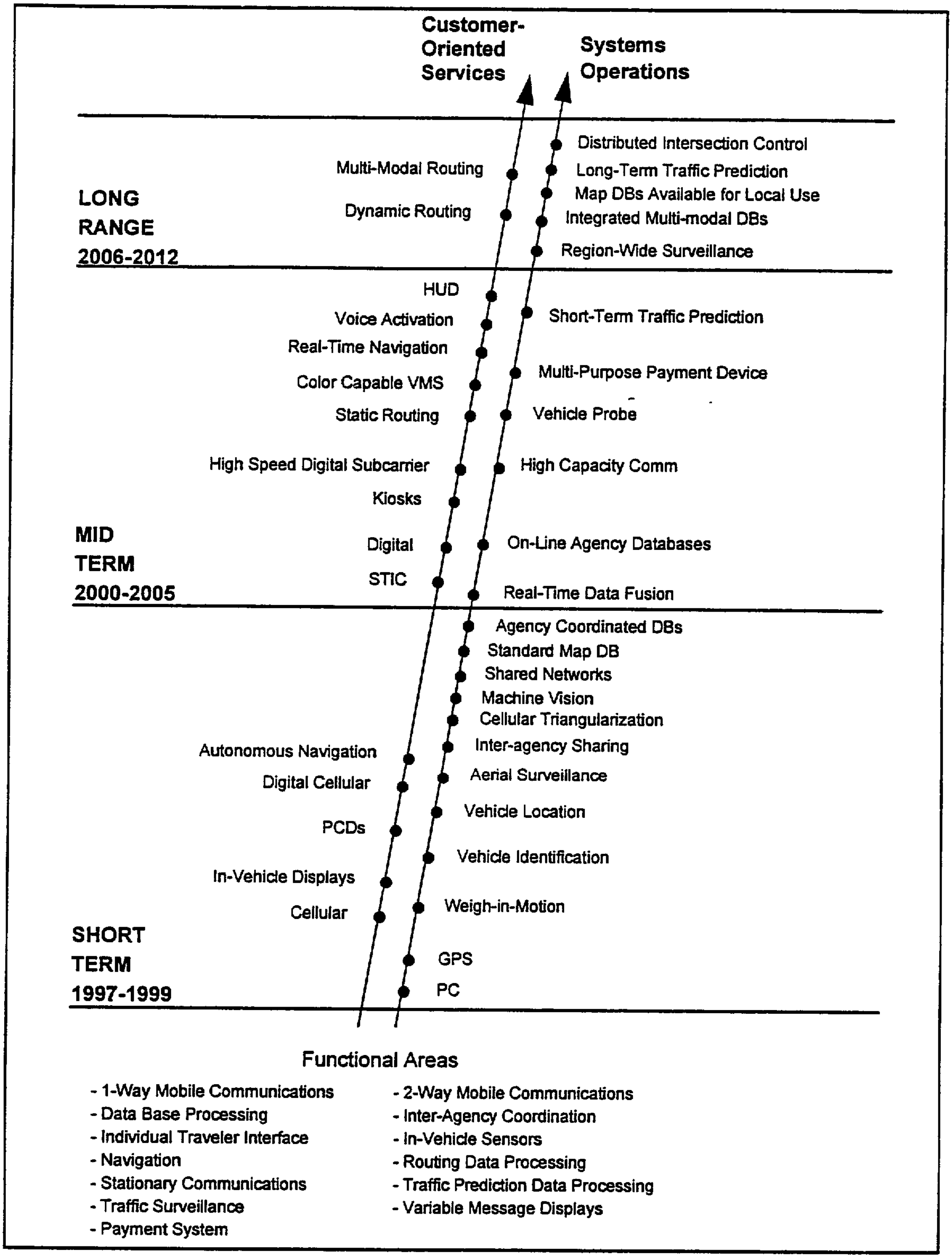


Figure 3.3 Travel and Transportation Management

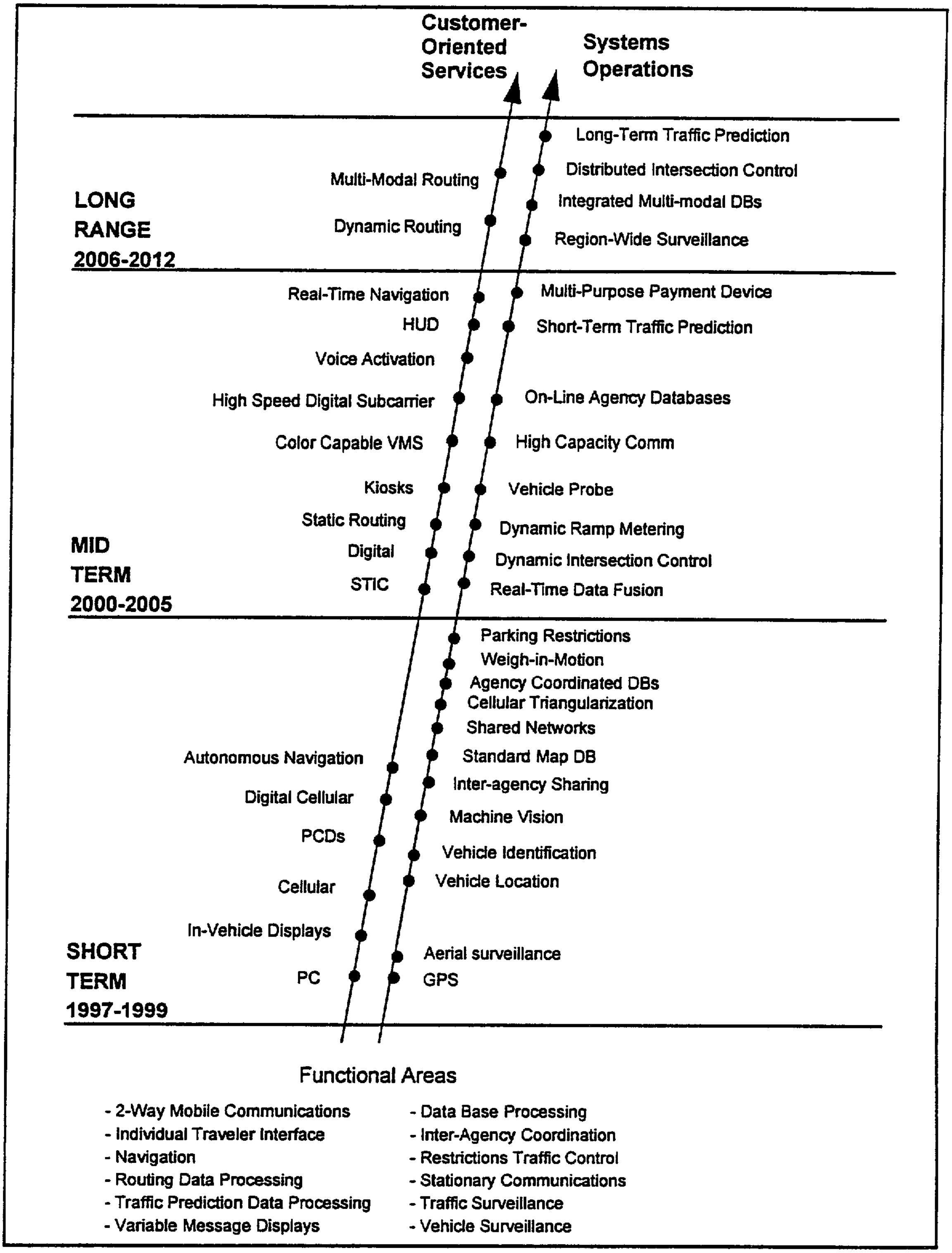


Figure 3.4 Travel Demand Management

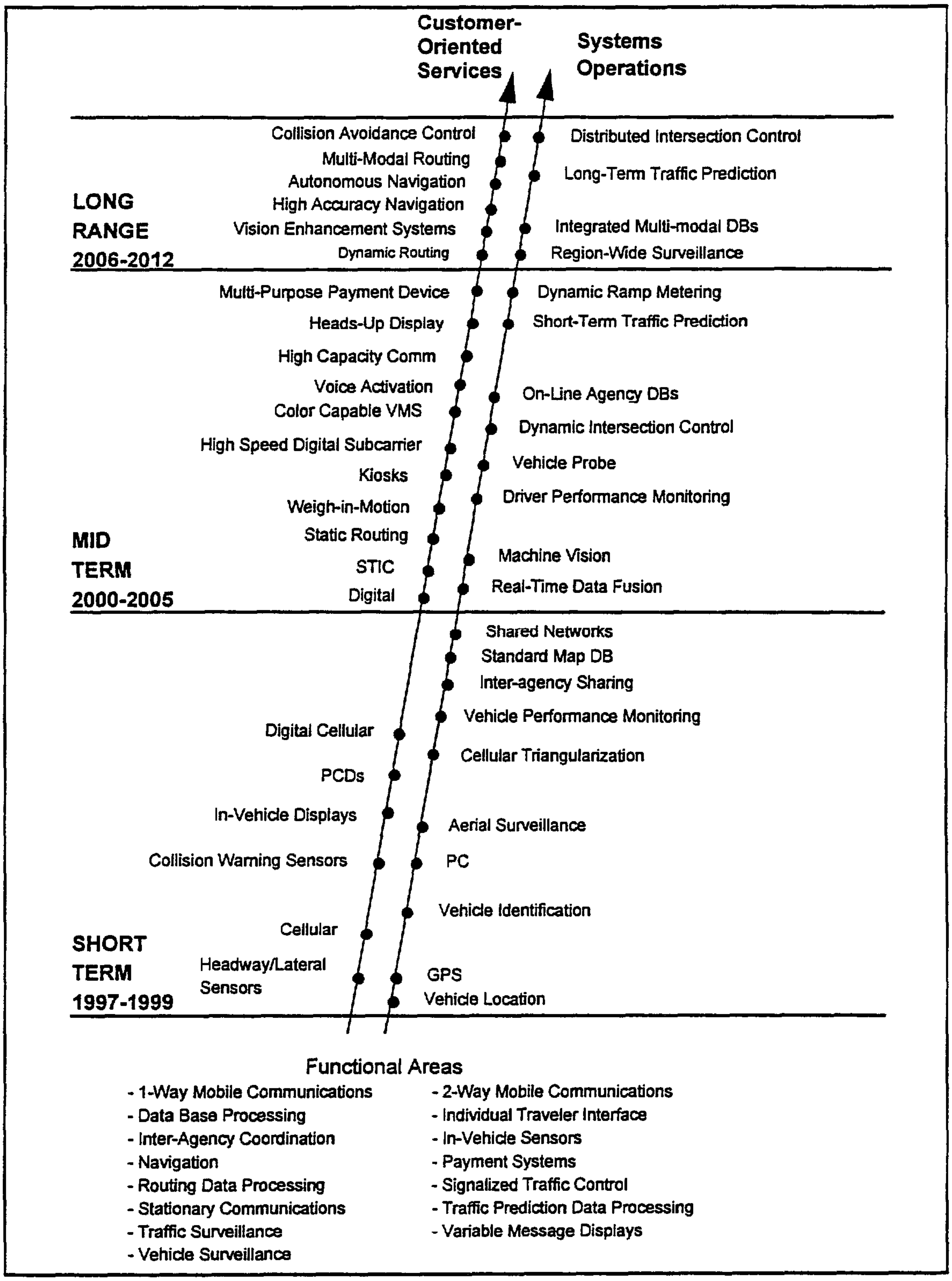


Figure 3.5 Public Transportation Operations

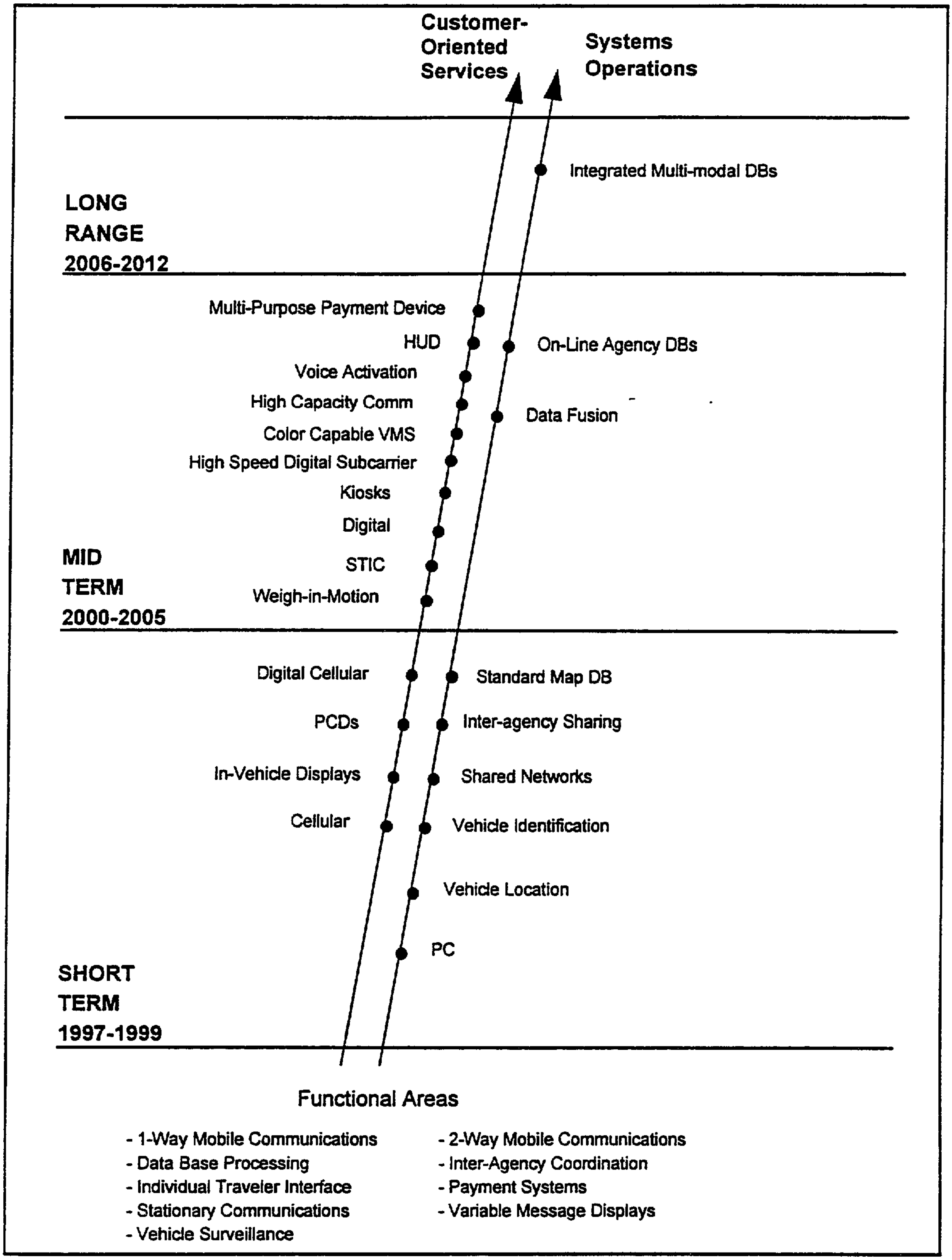


Figure 3.6 Electronic Payment

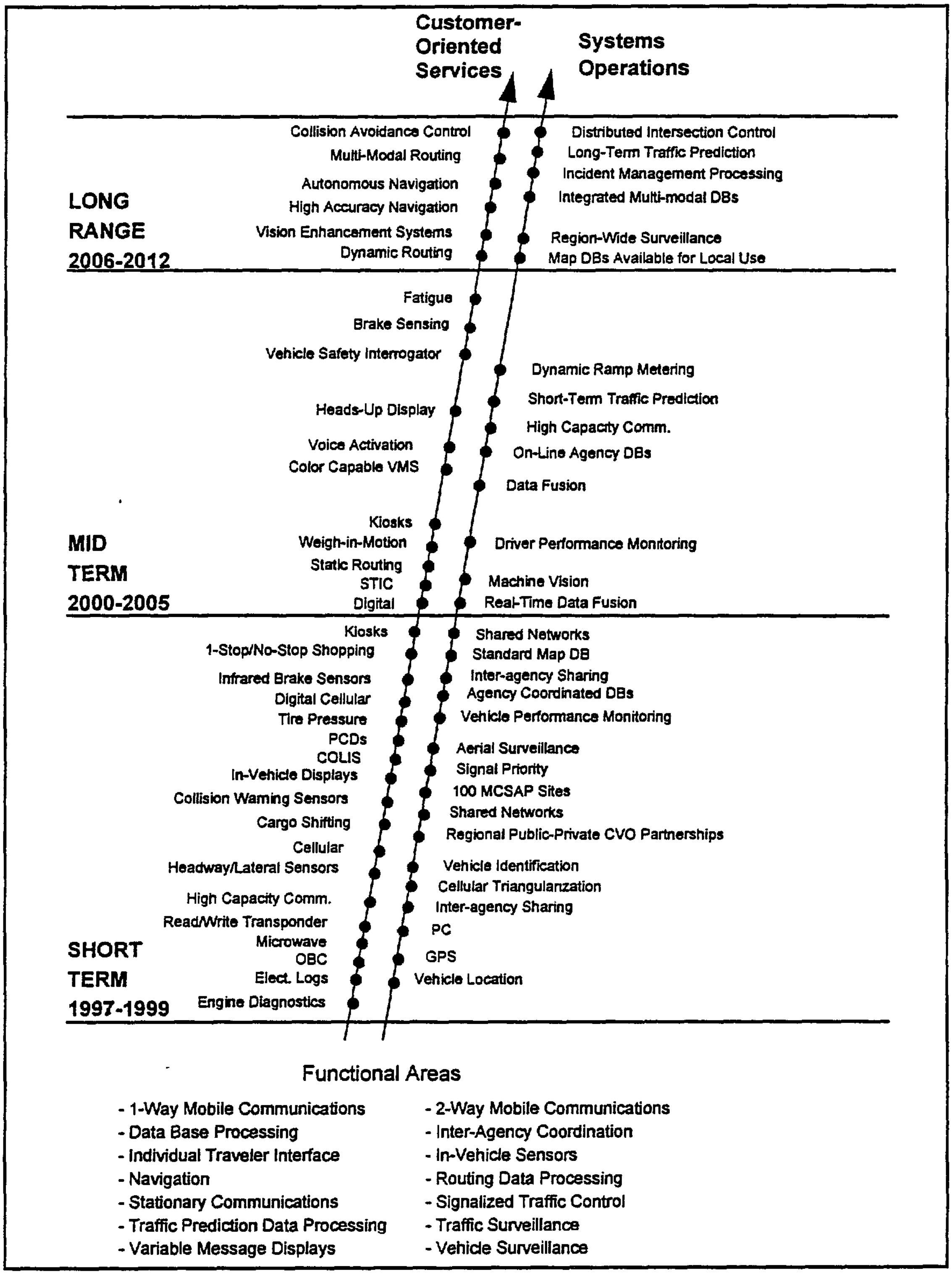


Figure 3.7 Emergency Management

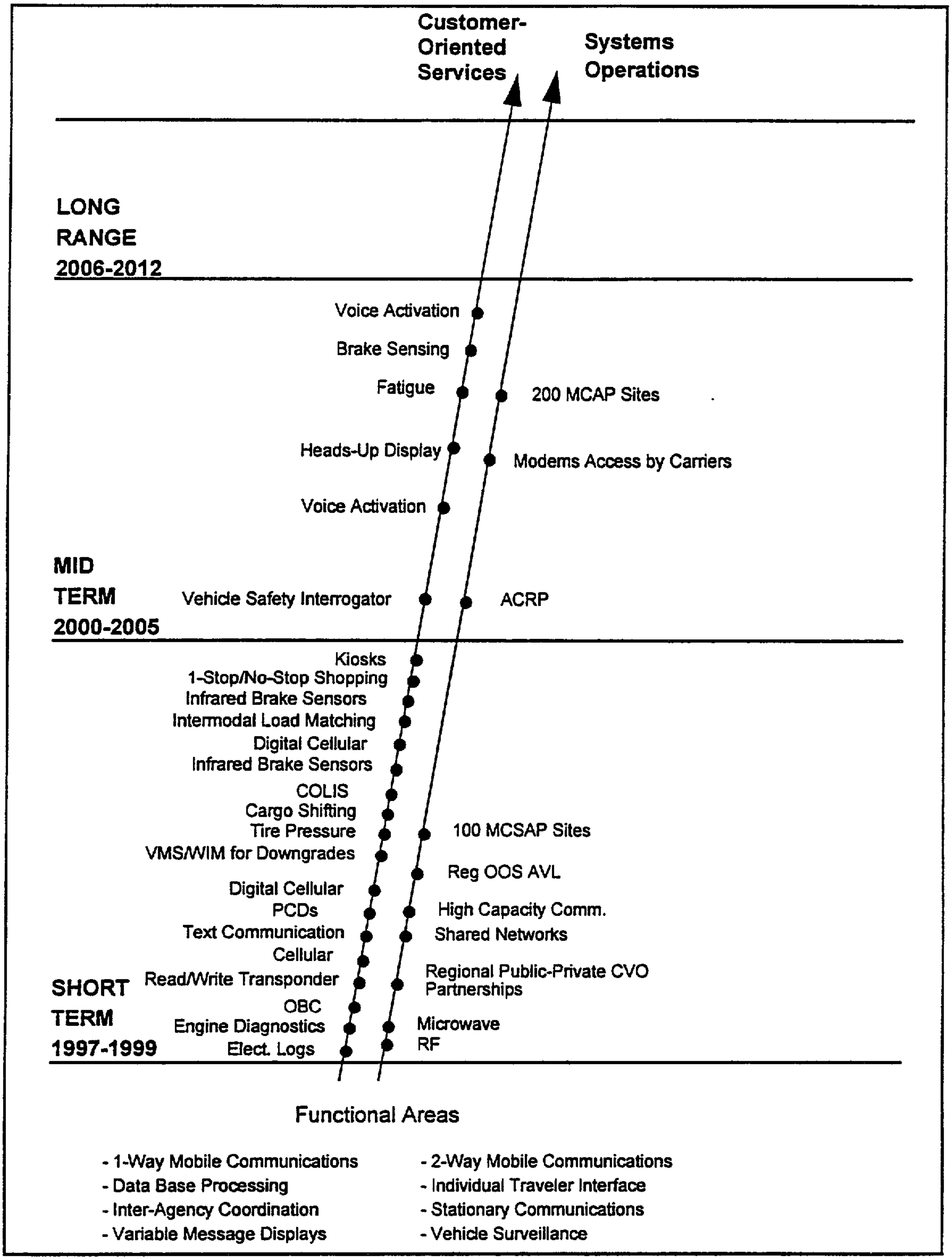
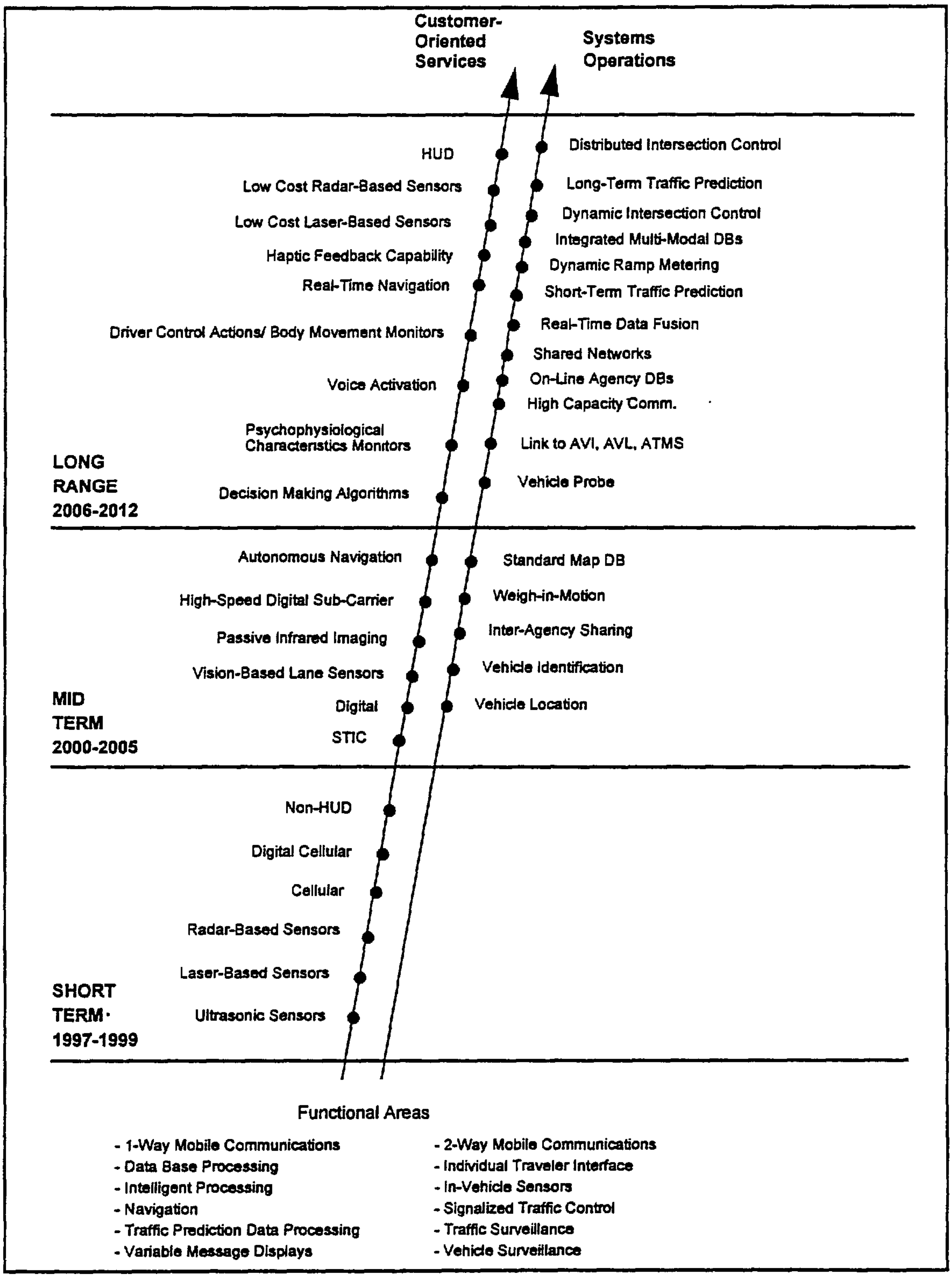


Figure 3.8 Commercial Vehicle Operations



Figures 3.9 Advanced Vehicle Control & Safety Systems

3.6.2 Recommended Services Deployment by Time Frame

From the mapping of the defined user service objective to the ITS user services and the migration paths identified for user service deployment, the recommended user service deployments by time frame are presented in **Table 3-4** below.

TABLE 3-4
RECOMMENDED USER SERVICE DEPLOYMENT BY TIME FRAME

USER SERVICES	SHORT TERM (1997-1999)	MID TERM (2000-2005)	LONG RANGE (2006-2012)
Travel & Transportation Management			
En-Route Driver Information	❍	●	
Route Guidance	❍	●	
Traveler Services Information	●		
Traffic Control	❍	●	
Emissions Testing and Mitigation		❍	●
Travel Demand Management			
Pre-Trip Travel Information	❍	●	
Ride Matching & Reservation	❍	●	
Demand Management & Operations		❍	●
Public Transportation Operations			
Public Transportation Management	❍	●	
En-Route Transit Information	❍	●	
Personalized Public Transit		❍	●
Public Travel Security	❍	●	
Electronic Payment			
Electronic Payment Services		❍	●
Commercial Vehicle Operations			
Commercial Vehicle Electronic Clearance	●		
Automated Roadside Safety Inspection	❍	●	
On-Board Safety Monitoring	❍	●	
Commercial Vehicle Administrative Processes	❍	●	
Commercial Fleet Management	❍	●	

Emergency Management			
Emergency Notification & Personal Security		❍	●
Emergency Vehicle Management	❍	●	
Incident Management	❍	●	
Hazardous Materials Identification	❍	●	
Advanced Vehicle Control & Safety Systems			
Longitudinal Collision Avoidance		❍	●
Lateral Collision Avoidance		❍	●
Intersection Collision Avoidance		❍	
Vision Enhancement for Crash Avoidance		❍	●
Safety Readiness		❍	●
Pre-Crash Restraint Deployment		❍	●
Automated Highway System		❍	●

❍ = Partial Deployment ● = Full Deployment

The recommendations are based on deployment at the regional level, with partial and full deployment targets identified. The recommendation for partial deployment of a user service is based on the projected availability of enabling technologies and technology functions. If all technology functions required to deploy a particular user service are projected to not be 100% deployable in a particular time frame, that user service is defined as not being fully deployable during that time. Therefore, staged implementation is recommended.

3.7 COORDINATION REQUIREMENTS

For some of the core jurisdictions, transportation agencies and organizations in the Northern Virginia Region, strategic planning has emerged over the years as a management tool, however, the study findings suggests that collectively in the region there has been very little, it any, relationship between the strategic planning that has been performed and the day-to-day operation s and budgets of the primary transportation agencies and organizations. This issue becomes even more prevalent in consideration of the impact that region-wide ITS deployment will have on each jurisdiction's, agency's, or organization's existing management philosophy. To date, conventional planning processes have been typically program or project oriented, and have not been oriented to the "system" viewpoint of management.

For the purpose of defining the institutional areas where improved coordination is required by the primary transportation agencies and organizations for region-wide ITS user services deployment, five categories were identified for evaluation: 1) policy;

2) planning; 3) operations; 4)management; and 5) economics. The latter, economics, is defined for this study as the efficiency with which funds available for transportation infrastructive improvements are utilized. Similar to the methodology for mapping of the user objectives to the ITS user services, the local (regional) ITS deployment objectives were mapped to the aforementioned categories. The summary results of this evaluation are presented in Table 3-5.

By comparative analysis to the recommendations for user services deployment, there is a direct correlation to the ranking of user services and the hierarchy of institutional areas identified for improved coordination. This analysis indicates that coordinated management with respect to integrated, intermodal transportation operations, and resulting improvements in system efficiency, is recognized by the jurisdictions/agencies as priority areas for further evaluation as the ITS strategic deployment planning process continues.

It is further recognized that improved total transportation management will effect, to some degree, the operational characteristics of the subsystems comprising the overall system, with the optimization of operational efficiency requiring improved coordination of the transportation policy structure to develop and/or modify comprehensive and cooperative agreements among the core jurisdictions and agencies in the aforementioned areas of management and operations. Specific coordination requirements under each of the above institutional areas will be refined as regional system performance criteria and needed functional areas for ITS deployment are identified, as this study progresses. The development of an effective approach to address these areas requires close coordination with establishing a regional system architecture and supporting communications infrastructure.

TABLE 3-5
SUMMARY OF INSTITUTIONAL AREAS RECOMMENDED FOR COORDINATION

Rank	Institutional Area	Eval. Score
1	Management	28
2	Operations	22
3	Policy	10
4	Planning	9
5	Economics	5

SECTION 4.0 VISION

4.1 INTRODUCTION

Simply stated, the vision for the NoVA ITS is total transportation management capability. This vision is to be achieved through the application of a client-server methodology for information exchange. For Northern Virginia, this methodology is supported by a systems architecture that provides peer to peer information exchange with centralized management coordination.

The vision is also multi-modal in appearance with respect to information processing requirements. The functional decomposition for traffic management – the cornerstone of ITS deployment for the Northern Virginia Region – presented in the Final Report: *ATMS* Implementation *Plan* includes process integration for traffic management, emergency services, public transportation management, and traveler information services. The emphasis with this approach was placed on the data interfaces between numerous existing "legacy" systems currently operating in the region to establish network data exchange and communication protocols. In addition, these existing systems currently operate under an equal number of organizational structures. And, these structures have independently evolved to generate varying requirements for internal information processing and reporting formats with respect to operations and maintenance. Therefore, data recording and reporting formats will also require further attention as the implementation progresses.

4.2 INTERAGENCY OPERATIONS

The analysis of the communication system requirements identifies a need to establish a wide-area-network(WAN) interconnecting the existing operations centers in the region for peer to peer information exchange. It is proposed the network level management function be performed by centralized coordination through a regional Transportation Management Coordination Center (TMCC). The term "center" relates only to the functionality of the total traffic management system.

4.2.1 Management Process Distribution

The architecture recommended for the NoVA ITS infrastructure provides for distributed data processing and control, therefore, management responsibilities can be similarly distributed on the WAN to any number of operating entities. The ultimate control of the individual agency systems remains with that agency. To maximize the efficiency of the process, however, the degree of management process distribution will need to be coordinated and mutually agreed upon by the jurisdictions and agencies involved through collective and comprehensive agreements. While many similar agreements are already in place among the various jurisdictions and transportation agencies in the region, it is expected that some minor adjustments to the terms may be required. This is largely due to the need to minimize overlapping functions of the individual agency systems, when integrated, to maximize regional system efficiency. With the implementation vision, this process can also exist in a dynamic state, i.e., as experience indicates through actual day-to-day operations once the regional network is implemented, the level of participation of the jurisdictions and agencies can be adjusted to accommodate the particular needs of any one individual party, without affecting overall efficiency of regional information exchange and system management.

4.2.2 Interagency Communications System

The vision also maximizes the utilization of the existing and available communication infrastructure for the backbone interagency communications system. The fiber optic (FO) communications backbone currently owned and maintained by VDOT will require some expansion and ultimately have fault tolerant capability, in the event of a communications failure along any segment of the backbone, to ensure continuous real-time data exchange between the majority of the agencies on the network. The current system utilizes, in part, a collapsed-ring topology which cannot provide the degree of protection and re-routing capabilities required in the event of spot failure on the backbone. A systematic program for this expansion is included in the vision to provide self-healing capability to the network.

4.3 INDIVIDUAL AGENCY OPERATIONS

The vision provides and maintains each individual agency's current level of autonomy, unless otherwise agreed upon for a particular need or circumstance. Implementation of integrated operations, however, will require each agency to actively participate in developing an internal plan to consider the NoVA ITS implementation requirements in their current facility maintenance programs and existing or planned system(s) expansion. This consideration is crucial for success in improving traffic management in the region. As the recommended deployment projects suggest, opportunities for public/public and public/private cost sharing will be an integral part of any project deployment, particularly in the emergency management and traveler information services.

The vision also offers opportunity for each agency to maximize its benefit in actively participating through economies of scale. The natural evolution of technology will make these opportunities apparent when they come into existence − and they should not be overlooked.

SECTION 5.0 PROGRAM STRUCTURE

5.1 INTRODUCTION

The contents of this section provide an overview of key elements of the recommended ITS program structure including, system-wide performance criteria, system architecture, and the proposed communication architecture for a region-wide ITS. The base system architecture, and functional processes from which it was developed, are presented in more detail in the Final Report: *ATMS Implementation Plan,* dated April 1996. As described in that report, an integrated approach was developed for overall system management coordination for traffic, transit, and emergency operations. Traveler information, as it relates to these management areas, was also presented.

5.2 PERFORMANCE CRITERIA

By the end of the mid-term deployment phase (2005), critical aspects of the architecture's technical performance and how they benefit network-level and TMCC/TOC operations will need to be evaluated by system-wide criteria. In order to evaluate how successful the system is or has been, a set of performance criteria needs to be developed to measure the effectiveness of the system. These criteria will need to reflect the expectations of the various users of the system. Specific quantitative criteria (i.e. changes in travel time, vehicle occupancy, etc.) alone will not fully gauge the success of the total system. Qualitative assessments such as surveys of the people (i.e. operators, general public) who interact with the system are also necessary. Presented with the following are the key aspects of the system that need to be assessed and the ways to assess these aspects (i.e. Qualitative or Quantitative).

5.2.1 <u>Goals</u>

The formulation of system-wide performance goals helps to describe our understanding of the connections between the system components and overall system architecture, technical performance characteristics, and likely benefits for ITS users. These goals help define the objectives used to evaluate network-level operations and the TMCC/TOC architecture in terms of technical performance and transportation system benefits. For the Northern Virginia Region's ITS, the study team considered functional characteristics, user acceptance, system efficiency, system effectiveness, impacts, and cost in developing specific objectives for measuring performance. The goals and objectives are briefly discussed on the following page.

5.2.1.1 *Network-Level Operations*

The goals for network-level operations contain MOEs by objectives. This breakdown allows the significance of the goal be recognized by the measures identified. An example of a measure of effectiveness is the *accuracy of reported flow rates or vehicle locations* which is mapped to meet the objective *assess the performance of the surveillance system*; this objective was identified to satisfy the first goal below. As for the System-Wide Performance Criteria relating to Network-Level Operations, the following six goals are recommended:

- Assess the performance and reliability of the system and the various components that make up the system;
- Assess the user's (e.g. driver, public official, management, etc.) estimate of value, appraisal of worth, estimate of preference, frequency of use and the willingness to purchase ITS services;
- Develop quantitative measures of operation (service) output/resource (cost) input;
- Develop qualitative measures of the ability of the system to meet established goals:
- Assess the environmental and socio-economic impacts of deployed strategies;
- Evaluate the cost efficiency of the system and/or individual subsystems.

5.2.1.2 *TMCC/TOC Architecture*

For the Transportation Management Coordination Center (TMCC), local Transportation Operations Centers (TOCs), and TMCC/TOC interface architecture, a specific performance evaluation methodology is recommended. The associated MOEs in this area are intended to specifically evaluate the performance of the hardware and software, assess the expendability and potential transferability to other geographical areas, evaluate the cost efficiency, and monitor operational practices in the TMCC/TOCs in the areas of policies and procedures.

A key element to this evaluation category is the identification of alternative architectures and cost options based on actual deployment and to utilize the results of these evaluations to optimize efficiency of the overall system as ITS deployments matures. The goals identified to evaluate the System-Wide Performance Criteria for the TMCC/TOC Architecture are:

- Evaluate the performance of the ATMS/ITS Architecture;
- Evaluate the expendability and transferability of the architecture:
- Evaluate the cost efficiency of the TMCC/TOCs;
- Evaluate operational practices at the TMCC/TOCs.

5.2.2 Performance Criteria

To attain these goals, six (6) objective categories are recommended, they are: system effectiveness; user acceptance; system reliability, performance, and maintainability; impact on transportation system and environment; institutional issues; and benefit/cost/risk analysis.

5.2.2.1 *System Effectiveness*

System effectiveness is among the first criteria that should be evaluated in a system after deployment. It is intended to mainly see if it was effective. Since this system is being deployed not to fulfill any specific quantified objectives (e.g., increase ridership on Metrorail by 10%) but rather to fulfill a broad set of goals (i.e., foster intermodal travel by implementing systems that are better capable of managing the public transportation system and providing improved transit services and mode choice information), its effectiveness cannot be assessed through purely quantitative means.

Evaluation plans for measuring system effectiveness should employ qualitative means such as:

- User Surveys
- Workshops
- Focus Groups

User surveys, workshops and focus groups to assess the users' (e.g. driver, public official, managements) estimate of the effectiveness of the system in fulfilling a particular objective. The surveys should be designed so as to yield information that is comprehensive and lends itself to statistical analyses and interpretation. The goal for the MOE under this category should be to develop qualitative measures of the ability of the system to meet established objectives.

5.2.2.2 *User Acceptance*

User acceptance and willingness to purchase ITS user services is critical to the ultimate success of ITS deployment. User acceptance of the ITS-oriented services provided should be assessed through user surveys. The context of these surveys should assess users' acceptance in several primary areas, such as the users' estimate of value, appraisal of worth, estimate of preference, frequency of use and the willingness to support funding issues and purchase ITS user services in a privatized regional market. The recommended measures of effectiveness in this area are:

- Frequency of use
- Driver preferences and impressions concerning message delivery format
- Changes in demand on driver attention
- Compliance with policies rules, regulations
- Perceived contribution to operational goals
- Preferences for information display alternatives

5.2.2.3 *System Reliability/Performance/Maintainability*

Assessing the performance and reliability of the system and the various components that make up the system is very important in order to identify any weak links in the system and in order to make any changes in the next stage of deployment, if necessary. Performance of the following components of the system need to be assessed:

- Surveillance system
- Data/voice communication system
- Navigation/guidance system
- Database component
- Data fusion component
- Route planning component
- Control strategies
- Traffic modeling component
- Incident detection component

Considerable efforts have been underway in the region to develop parallel performance measuring goals and objectives for the development of the ISTEA Congestion Management System (CMS) and the Public Transportation Management System (PTMS) through TPB/MWCOG and VDRPT. In reviewing the status of these efforts, additional measures to supplement these parallel efforts and specifically, address ITS deployment MOE needs from a systems viewpoint are recommended. As previously described, two primary categories should be considered for evaluation – Network-Level Operations and the TMCC/TOC Architecture.

Network-Level Operations

Measures of performance in this category relate to the assessment of the performance and reliability of the system and the various components of the system. Recommended criteria include assessing the performance of the surveillance system, data/voice communication system, navigation/guidance system, database component, data fusion component, route planning component, control strategies, traffic modeling component, and incident detection component.

Surveillance System

- Accuracy of reported vehicle location
- Accuracy of reported flow rates
- Accuracy of reported link travel times
- Accuracy of reported vehicle speeds
- Accuracy of reported queue lengths

Data/Voice Communication System

- Area of coverage
- Message load supported
- Transmission delay
- Message delivery rate
- Number of vehicles supported
- Variation between design and operational performance

Navigation/Guidance System

- Accuracy of the map data base
- Accuracy of the display vehicle position
- Accuracy of the guidance instruction
- Clarity of guidance instruction

Database Component

- Response time of database
- Static data storage and retrieval
- Dynamic data storage and retrieval

Data Fusion Comoonent

- Relative value of the data sources
- Accuracy of predictions
- Timeliness of predictions

Route Planning Component

- Route quality (time, distance, etc.) of the route planning component compared to user optimal routes;
- Route quality (time, distance, etc.) of the route planning component compared to unassisted drivers;
- Accuracy of route planning predictions;
- Impact of the use of real-time data in the route planning process.

Control Strategies

- Change in the number of vehicle stops
- Change in delay at intersections
- Change in vehicle travel times

Traffic Modeling Component

- Accuracy of traffic volume predictions compared to field data;
- Accuracy of the number of vehicle stop predictions compared to other models and test data;
- Accuracy of the delay at intersection predictions compared to field data;
- Accuracy of vehicle travel time predictions compared to other models and test data.

Incident Detection

- Accuracy of incident detection component in terms of error rate and false alarm rate
- Response time of the incident detection equipment
- Impact of the quality of data on the incident detection component

TMCC/TOC Architecture

Specific performance evaluation methodologies are recommended for the TMCC and supporting TOC architectures. The associated MOEs in this area are intended to specifically evaluate the performance of the hardware and software, assess the expendability and potential transferability to other geographical areas, evaluate the cost efficiency, and monitor operational practices in the TMCC/TOCs in the areas of policies and procedures. A key element of this evaluation strategy is the identification of alternative architectures and cost options based on actual deployment and to utilize the results of these evaluations to optimize efficiency of the overall system as ITS deployments are maturing.

ATMS/ITS Hardware

- Hardware functionality
- Hardware reliability
- Hardware maintenance requirements
- Hardware efficiency

ATMS/ITS Software

- Software functionality
- Software reliability
- Software maintenance requirements
- Software efficiency

Potential Alternative Architectures

- Number and type of system elements which could be simplified to reduce system complexity without compromising system performance;

Architecture Expendability.

- Number and type of system elements which could be simplified to reduce system complexity without compromising system performance:
- Number and type of elements and capabilities which are non-specific to the . Region which could be utilized in other geographic locations.

TMCClTOC Svstem Cost

- Fixed and variable capital costs
- Fixed and variable operating costs

TMCC/TOC Policies and Procedures

- Number and type of areas where policy and procedure impact efficient TMCC/TOC operations or operator workload;
- Number and type of revision to TMCC/TOC policies and procedures recommended to streamline TMCC/TOC operations or operator workload.

TMCC/TOC Staffing Reauirements

- Number and type of difficulties resulting from existing staffing levels experienced during TMCC/TOC operations which effect TMCC/TOC efficiency or operator workload;
- Number and type of revisions to TMCC/TOC staffing levels recommended to streamline TMCC/TOC operations or operator workload.

Alternative TMCC/TOC Cost Options

- Number and type of elements of the TMCC implementation which could be simplified to reduce system complexity without compromising system performance;
- Alternative cost options.

5.2.2.4 Impact on Transportation System and Environment

The synergistic effects the implementation of this system has on other parts of the transportation system need to be identified. Also, the effects on the environment in terms of air quality need to be assessed through air quality modeling studies. Performance of the system in this objective category is recommended to be measured through the following:

- Emission levels
- Transit ridership
- Incidental impacts (non-system user impacts)

5.2.2.5 Institutional and Legal Issues

ITS deployment and implementation will raise a number of new institutional and legal issues due to the extent of cooperation and coordination required between the agencies that will be required for successful region-wide deployment. An evaluation of these issues at every deployment phase is necessary for the success of that deployment effort. An evaluation of the institutional issues should involve:

- Identification of all institutional and legal issues encountered and appraisal of the extent of their impacts:
- Assessing participants' attitudes toward appropriate applications of ITS technologies;
- Identifying all institutional and legal lessons learned;
- Identifying those institutional and legal issues expected prior to deployment:

5.3 SYSTEM ARCHITECTURE

A system architecture is the framework that describes how system components interact and work together to achieve system goals. The architecture describes what the system operation is, what each component of the system does, and what information is exchanged among the components. System architecture may be divided into two kinds: logical and physical. In a broad sense, the logical architecture describes how the information flows as well as from and to which component; while the physical architecture describes how and what technologies are used to fulfill the goals of the logical architecture. Since many alternative technologies may be used to perform the same function in the logical architecture, many alternative physical architectures can be used to fulfill the goals of the logical architecture.

The assessment of functional requirements and the architecture development effort for the NoVA ATMS/ITS includes the following:

- **Identifying System Objectives**
  Identifying specific top-level system objectives for the implementation of an ITS in the Northern Virginia Region based on the recommendations of the User Service Plan.

- **Identifying Architecture Guiding Principles**
  Developing general principles to guide the architecture development so that it fulfills the objectives.

- **Developing a Logical Architecture**
  Identifying the different functional processes that are required to achieve the system objectives and the data flows between these processes.

- **Defining Decision Support Systems**
  Evaluating functional requirements for the different support systems or components that are required to support the processes identified in the logical architecture.

- **Developing a Physical Architecture**
  Involves the development of the physical architecture based on the logical architecture and the support system requirements, while taking into account existing infrastructure, institutional arrangements and issues, and technological factors.

- **Evaluating the Communications infrastructure**
  Identifying the communications infrastructure requirements to support the physical architecture recommended earlier.

5.3.1 System Objectives

The recommended specific top-level system objectives for the implementation of an ATMS/ITS in Northern Virginia are summarized in **Table 5-1.** These objectives are also supported by four principles recommended to guide the development of the NoVA ATMS/ITS Architecture. In conjunction with the system objectives, these principles include:

- Leveraging the existing and planned infrastructure to the maximum extent;
- Assuring equity in benefits and costs while splitting infrastructure elements over different agencies;
- Accommodating increasing levels of system integration in a phased deployment: and
- Promoting interjurisdictional coordination and cooperation.

TABLE 5-1
ATMS/ITS SYSTEM OBJECTIVES

- Incorporate the various components currently in place into a unified system in an evolutionary manner consistent with advanced technology development;
- Integrate a common communications platform to facilitate data sharing, coordination, and policy deployment, through out the various jurisdictions in the region;
- Expand the existing surveillance network to include major arterials and expansion of the traveler information systems to include these areas;
- Provide an integrated environment between the arterial signal control systems and the freeway management systems;
- Provide advanced monitoring features of system field components including controllers, detectors, communications, and other equipment;
- Provide an integrated environment between the traffic control systems and emergency services;
- Provide an automated method for evaluating system performance;
- Support efficient administration of maintenance operations with the development of integrated maintenance management systems;
- Provide ability to exchange traffic flow, systems operation, maintenance information, control commands, and messages between j&dictions and agencies;
- Provide for the management of all related system data in a format that can be easily accessed through industry standard database managers: and
- Enhance user perspective of system status with graphical user interfaces (GUI) to facilitate system management, operations, and dissemination of information.

5.3.2 Logical Architecture

The logical architecture identifies the functions required by the system to meet the user needs and to implement the associated ITS user services. In order to develop the logical architecture, it is necessary to understand the context of the system needed to fulfill the requirements of the related user services. First, the primary categories of external data sources, data providers, and data users are identified. These primary categories are then further decomposed to identify specific terminators in the context of the ATMS/ITS Architecture.

5.3.2.1 *Context Diagram*

The NoVA ATMS logical architecture context diagram, shown in **Figure 5.1,** provides **a** definition of the architecture boundary. It is made up of functional processes and a large number of terminators. The terminators provide the system interface information to support the user service requirements identified in the User Service Plan. The terminators are grouped into the following four categories: Users (Center Personnel, Roadside Personnel, Vehicle Operator or Traveler), System (Center System, Roadside System and Vehicle System), Environment, and other Subsystems (other Centers).

- **User Terminators:** These are the personnel at Center subsystems and Roadside subsystems as well as Drivers and Travelers who interact with ITS subsystems. The primary external data sources, data providers, and data users in this category include:

  Construction and Maintenance: Roadway maintenance personnel, roadway construction personnel, or other work crew personnel.
  Media: Entities which gather or disseminate information to the public (television, radio, newspaper, traffic reporting services, etc.)
  Information Service Provider: Providers of ATMS information.
  Travel Information Provider: Providers of any information oriented towards the traveler.
  Emergency Vehicles Police, fire, ambulance, towing or other special response vehicles.
  Emeraencv Ooerations: Emergency operations centers responsible for managing an emergency fleet (fire, police, ambulance, HAZMAT, etc.)
  Other Control Centers: Other jurisdictions, agencies, and traffic management centers which interface to the architecture.

- **System Terminators:** These are the non-ATMS centers (e.g., government agencies ATMS will interact with), roadside systems (e.g., traditional signals and sensors) and vehicle systems that ATMS will interact with. Primary external sources, providers, and users of this category include:

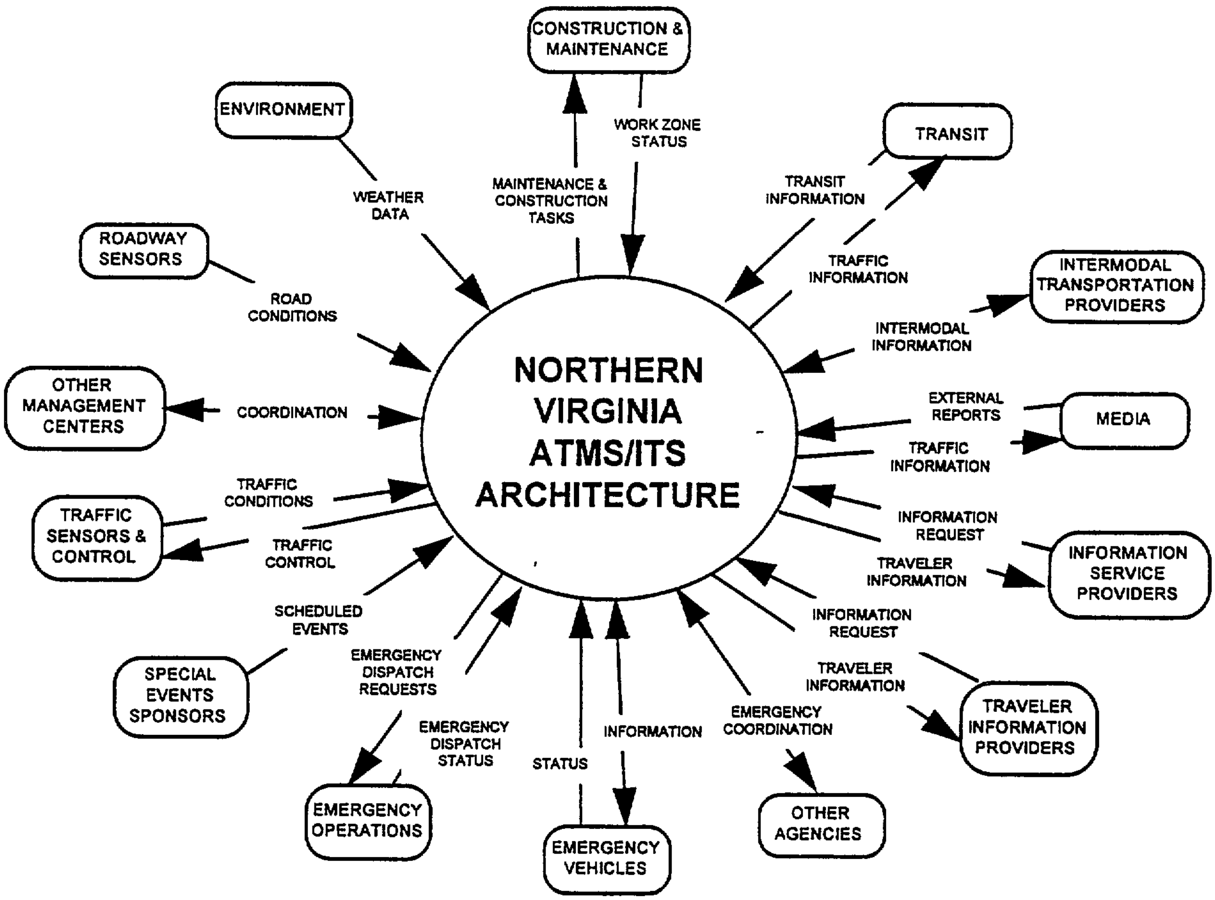


Figure 5.1 - Logical Architecture Context Diagram

Other Agencies: Non-jurisdictional agencies and service providers who may be called to participate in an emergency response.
Transit: Entity(ies) responsible for monitoring, managing, and planning the transit fleets.
Roadway Sensors: Sensors which report roadway conditions.
Traffic Sensors and Control: Traffic flow control and surveillance information.

- **Environment Terminators:** The environment–snow, ice, air quality, etc.–is sensed by ATMS subsystems.

Environment: Sensors which report weather and other environmental (emissions) data.

- **Other Subsystem Terminators:** These represent other operations and information centers that the NoVA ATMS Architecture interacts with.

  Intermodal Transportation Providers: Non-roadway transportation providers (airplanes, ships, trains, etc.)
  Special Events Sponsors: External entities which control, manage, or organize events which may affect the roadway.

As previously noted, the context diagram – Figure 5.1 – represents the functionality required to support external data sources, data providers, and data users associated with the Northern Virginia ATMS/ITS. An overview of the functional decomposition of the logical architecture is provided in the following section.

5.3.2.2 Functional Decomposition

The next step in developing the logical architecture is to group the functional requirements into functional processes. These processes identify the data flow needs between the architecture and the terminators. Four processes are included: traffic management: emergency services; public transportation management; and traveler information services. The modular nature of this architecture allows a phased deployment of functions depending on the needs and funding availabilities of the participating jurisdictions and agencies. The functions performed by each tree of processes are summarized below and described more fully in the Final Report: *ATMS Implementation Plan.*

Traffic Management Process

Includes the functionality needed for the management of traffic in the network. Included are traffic surveillance, traffic control, incident detection, demand management and emissions management functions, plus all associated capabilities. The traffic surveillance, traffic control, and incident detection facilities work closely together to both detect incidents from the traffic data and minimize the impact on the flow of traffic in the network.

A link is provided to the emergency services function so that detected incidents can be reported for action by the appropriate emergency service provider. The functions associated with the Traffic Management Process are:

- Manage Incidents
- Monitor Traffic Flow and Roadway Status
- Control Traffic Flow
- Manage Traffic Demand
- Manage Work Zones

Emergency Services Process

Performs the management functions needed for dispatch and control of emergency services responding to incidents and the activation of law enforcement agencies. It therefore has interaction with the Manage Traffic, Manage Transit, and Provide Driver and Traveler Services functions. The primary functions of this process include:

- Coordinate Emergency Response
- Manage Emergency Vehicles

Public Transportation Management Process

Integrates the transit monitoring functions which apply to fixed route transit services and flexible operations and control transit systems (demand responsive transit). Transit information is provided to the transit driver and transit user directly through this function. Interaction with the Manage Traffic Function is provided to support prioritization schemes at signalized roadway intersections and highway ramps, and also to reflect the overall coordination between transit and traffic management services. The Public Transportation Management Process identifies the functions required to manage both fixed and variable schedule transit vehicles and interface with the Traffic Management Process. It will provide transit scheduling activities including:

- Fixed-route planning and scheduling
- Monitoring transit schedules for schedule adherence
- Disseminating schedule information to travelers, operation centers, and terminals

Traveler Information Services Process

Provides the multi-modal trip planning, route guidance and advisory functions for travelers and all types of drivers. It also enables them to confirm and pay for yellow pages services and provides personal emergency notification functions (Automated Mayday). The multi-modal trip planning function enables trips to include private car and regular transit modes, plus ridesharing, demand responsive transit, and other modes. The Traveler Information Services Process includes functions required to interact with end users of ATMS services, principally vehicle drivers, travelers, and transit users.

- Trip planning
- On-board driver information systems
- Traveler information services

Commercial Vehicle Operations

An information system architecture is under development by Johns Hopkins University Applied Physics Lab (JHU/APL). This architecture, called Commercial Vehicle Information Systems and Networks (CVISN), provides a framework for development of public and private sector data bases and data processing capabilities as well as the interconnection of their networks.

A critical component of the CVISN architecture is the standardization of two interfaces, wireline and dedicated short range communications (DSRC). The wireline interface is primarily used to transfer information between public agencies or between a public agency and a private sector entity (i.e. motor-carrier). The DSRC interface is used to transfer information from a vehicle to a roadside facility. Some of the concepts of operation for CVO specific applications includes the following topics:

- Acquisition/installation of tag
- Enrollment
- Tag initialization
- Mainline screening
- International border clearance
- Driver's daily log
- Vehicle safety inspection
- On-board safety data
- Fleet and freight management

5.3.3 Physical Architecture

Of the four types of physical architectures evaluated – Fully Centralized, Peer to Peer with Decentralized Coordination, Peer to Peer with Centralized Coordination, and Peer to Peer with Permissive Control and Centralized Coordination – the peer to peer with centralized coordination best fit the overall ATMS/ITS deployment objectives for the Northern Virginia Region. The pros and cons to the recommended architecture are presented in Table 5-2.

TABLE 5-2
PHYSICAL ARCHITECTURE ANALYSIS

Recommended Alternative	Pros	Cons
Peer-to-Peer With Centralized Coordination	+ Full ATMS autonomy maintained + Consistent coordination + Information dissemination via common standard channels and interfaces + Inherently fault tolerant	+ Duplicate data processing and display equipment + Added complexity + Additional manpower supporting distributed operations + Central coordination facility to operate and maintain

Peer to Peer with Centralized Coordination is based on the concept that a central regional Transportation Management Coordination Center (TMCC) is established. The TMCC would be responsible for providing regional coordination between the different users and agencies associated with traffic management activities. The TMCC would be manned by representatives from critical agencies which would include VDOT, transit, and emergency services personnel. With the communications backbone providing real-time and comprehensive data from local jurisdictions/agencies and VDOT, required information would be available at the TMCC for analysis as well as decision making. The facility would be the key interface between the Northern Virginia ATMS and other regional traffic management centers including Maryland and the District of Columbia. This architecture is presented in **Figure 5.2.**

The TMCC will utilize low cost computer, data processing, and communications equipment, and would not significantly increase the quantity of operations and maintenance personnel required for the overall system. Personnel utilization would be efficient since the personnel will be able to perform multiple job functions. This would be especially true during emergency situations or times of critical needs. The TMCC would have the ability for operators at the TMCC to provide "hands-off control of field equipment normally controlled by local transportation operations centers. This would allow the local jurisdictions to maintain their autonomy, but would allow operations to continue during off-hours or other times when the primary management center is unavailable. The TMCC would also support the centralized collection and storage of ATMS, APTS, CVO and ATIS data. A database would be created and available for use by all users.

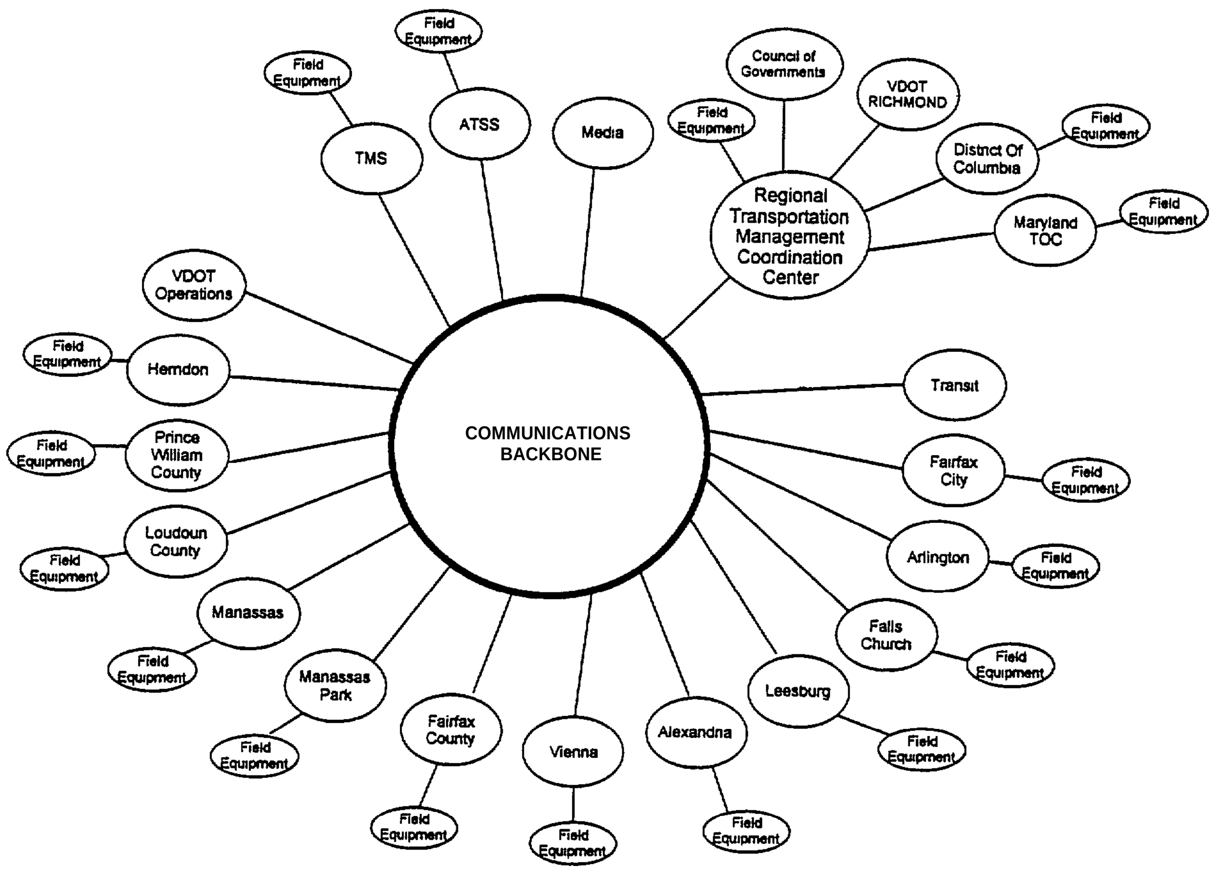


Figure 5.2 - Peer to Peer with Centralized Coordination Architecture

5.3.4 Decision Support Systems

Various support systems are recommended to support the ATMS/ITS architecture for the Northern Virginia Region. These support systems operate with the existing infrastructure and facilitate the transition from the current state-of-the-practice to the implementation vision. The following principles should be enforced:

- **Flexibility** - Variations to system configurations will be controlled through input parameters. Object-Oriented Design (ODD) techniques should be adopted in the development of the support systems to promote flexibility in modifying input parameters;

- **Modularity** - The different agencies and jurisdictions will have unique priorities and fiscal resources over the ATMS implementation time frame. For this reason, interdependencies between the support systems must be minimized. Standard interfaces must be used so independent users have the ability to tailor the use of the support system to their needs;

- **Interoperability** - The support systems deployed by the different agencies must be able to work together (i.e., compatible). At a minimum, they must facilitate the free exchange of information;

- **Maintainability** - Maintainability should be promoted through modularity, high-level programming languages, state-of-the-art software engineering principles and practices, standard operating systems, and general purpose processors.

The functionalities of the proposed transportation management coordination center (TMCC) and networked local traffic, transit, and emergency centers will be augmented by providing operations personnel with new tools for managing data, generating information on the operational status of the network, detecting and resolving incidents, controlling the traffic network, simulating real-time proposed alternatives to control and assess their impact, and facilitating the dissemination of traffic and travel information to other sources. Automated decision support mechanisms are recommended in five (5) areas for the Northern Virginia ATMS/ITS.

- Traffic Management
- System Management
- Analysis and Modeling
- Monitoring
- Communications

Primarily intended to support integrated transportation system operations and management, the support systems are flexible and expandable to other ITS concerns. These support systems and their relationship to the proposed NoVA Architecture are presented in detail in the Final Report: *ATMS Implementation Plan.* This contents of this section provide a brief summary of the categories of required support systems recommended for implementation. Input parameters for planning ATMS/ITS or ITS-related project deployments are also provided.

Traffic Management

Traffic management is responsible for management of the traffic network. All traffic control is performed by the traffic operations control systems in the jurisdictions, TMS, ATSS and others Wide-Area traffic management is proactive and coordinates with the various TOCs for network-wide optimization. Under the NoVA ITS vision, the TOCs are responsible for implementing the optimization by directly communicating with their respective field equipment. This support system category is recommended to be composed, at a minimum, of the following:

- Wide-Area Traffic Management
- Incident Management
- Traffic Control (for Surface Streets and Freeways)

System Management

This category monitors, configures, and manages the ITS assets. Support for planning and scheduling of construction and special events is also provided. The system management category consists of the following support systems:

- Maintenance Management and Repair Scheduling
- Managemenffoperation Center Hardware and Software Monitoring
- Configuration and Inventory Management
- Event Planning and Scheduling

Analysis and Modeling

This category is intended to provide system-wide capabilities for analyzing and modeling all aspects of an integrated traffic and transit network. It is also intended to provide a standardized, common access and entry approach to system-wide analysis and modeling and is composed of five support systems managed by an integrated modeling manager including:

- Origin-Destination (O-D) Processing
- Historical Data Analysis
- Traffic Simulation Models
- Dynamic Traffic Assignment Models
- Signal and Control Optimization Models

Monitoring

This category performs the data processing and provides the necessary controls and interfaces to the operator for monitoring the network. Its functions track the location of vehicles equipped with automatic vehicle identification/automatic vehicle location (AVI/AVL) by displaying them on a graphical user interface superimposed on a map grid; processes the raw image data from closed-circuit television (CCTV) cameras in the field; and processes multiple traffic and environmental sensor measurements to generate link-based estimates of traffic and environmental variables for use by all other support systems: etc. It is consists of:

- Vehicle Tracking
- Surveillance Image Processing
- Traffic and Environmental Monitoring

Communications

Provides the capabilities needed for interfacing with external entities. It receives data from external electronic systems and agencies. Its functions are -responsible for: handling the data scheduling that needs to be transmitted to other systems; transmitting data to destinations external to ATMS which include: ATIS, CVO, APTS, etc.; and collecting data from sources external to ATMS, this includes: AVCS, other ATMSs; Organizational Users (e.g., MPOs); etc. This category also performs communications protocol handling and includes reading the appropriate communications channel, capturing and buffering the data, performing communications integrity checks, and removing communication artifacts (e.g., packet headers and trailers. This support system is composed of the following three systems:

- I/O Manager
- Input Stream Processing
- Output Stream Processing

5.3.5 Communications Architecture

This section provides recommendations on communications technologies to implement the Peer to Peer with Centralized Coordination Architecture. The logical architecture presented the types of information to be transmitted in and between the four major processes associated with the Northern Virginia Region ATMS/ITS. For the analysis presented in this section, the information which will be transmitted within the Architecture requires three basic types of transmission: data, video, and voice.

The peer to peer communication strategy is based on a distributed system architecture, with processing functions and common databases resident at the TMCC and local TOCs. The configuration of the existing VDOT and other agency operations centers, maintenance centers, and agency-owned communications facilities lends itself to this approach. Phased improvements and expansion of this existing communications system will be programmed to allow for ease of future system expansion to share information such as maps, video images, and transportation system information with an unlimited number of sites.

For Northern Virginia, the architecture can be supported by a variety of existing and new communications systems and services. These generally fall under three basic categories: 1) communications between the elements of the infrastructure and with other supporting organizations and agencies; 2) communications between the ITS infrastructure and vehicles; and 3) communications between vehicles.

5.3.5.1 *Major Communication Subsystems*

There are five (5) distinct subsystem classes that share basic functional, deployment, and institutional characteristics for the Northern Virginia system. These classes are derived from the service requirements traceability presented in Section 3.5, which identified the recommended functional concept for regional transportation management coordination including transportation system operations (primary service providers) and customer-oriented transportation services (secondary service providers/end users). For the recommended communications architecture, this functional concept is applied considering the integration requirements of the three basic categories of communications previously described. The five (5) subsystem classes include:

- Regional Management Systems (System Operations)
- Customer-Oriented Service Programs
- Local Center Subsystems
- Network Subsystems (Infrastructure Elements)
- Vehicle Subsystems

These subsystems align closely with the existing jurisdictional and physical boundaries that underscore the operation and maintenance of current transportation systems in the Northern Virginia Region. By mirroring the current transportation environment with the identified subsystems, the subsystem boundaries identify the likely candidates for interface standardization. The architecture recognizes these boundaries to minimize the impact associated with the adoption of the architecture.

Figure 5.3 illustrates how the subsystem classes are recommended to relate to one another through various communications elements or links. These links are recommended to maximize the utilization of the prevailing transportation communication media in use in the region, wireline,

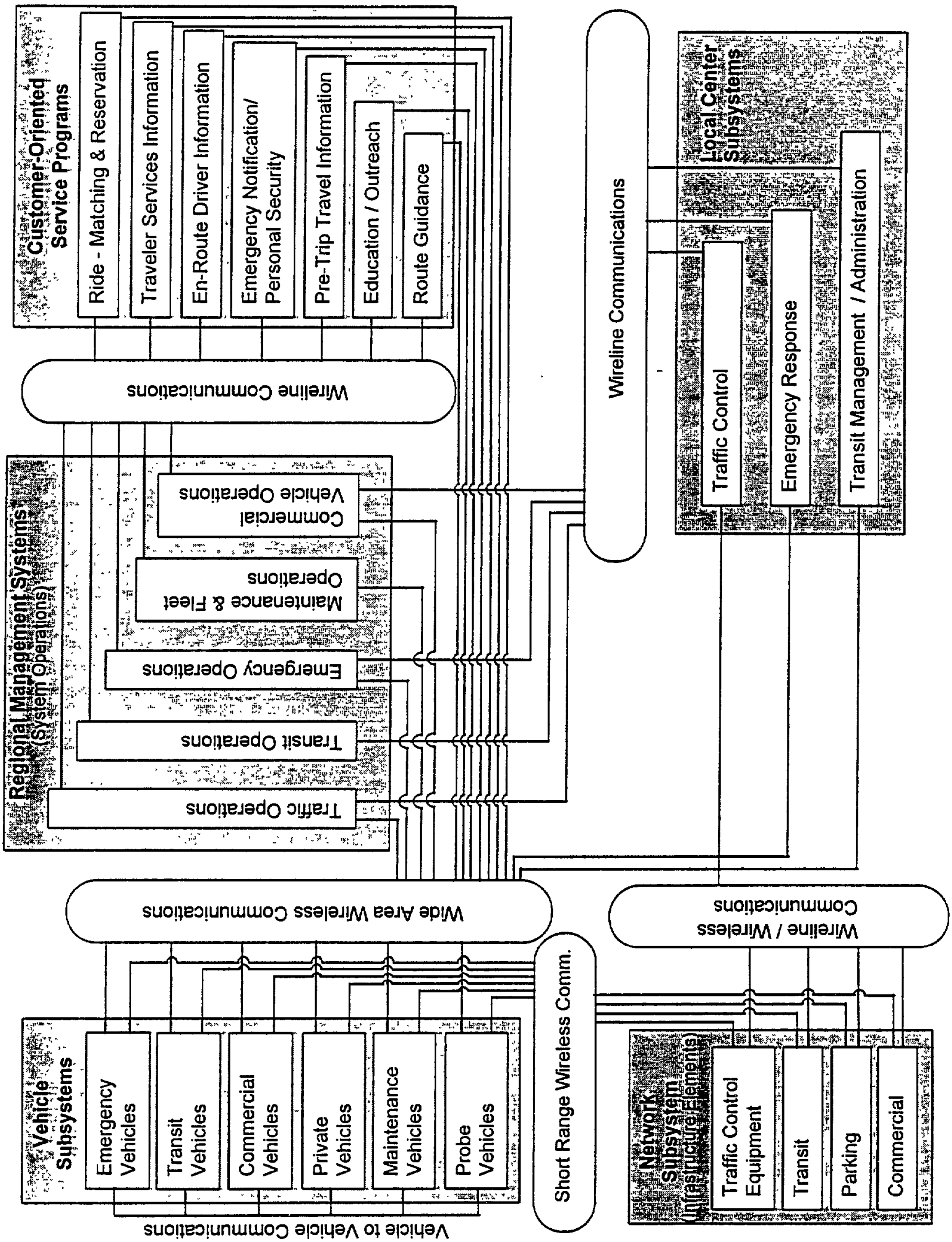


Figure 5.3 - Communications Architecture

and allow flexibility for integrating network and vehicle subsystems. It should be noted that the recommendations of this report vary somewhat from the current communications architecture under development at a national level in that a hybrid of wireline and wide-area wireless communications is foreseen over the time frame considered for ITS deployment (1997-2012) for linkages between the network and vehicle subsystems and the other three elements of the regional ITS communications architecture. Each of the subsystems is briefly discussed.

Regional Management Systems

The regional management systems provide operations management, administration, and support functions for the coordinated regional transportation system. Both public and private sector elements are included as primary service providers. Referring to the functional management concept identified in Section 3.5.1, these systems represent the transportation system operations element of the overall system. These top-level systems are designed to communicate with local center subsystems and customer-oriented service programs. The regional management systems also communicate with the network and vehicle subsystems to gather information and provide coordinated information and management. Five (5) operations areas are recommended to include:

- Traffic Operations
- Transit Operations
- Emergency Operations
- Maintenance & Fleet Operations
- Commercial Vehicle Operations

Customer-Oriented Service Programs

There are seven elements that are envisioned to represent ITS deployment at the secondary service provider/end user level. Deployments under this program are envisioned to be primarily through the private sector, with some overlap with existing public sector service programs in the region, such as ride matching and reservation. These subsystems communicate with the regional management systems and local center subsystems to gather data and real-time information on the status of the transportation system operations and interface with the vehicle subsystems through wide area wireless communications. These seven (7) elements are:

- Ride Matching & Reservation
- Traveler Services Information

- En-Route Driver Information
- Emergency Notification & Personal Security
- Pre-Trip Travel Information
- Education/Outreach
- Route Guidance

Local Center Subsystems

Similar to the regional management systems, the local center subsystems also communicate with the network and vehicle subsystems to gather information and provide information to the regional management systems. They also interface with the network and vehicle subsystems, as applicable, for information exchange. Included in this communications subsystem class are:

- Traffic Control
- Emergency Response
- Transit Management/Administration

Network Subsystems *(Infrastructure Elements)*

These subsystems provide the direct interface to the transportation network, vehicles traveling on the network, and travelers. All network subsystems interface to one or more of the regional management systems which includes overall operations of the infrastructure elements. The network subsystems also generally include direct user interfaces to drivers and transit users and short-range interfaces to the vehicle subsystems to support operations.
This subsystem is comprised of:

- Roadside Equipment
- Transit Infrastructure
- Parking Subsystems
- Commercial Vehicle Subsystems

Vehicle *Subsystems*

The vehicle subsystems are vehicle-based and share many general driver information, vehicle navigation, and advanced safety system functions such as communicating with to roadside and the regional management systems for the provision of information to the driver. The six (6) vehicle subsystems are recommended to include:

- Emergency Vehicles
- Transit Vehicles
- Commercial Vehicles
- Private Vehicles (non-commercial)
- Maintenance Vehicles
- Probe Vehicles

The interconnection between each of the subsystems is accomplished through the communications layer depicted in Figure 5.3. The communication architecture has two main components – wireline and wireless communications. Information transfer will be supported by one or both of these components.

Over the deployment time frame considered by this study, 1997-2012, a combination of both is anticipated for communications between the local center subsystems and the network subsystems. Similarly, wide area wireless communications is envisioned to provide communications between the recommended customer-oriented service programs and vehicle subsystems.

A brief overview of each type of recommended communication is provided as follows:

- **Wide Area Wireless** - Defines a cell-based wireless infrastructure that supports wide-area information transfer. Connections between mobile users or between mobile and fixed connected network users are possible, such as with the current cellular telephone network. Both voice and data are included.

- **Short Range Wireless** - Represents close proximity (less than 50-100 feet) transmission between a mobile user and a receiver. The most common example of this type of communication is at electronically equipped toll booths with the transfer of vehicle identification numbers.

- **Vehicle.to Vehicle** - Includes a dedicated wireless system that is oriented on Automated Highway Systems (AHS) related data flows. This takes place with vehicle to vehicle transceiver radio systems, and is typified with high data rate, low probability of error, and line of sight communications.

- **Wireline** - Addresses the transfer of information between two fixed entities. This interface may use one of the many alternative existing public or private networks.

5.3.5.2 *Communication Infrastructure*

The maximize leverage on the existing communications infrastructure, a systematic expansion of the existing VDOT owned and maintained fiber optic backbone in the Northern Virginia Region, is recommended to serve as the backbone communications medium. The architecture proposed is the Synchronous Optical Fiber Network (SONET) that is currently under implementation in portions of the existing infrastructure supporting freeway management system operations in the region. This network and associated analysis is described in the Final Report: *ATMS Implementation Plan*, including options for the backbone to local TOC communications laterals and is not presented in detail in this section of the Strategic Deployment Plan. Key elements of the proposed phased implementation of the communications infrastructure, however, are presented in Section 7.0 of this report to clarify and depict the overall sequencing priorities for ITS deployment.

SECTION 6.0 KEY DEPLOYMENT ISSUES

6.1 INTRODUCTION

Issues involving deployment encompass various facets; these facets surface at different times over a deployment process but some issues seem to be omni-present. These are technology maturity, resource constraints, and resulting sharing/integrating potentials from the collective consideration of both. The concerns these matters attribute to are being addressed nationally and will continue forth to achieve and assure the success of deploying ITS, whose goals support the vision and missions set forth by *FHWA National Strategic Plan 1996, Highways Make The Connection.*

Technology maturity simply states if the developed and functional aspects of a technology can meet the needs of a user service requirement defined for a system, or even on its own merit, then it can perform what it is designed to do.

Resource constraints refer to the funding and staffing issues concerned by all agencies that is federal, state, and local. Funding issues are addressed in numerous planning documents relating to the Northern Virginia Region. Two key documents are the *Long-Range Transportation Plan for the National Capital Region,* National Capital Region Transportation Planning Board, September 1994 and *Transportation Service Coordination Plan-Eleventh Annual Report,* Northern Virginia Transportation Commission, September 1995.

Staffing constraints are addressed on a local level regarding government downsizing and staff capabilities. And as for the components for sharing/integrating, the Commonwealth of Virginia released the legislative framework for public-private partnerships – under the Public-Private Transportation Act of 1995 – qualifying local governments and other political entities to enter into agreements authorizing private entities to acquire, construct, improve, maintain, and/or operate any transportation facilities.

6.2 TECHNOLOGY MATURITY

Technology maturity plays an important role in the deployment of ITS for the region. ITS deployment principles rely on technology capabilities, without mature technology any practice of ITS services would simply remain a dream. Developed technology can provide assurance to the systems functionality as opposed to a non-developed technology which may be going through its trial and error stages out in a field application. Other factors contributing to technology maturity in a deployment stage are economic issues, standards development, and coordination with the National *ITS Program Plan.*

Recently, the creation of the national Intelligent Transportation Infrastructure (ITI) by the US Department of Transportation, has reclassified the ITS technologies into elements which are both stand-alone and components of a larger ITS platform. Each component of the ITI can be deployed on its own merits. If deployed as an integrated system, however, the performance of these technologies would be enhanced. An example of enhancement would be having the capability for a freeway management center and traffic control center talk to each other and share information. This capability helps the centers manage their system better without necessarily giving up authority and control. Up-to-date or real-time information will enhance the operations of multiple users such as: transit systems, multiple management and control centers, emergency vehicles, etc.

The *FHWA's National Strategic Plan* 1996 states the goals for research and technology as follows: *develop, transfer, and implement technology through alliances with our partners and the international community. By* following FHWA's goal, technology development can be attained in a sound fashion and technology maturity can then be carried over in a sound manner. For this plan, the following areas are addressed:

- Economic issues
- Standards development
- National ITS Program Plan Coordination

6.2.1 Economic Issues

What modes of financing will best serve the region in deploying ITS? This challenging question is posed at many levels of organization, such as regional, state and beyond. As with any other transportation jmprovement project financing is needed to deploy the integral parts of the ITS infrastructure. Fortunately, ITS's goals address the key issues identified in the TPB's *Long-Range Transportation Plan for the National Capital Region.* These issues are:

- Maintaining, Operating and Managing Our Transportation System;
- Limiting Traffic Growth and Reducing Automobile Emissions;
- Serving Diverse Markets;
- Serving Dispersed Population and Employment Centers;
- Moving towards intermodalism; and
- Financing New Facilities.

Recognizing that a large portion of the region's funding will be used for maintaining and operating the existing transportation facilities in the region, ITS's focus-improving the safety and effectiveness of the transportation system-helps to address this funding allocation. The current financially constrained transportation improvement planning process, faced with a transportation infrastructure that is need of billions of dollars, requires the region to identify major new sources of funding. With the current funding mechanisms, this could signify substantial increases in transportation user fees, such as tolls, gas taxes and parking charges.

The state legislature, Virginia's General Assembly, and its members have also determined their legislative agendas and communicated desired actions. Two key issues involving state institutions are:

- Consideration of additional state transportation funding;
- Greater involvement of the private sector in constructing, operating, and financing transportation projects.

An effort to develop major new revenues would require substantial cooperation among the states and local jurisdictions in the region, and much greater public commitment to transportation improvement. It is clear to most people today that, unless fairly significant changes are made in the way the region finances transportation projects, we will not have the resources available to meet the expected demand in the upcoming decades. The distinction between spending and investment should be acknowledged when a decision is being made on financing a project. The implications of economic issues on technology maturity are the possibilities of any missed opportunities or investments an organization may attain from deploying an ITS service.

6.2.2 Standards Development

ITS standards development will accelerate ITS development and deployment. Standards play an important role in product development, system interoperability, compatibility and inter-changeability to ensure ITS components will operate in a consistent – predictable – way and helping U.S. industries gain greater access to the international ITS marketplace. Standards will allow a vehicle to travel anywhere in the country and receive real-time information on traffic conditions using their compliant equipment; and will allow for multiple vendors of equipment and software to directly connect with one another without any adverse effects on overall system performance. Industry standardization will also boost consumer confidence because new ITS products would be more likely to retain their value.

Standards can be developed and adopted for hardware, software and procedures at any level. But there are tradeoffs on having standards, although a standard deployed at one level in a technology would promote competition and flexibility; however, deploying a standard at a different level in the technology complexity may reduce flexibility. Understanding tradeoff issues and developing selection criteria is crucial to the development process. The standard development process requires that certain critical questions be answered. Some samples are listed:

- What type of standards are needed?
- What is the criteria for evaluating and selecting the standards?
- Who is involved in the process?
- Who pays for the development process?
- At which level are interfaces required? National, Regional, Product?
- Since ITS deployment is several years ahead of supporting standards, how will incompatible equipment, made obsolete-by emerging standards, be addressed and retrofitted?
- What is the impact of de facto standards?

The standards will need to have considerable flexibility allowing for future changes in the technology. A standard developed without flexibility will hinder development along with new innovative technologies. Once a standard is developed, premium advanced technologies that are incompatible will not be pursued and will hamper technological advances. Consideration will also have to be given to geographic variability.

Some new and future standards activities that require close attention are:

- Emergency management to other centers - a standard for on-board land-vehicle mayday reporting interface is a new activity that may include emergency . emergency center interface;

- HAZMAT . this is a new standard activity that is crucial to ITS;

- Transit - the US can consider the standards in use in other countries (i.e., Europe and Japan). Some existing and to be developed standards include: wireline data flows for transit management to remote traveler support for kiosks at transit stops; wireless data flow for transit management to transit vehicle communications; etc.

6.2.3 <u>National ITS Proaram Plan Coordination</u>

National compatibility of ITS products and services is important to provide interoperability. Product providers such as automobile manufacturers and software, map, sensor, and communications companies, want to be certain that their products will be technically compatible with related ITS products on a national basis. Traffic information services, phone and cable companies, and toll authorities want to invest in the development of services cars, trucks and homes will be equipped to receive. Transportation departments and organizations want to invest public funds on systems which will function smoothly with systems used by other jurisdictions or agencies and have the capability of expanding to future capabilities.

Today, in the information and communications age, intelligent transportation services have gradually assumed an important role with relatively mature technologies in improving the operation of the Nation's surface transportation system. Some examples are:

- Ramp meters and roadside cameras are common sights along the roadway;
- Vehicle location systems and on-board computers are used to manage fleets by commercial and transit operators;
- Electronic toll collection systems are springing up locally and around the country; and
- In-vehicle route guidance systems are available to consumers.

A successful evaluation of ITS deployment proclaims for dedicated efforts to be directed at reducing the friction inherent in change. The nontechnical considerations may present the more demanding challenges to sustained and widespread expansion of ITS user services. Congress recognizes the importance of nontechnical issues by requiring US. DOT to submit a report assessing these challenges to deployment. Some problems will be posed in the near term, while others could become more serious in later stages of deployment.

Major challenges for near-term deployment of user services are:

- Lack of market information
- Uncertain public infrastructure base
- Competition for scarce resources
- Need for new skills
- Inexperience in partnerships
- Potential loss of privacy

Longer-term institutional challenges are:

- Implication of ITS deployment for society
- Concern for the environment

- Improving procurement processes
- Managing liability risks

Technology maturity is one of the informal challenges according to the ITS National Program. The plan drew several conclusions regarding the appropriate steps that must be taken to achieve national ITS deployment. There is a clear national interest in:

- Realizing the benefits of enhanced transportation management, traveler services, safety, and productivity; and
- Establishing the U.S. ITS market early to gain a competitive global advantage for the domestic ITS industry.

To further this interest, it is recommended:

- The region be more assertive in facilitating the deployment of ITS information and communications infrastructure, leveraging off of private sector facilities and services wherever feasible;
- The private sector retain primary responsibility for the development and commercialization of transportation information delivery and in-vehicle systems; and
- The Commonwealth's Public-Private Transportation Act continues as model legislation for . private partnerships needed for sustainable deployment of ITS user services.

6.3 RESOURCE CONSTRAINTS

There are a host of non-technical constraints relating to ITS deployment and architecture; and there are a host of reports that already address these constraints at both the national and local levels. Some of these are the FHWA *Non-technical Constraints and Barriers to Implementation of Intelligent Vehicle-Highway* Systems. Washington, DC.: U.S. Department of Transportation, and also Horan, T, *Institutional and Policy Challenges to the Deployment of ITS/ATS in California,* Berkeley, CA: California PATH Program, June, 1995.

In this plan, the key limiting resources for ITS deployment in the region will be funding and staffing. Funding is recognized as a scare resource in many if not all areas of deployment either for an ITS project or traditional infrastructure improvements such as expansion of a highway or transit facility.

The region's Long-Range Transportation Plan contains capital improvements, studies, actions and strategies proposed for implementation by the year 2020 and identifies the anticipated cost of major facilities in the plan. Financing is listed as one of the key issues facing the region, including the question of how a more ambitious regional transportation plan can be financed. Three-quarters of the available transportation revenues for the region for the next two decades will be consumed by the operation and maintenance of the existing highway and transit system.

The implication of any constraint is that it can delay the achievement of needed early benefits and increase the costs for all sectors. Consequently, a diversity of approaches for encouraging ITS systems architecture deployment will need to be followed. This includes strategic financial incentives to promote efficient and innovative investment action and facilitating knowledge and participation by both public and private sector to improve training and ensure the successful implementation of ITS.

6.3.1 Funding

In October 1995, the U.S. DOT and FHWA published *Rebuilding America Partnership for Investment-Innovative Financing Handbook Test & Evaluation (TE 045*). A quote from the Federal Highway Administrator, Rodney E. Slator, is as follows:

> *"FHWA can provide national leadership on innovative Financing with the States by creating a record ofachievement . . . the best approach to this challenge is to identify specific projects, develop a plan of finance, and offer those projects as examples of creative financing solutions."*

Substantial changes in the structure of federal transportation funding may occur when ISTEA is reauthorized in 1997. In the meantime, funds of particular interest to the region are generally passed down to states and localities in one of three ways:

- Formula money allocated to the state
- Formula money allocated to the metropolitan planning organization
- Discretionary and formula money allocated directly to transit systems

The state transportation funding sources and the formula by which the funding is allocated have grown and changed over time, resulting in a complicated method of distributing state transportation monies. The bulk of transportation revenues in the state flow to the highway maintenance and operating fund; its sources include gas tax and motor vehicle sales tax revenues, along with fees collected from motor vehicle registration and license plates.

Recognizing the trend in decentralization and downsizing of government services, two required approaches for the region were presented in the *Final Report: ATMS Implementation Plan,* these are: the procurement approach that maximizes the cost sharing potential among the participating agencies: and the implementation approach that ensures quality, provides the needed enhancements (to the region's transportation system) in a timely manner, and produces reliable systems.

Today, most members of the community are relatively clear that significant changes are required in the way the region finances transportation projects, the region will not have the resources available to meet the expected demand in upcoming decades. And it does not appear likely that the federal government will be contributing any new monies in the near future.

The region must then look to innovative funding sources and financing mechanisms if it is to keep up with projected growth. Both of these areas can provide forms of funding ITS deployment to meet the regional and local needs. The former, innovative funding, is addressed in the goals of innovative financing from *Rebuilding America: Partnership for Investment-Innovative Financing Handbook Test and Evaluation 045 (TE 045).* The goals are:

- Create incentives for States to take full advantage of Inter-modal Surface Transportation Efficiency Act (ISTEA) financing opportunities:
- Learn what new financing strategies and policies really work and make the changes that are needed;
- Assist States in their efforts to leverage their current funding and produce additional funds - both public and private; and
- Move projects into construction more quickly than under traditional financing procedures.

As for the later, financing mechanism charges the cost of the system more directly to its users (i.e., a user fee or pricing). Some suggestions for pricing are:

- Special tax district - a particular area agrees to tax itself in order to pay for a facility from which the resident believe they will benefit (e.g., Rte 28 Tax District in the Dulles Corridor);

- Cash-out parking - a system in which an employee may choose to receive employer-paid parking privileges, as most employees in this region do, or the cash equivalent. Employees can make the best use of the benefit available to them.

- Toll - one of the oldest, and new technologies such as Automatic Vehicle Identification (AVI) allow tolls to be deducted automatically from drivers accounts, increasing both the capacity and the safety of toll facilities. Congesting pricing, in which tolls are increased during peak periods, encourages people to share trips during those times or drive at other times.

Recognizing the challenge of increasing infrastructure needs in an era of budget discipline, FHWA and the States must do business in a new way.

6.3.2 Staffing

Aside from funding, the staffing of an ITS facility is also a key concern for the region. A goal identified in the *FHWA National Strategic* Plan 1996 addresses organizational changes, which states:

> *Increase and enhance FHWA's organizational capacity through innovative and effective human resources, information, and administrative management program-s and improvements.*

The staffing requirements to operate and maintain ITS facilities will represent a significant challenge to the transportation and communication industry. While urban institute reports have suggested this demand will be met through the market place, there is nonetheless the challenge of taking necessary training and educating steps to ensure successful deployment and operations.

A key issue for public sector deployment is in the staffing and managing of regional transportation management centers. Locales with operational traffic management centers have operators and technicians with some of the necessary skills and these personnel can be retrained as needed as components of ITS are deployed. A few of the locales in the region do have such capability, which means there is a pool of trained personnel available. This existing staff will form the backbone of the ITS operations and maintenance staff.

As an example, the region's Transportation Operation Center (TOC) has addressed staffing needs as follows:

- Minimum of two (2) fully trained personnel to man off-peak shifts
- Minimum of seven (7) fully trained personnel to man peak use periods (may vary by day of the week and time of day)
- Initial and Current Needs:
  - one (1) Manager
  - two (2)Supetvisors
  - 10 Traffic Controllers (4/l 0 shift rotation)
  - three (3) Traffic Controllers (5/8 shift, hour variety to cover needs)

There are also minimum TOC personnel training requirements, which are:

- 14 days certified dispatcher school
- Three (3) days EIS training
- Three (3) days local computer network training
- One (1) day Highway Advisory Radio (HAR) training
- Three (3) days minimum Advanced Traffic Signal System (ATSS) training
- 60 day formal on the job training

These staffing numbers are transferred from other Operational Sections to TOC and some of these sections are putting their activities to contract.

The skills required for ITS deployment and operations are limited in both the state and local government. But even if skilled staff were available, a strategic shift would be required to redirect staff resources for regional ITS deployment and operations. A lot of the specialized expertise required can be obtained in the private sector by contracting, rather than increasing staff level in the operating agencies to manage ITS deployment and operations. The advantage to this, which the TOC is acting on, is the local governments generally do not have the flexibility to offer levels of salaries and financial incentives that specialists will require.

6.4 COMPONENTS FOR SHARING/INTEGRATION

The components for sharing/integration are obtainable from many directions. Consensus of sharing and integrating is accepted by majority of the agencies/jurisdictions in the region. The region is currently in the process of forming a technical/steering committee from this project to follow through with the actions needed to make ITS deployment a reality. While there are overlapping areas of public and private sector roles, the vision for Northern Virginia is driven by the existing and near-future political climate and the adopted regional transportation policy goals and objectives for transportation infrastructure improvements.

The opportunities for sharing and integrating will be readily available once the building blocks are in place. These are basic technological functions, such as communications or surveillance, deployed for one or more related services, where additional functions needed by one or more related services may require only a small incremental cost in producing additional benefits. The Commonwealth of Virginia enacted the *Public-Private Transportation Act* of 1995 which is the legislative framework qualifying local governments and certain other political entities to enter into agreements authorizing private entities to acquire, construct, improve, maintain, and/or operate any transportation facility.

The fundamental element of the functional concept recommended by the study team is one that is based on cooperation and coordination of the operating transportation agencies and organizations in the region, supports continuing investment in the transportation infrastructure, and creates opportunities for private sector involvement. The customer-oriented transportation services node would consist of various service programs and supporting subprograms established through the secondary service providers and end users in the region.

6.4.1 Public Sector

The results of this study's analyses indicate that successful ITS deployment in the region will be driven by the degree to which the primary public transportation agencies and organizations, as well as private transportation service entities (e.g., emergency services, commercial vehicle operators) can retain their autonomy and solvency in the current business environment of the region through a common objectives structure.

The transportation industry's vision of ITS stakeholder roles has been primarily focused on establishing a coalition structure that is based on public/private sector coordination, cooperation, and potential partnering for transportation infrastructure improvements. The role of the public sector has been seen as the information provider, having the ability to control market access, and serving as the facilitator to achieve the ultimate vision for ITS deployment.

Also on the public sector side, high-technology procurement is generally viewed as difficult for the public sector since it is not amenable to low-bid procurement, etc. Also, establishment of public/private partnerships in the deployment of market-packages can evoke concerns about various practices, such as retention of intellectual property constraints. While the ITS System architecture does not mandate such new arrangements, they are inherent to ITS and therefore need to be addressed as part of the deployment.

Deployment benefits to the end-user are seen as an element that will result from improved coordination of transportation system operations at an intermodal level. Overcoming credibility problems with existing operations and improving public image of the primary transportation service providers through improved service reliability were noted as key factors to successful regional ITS deployment. Accordingly, the near- and mid-term projection for ITS user services deployment is envisioned to integrate the primary service providers, both public and private, for transportation in the region. This functional concept, presented in Section 3.5.1, identifies the core management systems, supporting subsystems and the proposed user services recommended for deployment under each. The core management systems and its supporting subsystems are:

- Traffic Operations
  - Freeway Systems
  - Arterial Systems
- Transit Operations
  - Local
  - Interregional
- Emergency Management
  - Fleet Management
  - Response Coordination
- Commercial Vehicle Operations
  - Fleet Management
  - Administration

6.4.2 Private Sector

On the private side of the public/private partnership equation, emphasis has been placed on the infrastructure improvements, developing pro-active marketing programs to promote advanced technology applications, and driving technology development in a very competitive, product-oriented market. This element of the functional model is "demand" oriented and primarily serves to function as the information provider to the system end users and secondary service providers, control market demand on transportation system operations, and provide the interface to information support services in areas that are non-transportation oriented.

The ITS customer-oriented transportation services are recommended to be deployed primarily through various service programs at the private level. The agency level service programs are proposed to be networked with the remaining service programs recommended for the region: traveler information services; emergency services; and public media programs. These service programs are intended to provide an interface with the functional model for transportation systems management coordination through secondary-service providers and the end users of the system. As with the concept for transportation system operations the core service programs for deployment under each are as follows:

- Public Agency Services
- Private Agency Services
- Traveler Information Services
- Public Media Programs
- Emergency Services Programs

SECTION 7.0 REGIONAL ITS DEPLOYMENT RECOMMENDATIONS

7.1 INTRODUCTION

Wide spread deployment of ITS services in Northern Virginia will result from a multitude of individual deployment decisions by public agencies and the private sector. These individual implementations resulting in 'islands' of ITS capability will be linked through the application of a client server methodology for information exchange. For Northern Virginia, this methodology is supported by a systems architecture that provides peer to peer information exchange with centralized management coordination. The phased implementation plan presented herein builds from the NoVA ATMS architecture definition to specific implementation recommendations for region-wide ITS deployment. Through these recommendations, the implementation strategy provides a general vision of how an efficient deployment of systems compatible with the NoVA ATMS architecture can take place over time.

7.2 ITS OPPORTUNITIES

Advanced technology applications provide an opportunity for the region to address transportation system needs and improvement opportunities in the following categories :

- Transportation and land development
- Transportation, environmental, and energy
- Congestion management
- Transportation for persons with limited mobility
- Interregional transportation
- Transportation systems

Transportation and Land Development

Ultimately, ITS deployment initiatives will introduce, on a large scale, the next generation of transportation planning and management concepts at the systems level. This will be accomplished through the utilization of ITS functions to integrate the six (6) monitoring and management systems mandated by ISTEA. The ultimate development of expert systems and predictive, pattern recognition techniques will enable systems integration with the comprehensive land-use planning models through the interaction of the dynamic databases for each system.

Transportation, Environmental, and Energy

Through improvements in the regional transportation network operations, the increased efficiency realized by ITS applications will serve to minimize adverse effects on human health, the environment, and energy consumption. At the present state of ITS development, the potentials for mitigating significant environmental issues relative to transportation network operations are just now being recognized. One of the most promising potentials for realizing benefits of ITS deployment in this objective category is the development of advanced vehicle diagnostic systems and their interface to the ITS infrastructure via linkages of Vehicle-Area Networks (VANS) and the transportation system's communications infrastructure. Linked to the infrastructure via vehicle-to-roadside communications, the potential to more accurately monitor system(s) performance with respect to environmental impact and energy consumption are foreseen – improvements that will have significant impact not only on the efficiency of transportation system operations, but the overall quality of life in the region, as well.

Congestion Management

Of the transportation objective categories identified by the TPB for the long-range plan, this objective category most closely parallels the underlying philosophy of ITS deployment. At issue, however, within the region and throughout the industry is the redefinition of "congestion" as it relates to a systems approach to transportation network-level analysis. The issue at hand is what is the preferred way to manage congestion, modal or intermodal by corridor and/or trip origin-destination data. The potential for ITS technology applications to address the most efficient means to evaluate this issue relative to region-wide systems deployment is very high.

Transportation for Persons With Limited Mobility

This is an area that has received considerable attention over the past years, and has become one of the key factors in evaluating the potentials for ITS technology applications to public transportation services. Public transit operations in a dynamic state, versus fixed route, is rapidly becoming recognized as a significant tool to immediately address congestion of the transportation network. It also has the potential to enhance public transportation and general mobility of the region's growing elderly and handicapped population, and thus has particular significance to evaluating demographic issues relating to transportation system planning.

Interregional Transportation

Interregional system planning and development is of particular concern in considering the extent to which ITS technologies will play a role in coordinating intermodal transportation infrastructure improvements with the Northern Virginia Region's neighboring areas. It also is of particular significance in evaluating user service objective and planning compatibility issues relating to systems development, not only within the National Capital Region, but the eastern United States, under the ITS Priority Corridor Program (I-95) initiatives, as well.

Transportation System

Evaluation of the adopted transportation system objectives for the region are of extreme importance in this study's evaluation due to the nature of the perception the long-range plan presents in addressing systems applications. This perception is to develop and fund an inter-modal transportation system that meets the region's transportation goals and objectives, as well as supports the region's development, environmental, social and economic goals. As the objectives state, consideration is given to the continuing development of the ISTEA management systems, namely: pavement; bridge: inter-modal facilities; public transportation facilities; and equipment management systems. The development and implementation of a coordinated system of public transit and traffic facilities is also addressed.

7.2.1 Sequencing Priorities

Deployment priorities are established by evaluating the ranking of user service deployment needs against the system functions presented in this report. Seven of the user services were evaluated in the development of the ATMS Implementation Plan for the region. This report was a separate deliverable under this study.

The Final Report: *ATMS Implementation Plan* identified 16 of the total 29 user services as deployment targets. Of these 7 were considered primary service areas under the ATMS deployment strategy.

- Incident Management
- Traffic Control
- Emergency Vehicle Management
- Electronic Payment Services
- Public Transportation Management

- Route Guidance
- Commercial Vehicle Electronic Clearance

The ATMS interface requirements with traveler information systems was also presented in that report. These priorities were recommended to be addressed over the next 1-8 year time frame, coincident with the end of the mid-term (2000-2005) deployment window.

Commercial Vehicle Electronic Clearance was proposed to be implemented under other ITS deployment areas, namely the Commercial Vehicle Operations service bundle. The deployment of user services in this bundle is largely dependent on federal and state regulatory requirements and private sector involvement, through the recent Commercial Vehicle Information System Network (CVISN) initiative and therefore are not considered in this report in detail. Information exchange requirements and regional efforts to support state-level programs are considered, however, in the recommended ITS deployment strategy.

The remaining 9 of the 16 target services were considered as secondary services relative to the region's ATMS deployment needs in the ATMS implementation Plan.

- En-Route Driver Information
- Emergency Notification & Personal Security
- En-Route Transit Information
- Public Travel Security
- Demand Management 8 Operations
- Personalized PublicTransit
- On-Board Safety Monitoring
- Emissions Testing & Mitigation
- Automated Roadside Inspection

Similar to Commercial Vehicle Electronic Clearance, the application of advanced technologies to provide Automated Roadside Inspection capabilities is considered to be primarily under the Commercial Vehicle Operations bundle. In addition, 2 of the 13 other user services -Commercial Fleet Management and Commercial Vehicle Administration – are recommended for deployment under the region's numerous private, commercial transportation service providers in addition to the regional element of the interstate trucking industry under the Commercial Vehicle Operations user service bundle.

For the overall ITS deployment program the remaining user services, including HAZMAT Incident Response, Ride Matching and Reservation, Pre-Trip Travel Information, Commercial Fleet

Management, Traveler Information Systems, and Commercial Vehicle Administration are considered. One aspect of CVO that merits emphasis is that while the deployment of the user services under this bundle is dependent on the CVISN initiative and mostly perceived as benefiting interstate trucking, the opportunities for local trucking service, and distribution fleets (Ex. FedEx, UPS, etc.) cannot be ignored. Local trucking and distribution services are expected to deploy fleet management systems to optimize schedules, routing and maintenance. Such fleet management systems will be able to use and benefit from the wealth of traffic data available from the NoVA ATMS, and vice versa..

Of the 29 user services, seven (7) fall under the Advanced Vehicle Control Systems bundle. The enabling technologies for these user services are still at different stages of development. The development and deployment of these user services is driven by the private sector, as these technologies are mostly in-vehicle technologies to improve passenger safety. The only aspect of AVCS that concerns regional deployment is the ability of the infrastructure to support and integrate these technologies as they are deployed.

7.2.1.1 *Transportation System Operations*

The deployment recommendations for the NoVA ITS may be broadly divided into two categories: System Operations oriented and Customer Services oriented. The System Operations oriented user services are those that directly impact the operation of the transportation system. Seven such user services were identified and recommended for deployment in the ATMS Implementation Plan. The required functionality for these user services is provided through management systems deployed in the TMCC and other supporting systems deployed in the local TOCs. Due to their interregional and interstate connotation, the user services in the CVO bundle which also directly impact system operations were not considered in the ATMS Implementation Plan. However, as mentioned earlier the opportunities for local trucking services and distribution fleets cannot be ignored and hence these user services are included in the Strategic Deployment Plan.

7.2.1.2 *Customer Oriented Services*

Customer Oriented services are value added services that utilize data generated by the system operations oriented services to provide enhanced services to paying customers. These services are envisioned to be provided by information service providers who tailor the information according to the specific needs of their customers. While these services will have an impact on the system operations, the extent of such impact is dependent on the market penetration of these services. Some of the customer oriented services recommended for this region are:

- Ride Matching and Reservation
- Traveler Services Information
- Emergency Notification / Personal Security
- Pre-Trip Travel Information
- En-Route Driver Information

Ride Matching and Reservation

Ride Matching and Reservation is a key Demand Management strategy for reducing roadway vehicle demand by developing and encouraging ridesharing as an alternative form of travel. The Advanced Ridesharing and Travel Information System operational test involving the Potomac and Rappahanock Transportation Commission and the Instant Carpooling project for the Shirley Highway represent opportunities the region can build upon.

Traveler Services Information

This service will eventually provide travelers with access to information regarding a variety of travel-related services and facilities in an yellow pages format. The region should encourage and build upon initiatives such as the information kiosks in Alexandria and Manassas set up by local vendors. Opportunities to involve the tourism and hospitality industry in the region and information exchange with the National Capital Region Traveler Information Showcase should be pursued.

Emergency Notification / Personal Security

Automatic Mayday devices that automatically notify independent service providers in case of an accident are presently being introduced and are expected to be commonplace in a few years. Their potential for reducing incident notification and reaction time is immense. The region should explore possibilities for partnerships with such service providers in incident management. Further, concerns of personal security may discourage the use of certain modes of transportation. Security enhancements such as CCTV surveillance and emergency call boxes at intermodal facilities will encourage use of alternative modes of transit.

Pre-Trip Travel Information

The National Capital Region Traveler Information Showcase, which is expected to be deployed in the next three years, will provide Pre-Trip Travel Information through a host of Independent Service Providers. This presents an opportunity for the agencies in the region to participate and benefit from the additional surveillance and information dissemination infrastructure that is deployed as part of the project.

En-Route Driver Information

The National Capital Region Traveler Information Showcase mentioned above will also provide enroute driver information through in-vehicle devices. It is envisioned that the agencies in the region will participate and benefit through information exchange with the showcase project.

7.2.2 Phasing Criteria

The deployment phasing for ITS deployment in NoVA builds upon the foundation of the primary user services to provide the secondary user services. The deployment of the primary user services recommended in the ATMS Implementation Plan will bring into place supporting infrastructure for the deployment of the secondary user services.

- Establishing the Regional Information Exchange Network will make more information available to the information service providers to disseminate to the public. These considerations are given particular attention with the project deployment recommendations in the 3 - 6 year deployment time frame.

- Similarly, the completion of the TMCC and the coordination of traffic and transit operations through the Traffic/Transit Data Exchange project will make it possible for the Information Service Providers to provide enhanced services to travelers. These considerations are given particular attention with the project deployment recommendations in the Post TMCC (6-12 year) deployment time frame.

- In-vehicle technologies such as En-Route Driver Information Systems and Automated Mayday systems being developed by the private sector are expected to mature in the next five to seven years and hence their deployment is expected in the 6-12 year deployment time frame. These technologies will further evolve to integrate with AVCS technologies and hence their deployment may extend into the long term (10 - 16) deployment time frame.

7.2.3 Communications Infrastructure

The Communications Infrastructure to support ITS deployments in Northern Virginia is anticipated to be developed through the deployment of the 12 core projects identified in the ATMS Implementation Plan. The existing fiber optic network is proposed to be expanded to form two fault tolerant rings. The participating agencies can connect to this fiber backbone through a communications medium of their choice. The communications infrastructure is envisioned to be deployed in eight stages.

Stage 1: Initial Regional Center Network

- Laterals to TOC (NoVA) District), VA State Police(Fairfax) for voice, data, video
- Dial-up access with other major centers (MWCOG, MDSHA, DCDPW, VRE) for short-term

Stage 2: Phase I Fiber Optic Backbone Expansion

- Interface with Dulles Toll Road fiber backbone
- Expand fiber optic backbone along Dulles greenway to Leesburg
- Extend fiber optic backbone to Rte. 234 along I-66

Stage 3: initial Arterial Signal Systems and Emergency Service Providers integration

- Laterals to Arlington County and City of Alexandria for voice, data, video
- Initial "real-time" data exchange with NoVA ATSS (Note: ATSS covers Fairfax, Loudoun & Prince William Counties with exception of cities and towns within)
- Laterals to local Emergency Service Providers

Stage 4: TMCC Phase I

- Initiate integrated traffic/emergency management operations coordination
- "Enhanced" TOC
- Establish data and video links with all media
- Establish "on-line" links with other major centers(MWCOG, MDSHA, DCDPW, VRE) via leased line (possible direct fiber link from TMS to DCDPW)

Stage 5: Initial Transit Data Exchange

- Establish real-time data exchange with transit for schedule adherence, system status, coordinated emergency operations.
- Laterals to interregional (WMATA, VRE) and local (Alexandria DASH, Arlington Trolley, City of Fairfax CUE, Fairfax Connector, PRTC Commuterride, Tysons Shuttle)

Stage 6: Additional Arterial Signal Integration

- Laterals to remaining jurisdictions (Cities of Fairfax, Fails Church, Manassas; Towns of Vienna, Herndon, Leesburg, and Manassas Park) for voice, data, video
- Provide "central system" status for those jurisdictions that currently do not have central systems to access/exchange data with TMCC.

Stage 7: Phase II Fiber Backbone Expansion

- Complete Fiber Backbone with installation in Rte. 234 and U.S. 15 corridors
- Install additional fiber on I-66 for full ring topology

Stage 8: TMCC Phase II

- Complete TMCC deployment
- Provide "ports" for future expansion/interfaces with other TMCC management systems

For the purpose of providing a comparative analysis of the various communication technologies and options for the lateral communication links to accommodate the proposed architecture, a cost analysis was performed. initial and life-cycle costs were generated. Three technologies (fiber, leased line, and wireless) were evaluated. With in each communication technology category, the alternatives were further decomposed to evaluate the options for full video, high speed data and voice, and low speed data and voice exchange capabilities. **Tables 7-1** summarizes the projected initial costs for the three alternatives. It is important to note that the cost analysis is based on a homogeneous application of each technology alternative and option to compare costs.

It is assumed that over the ATMS deployment period the existing fiber network will be expanded to form two rings so as to make the backbone fault tolerant, as previously described. This expansion is expected to cost $28,859,332 and is common to all options and technologies considered.

The initial cost to have full video capability for the local centers utilizing the fiber communications technology is estimated at $52,973,700. To obtain the same communications capability, the initial cost for utilizing the T-l leased lines is $8,776,812 and the Microwave is $25,594,000. Other communications options are as stated in the table. For further details about the cost analysis the reader is referred to the *ATMS Implementation Plan* for this region which was a separate deliverable under this study.

TABLE 7-1
INITIAL COSTS FOR LATERALS FROM LOCAL CENTERS TO FIBER BACKBONE

COMMUNICATION TECHNOLOGIES	COMMUNICATIONS OPTIONS		
	LOW SPEED DATA & VOICE	HIGH SPEED DATA & VOICE	FULL VIDEO
FIBER		$50,845,200	$52,973,700
LEASED LINES (DS-3 & DS-1)			$8,776,812
LEASED LINES (T-1)		$4,059,276	
MICROWAVE		$17,115,000	$25,594,000
LEASED LINES	$267,300		
LEASED LINES (28.8-Kbs)	$205,425		

Note: An additional $28,859,332 is required for expansion of existing fiber backbone with each of the above options. The cost figures shown in the table do not include this amount.

Figures 7.1 to 7.6 on the following pages depict the state of the network after each stage of deployment.

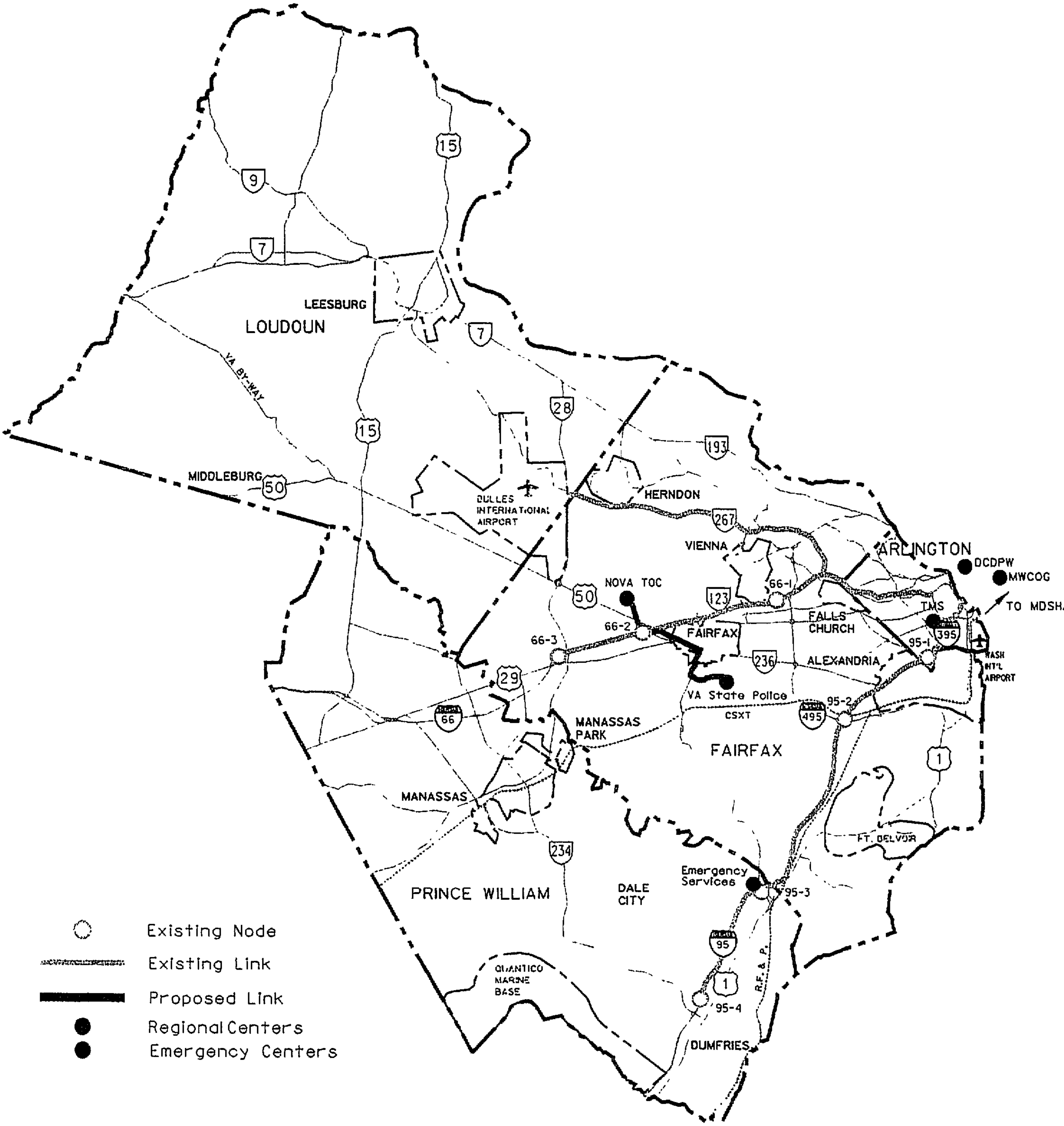


Figure 7.1 - Communications Infrastructure - Stage 1 Expansion

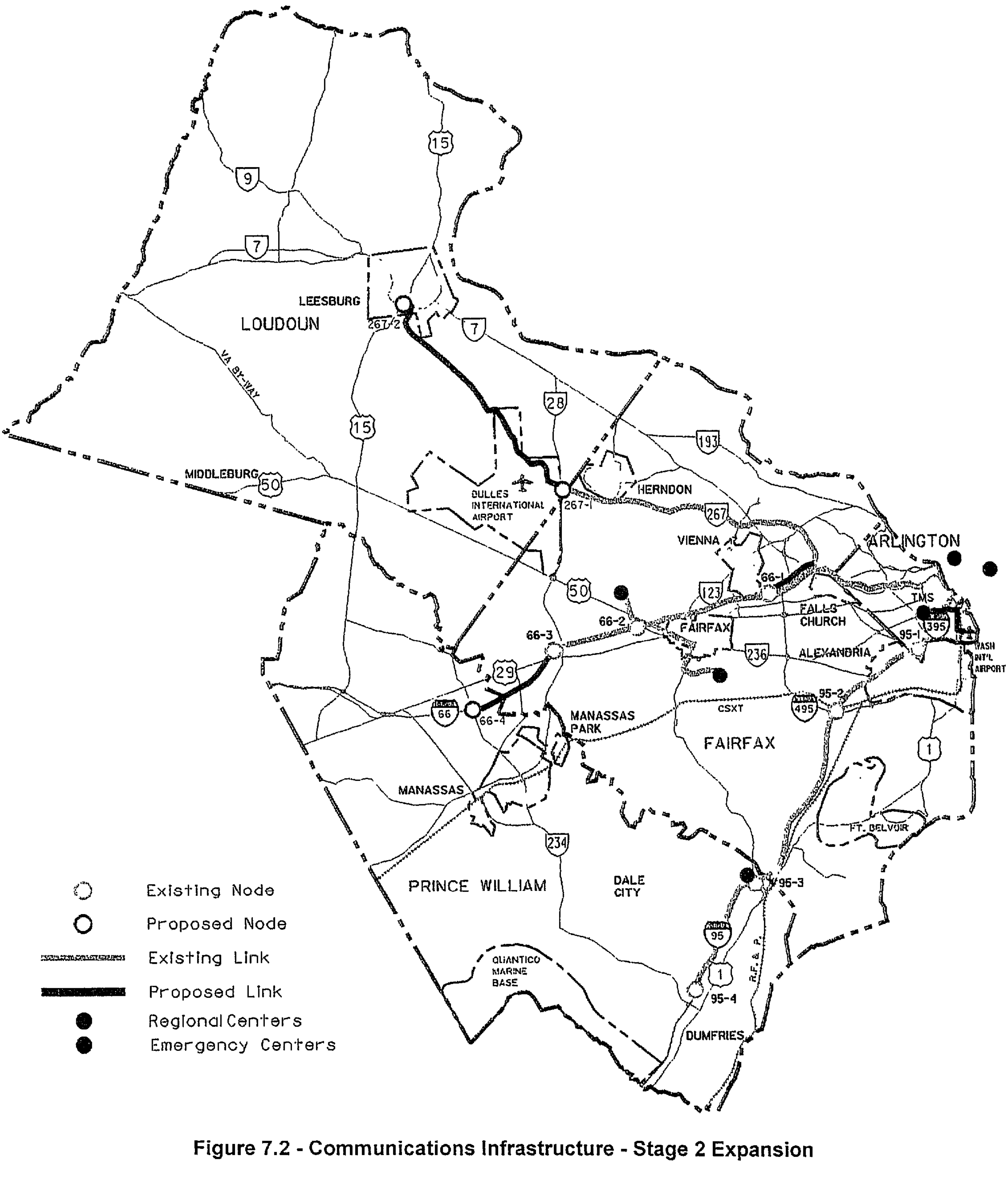


Figure 7.2 - Communications Infrastructure - Stage 2 Expansion

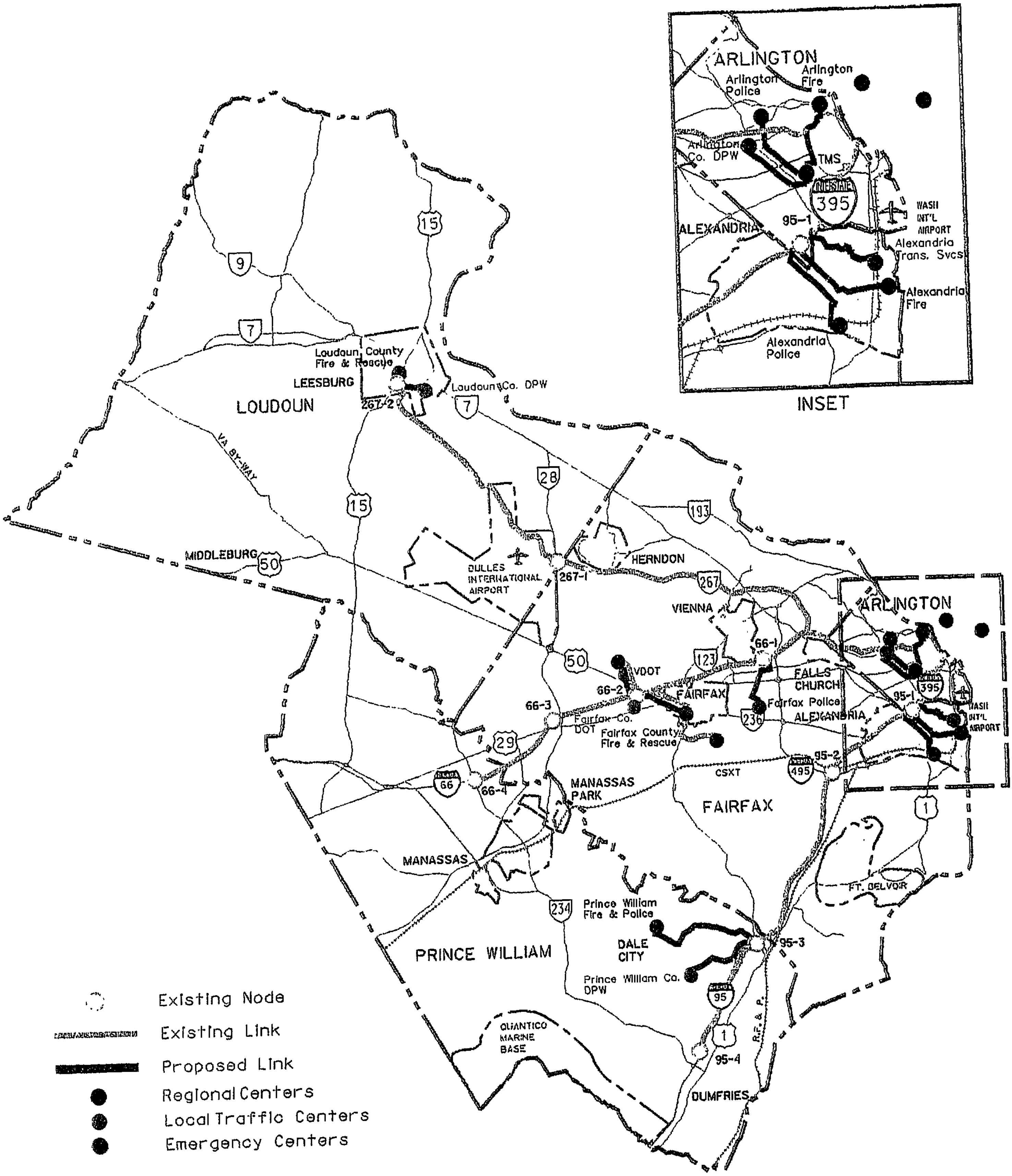


Figure 7.3 - Communications Infrastructure - Stage 3 Expansion

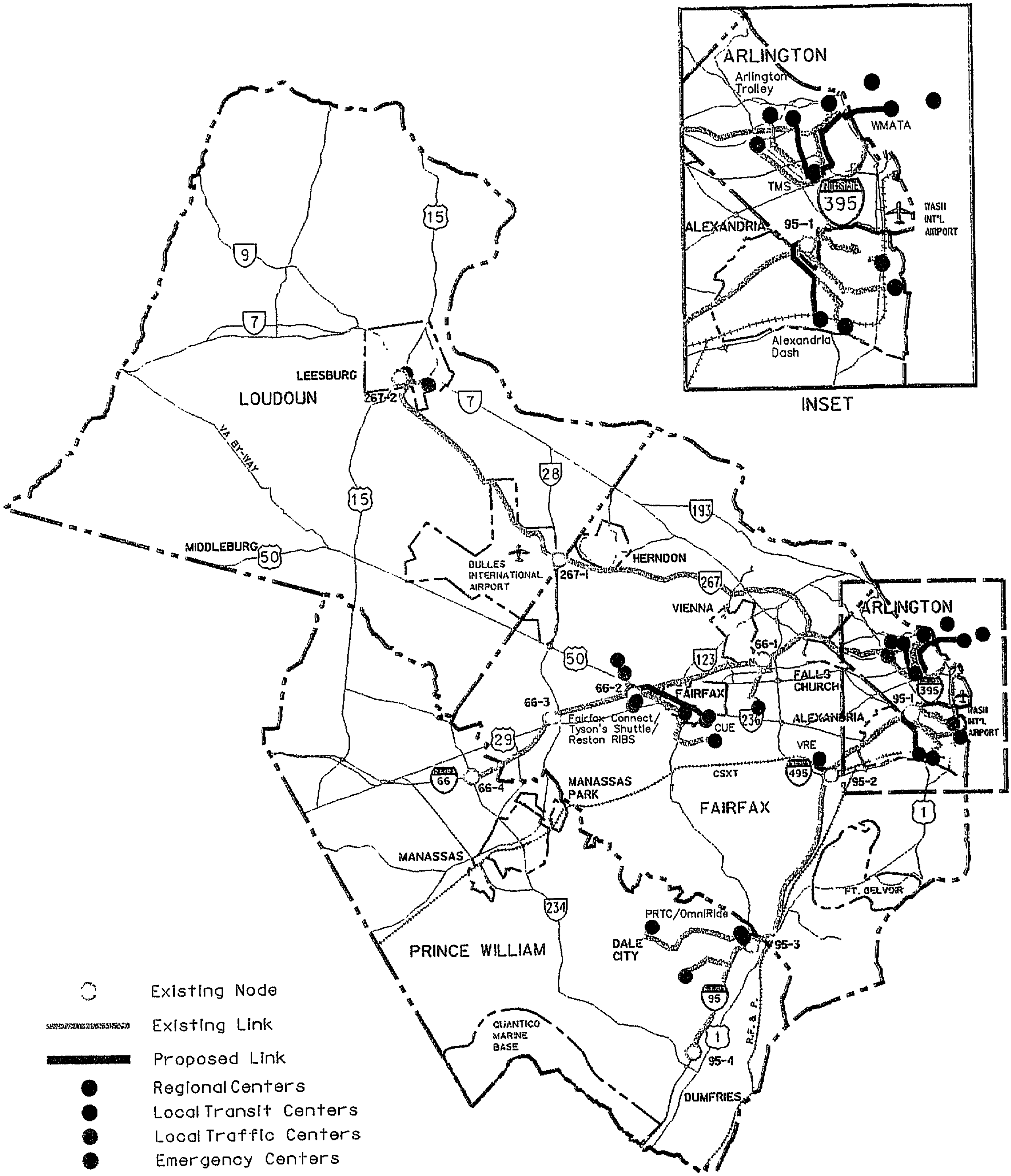


Figure 7.4- Communications Infrastructure - Stage 5 Expansion

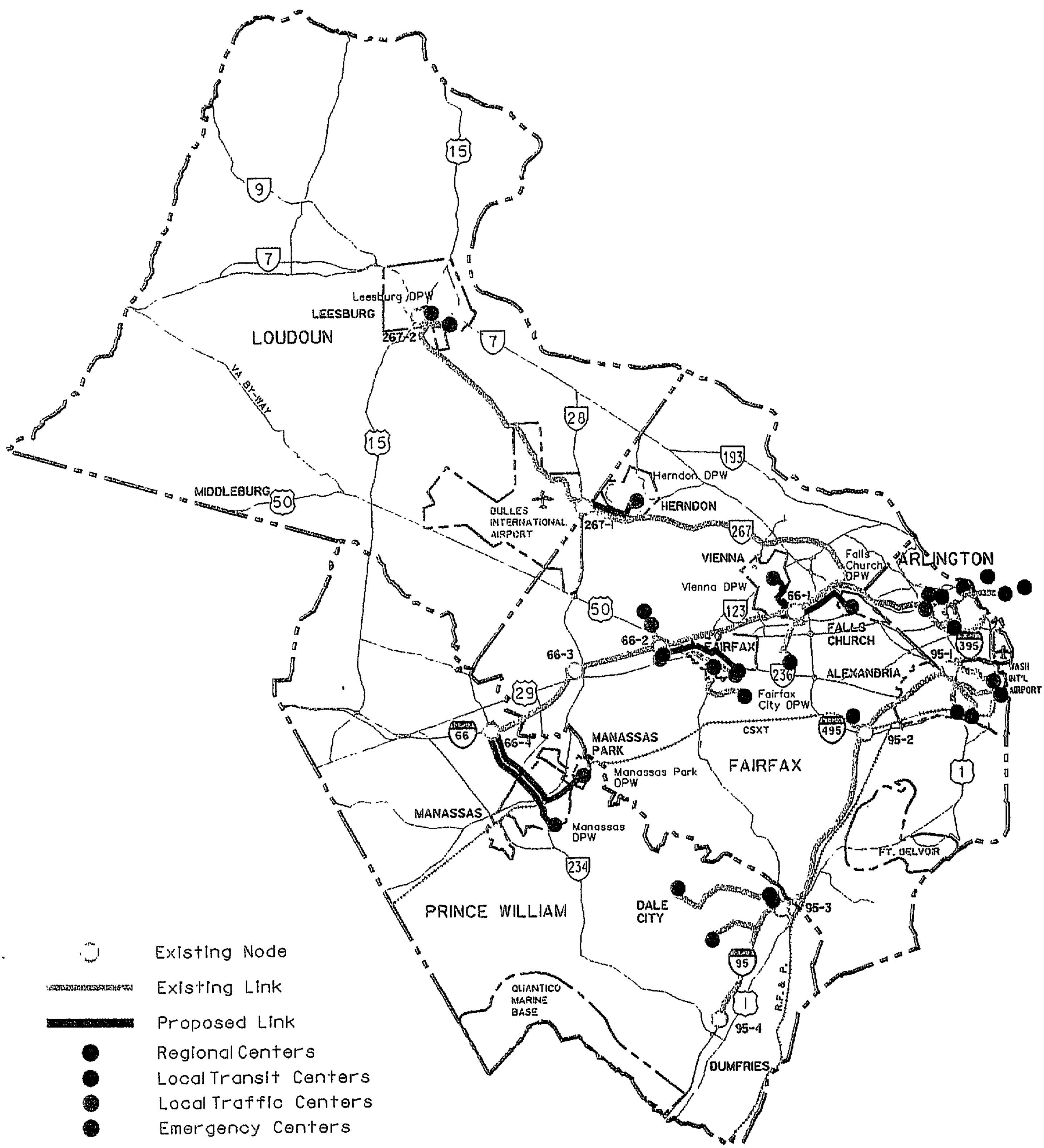


Figure 7.5 - Communications Infrastructure - Stage 6 Expansion

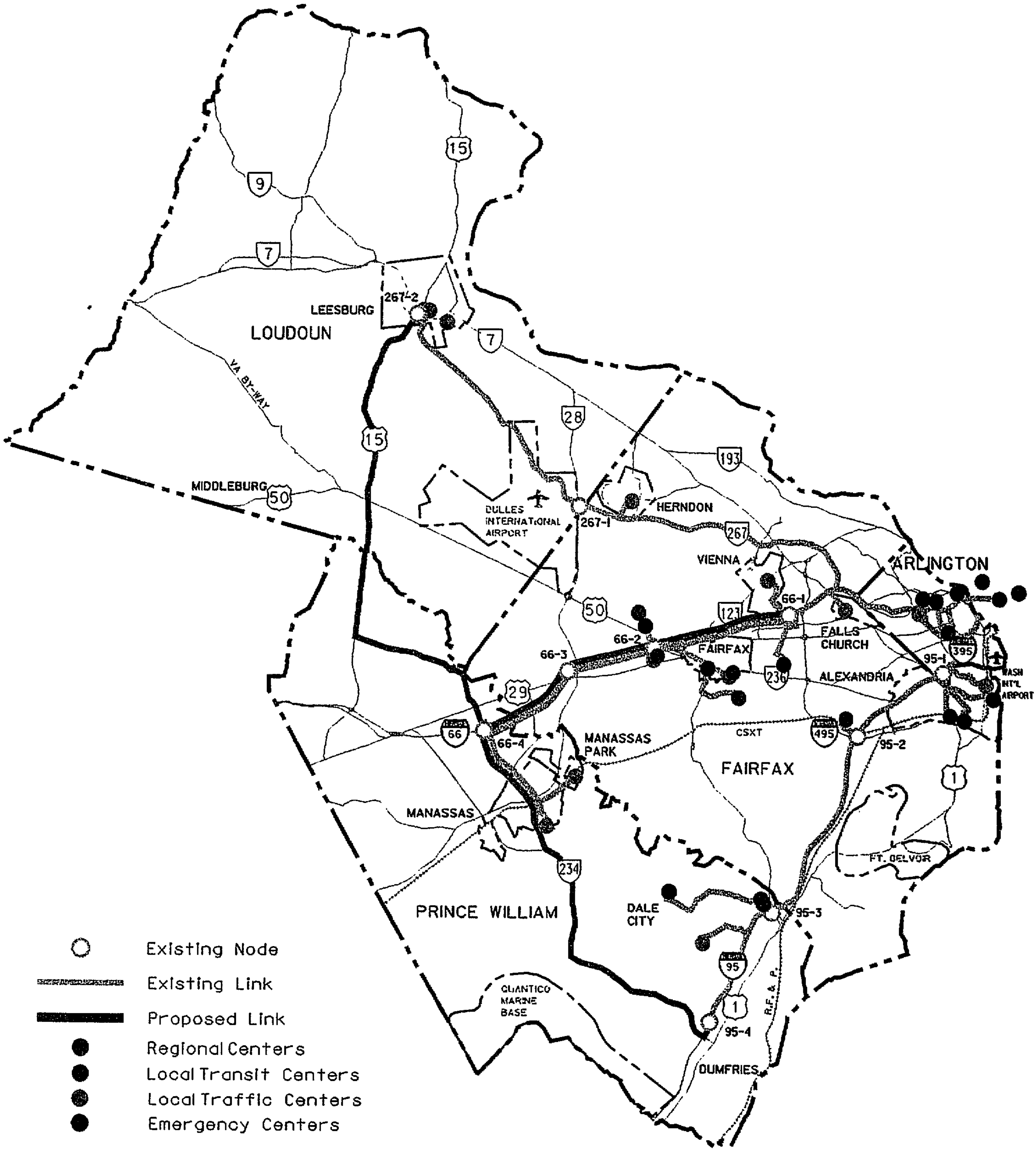


Figure 7.6 - Communications Infrastructure - Stage 7 Expansion

7.3 RECOMMENDED DEPLOYMENT SCHEDULE

The recommended ITS deployment schedule for the Northern Virginia Region is presented in **Figure 7.7**. As mentioned earlier, this schedule builds upon the ATMS implementation schedule recommended in the ATMS implementation plan. The user services expected to be deployed by the private sector and dependent on supporting public sector infrastructure are identified and scheduled for deployment appropriately. Other elements of the schedule are self explanatory.

7.4 INSTITUTIONAL REQUIREMENTS

7.4.1 ITS Coalition Functional Needs

In order to guide the NoVA ITS initiative from the planning stage to deployment it is recommended to constitute a coalition of the agencies in the region. The coalition should be comprised of the primary tier jurisdictions/agencies identified in Table 2-2 and meet the following general criteria and/or functional requirements:

- Include representatives from each agency within the study area who are involved in managing transportation systems development and/or transportation operations:
- Enhance inter-agency communications(span both vertical and lateral) and provide a forum for effective information exchange;
- Provide direction in the areas of policy, institutional procedures, and strategic management initiatives at the regional level;
- Through the above, establish the process by which the goals, objectives, and framework to build a regional transportation coalition will be accomplished. This would be formally addressed in the longer-term (post-Early deployment Planning activity) through the execution of agreements that formally establish each agency's responsibilities for continuing, coordinated operations;
- Given the complexity of the transportation network of the region and the current direction of national ITS program development, the committee must be multi-modal in its representation:
- Possess the ability to promote cooperative ventures for regional ITS deployment and explore possibilities for new and innovative revenue generating options, e.g., communications companies, the media, information or motorist services, trucking firms, moving services, overnight delivery companies, etc.;
- Possess the ability to promote a proactive marketing program that would include: public information, justification, and lure of potential investors.

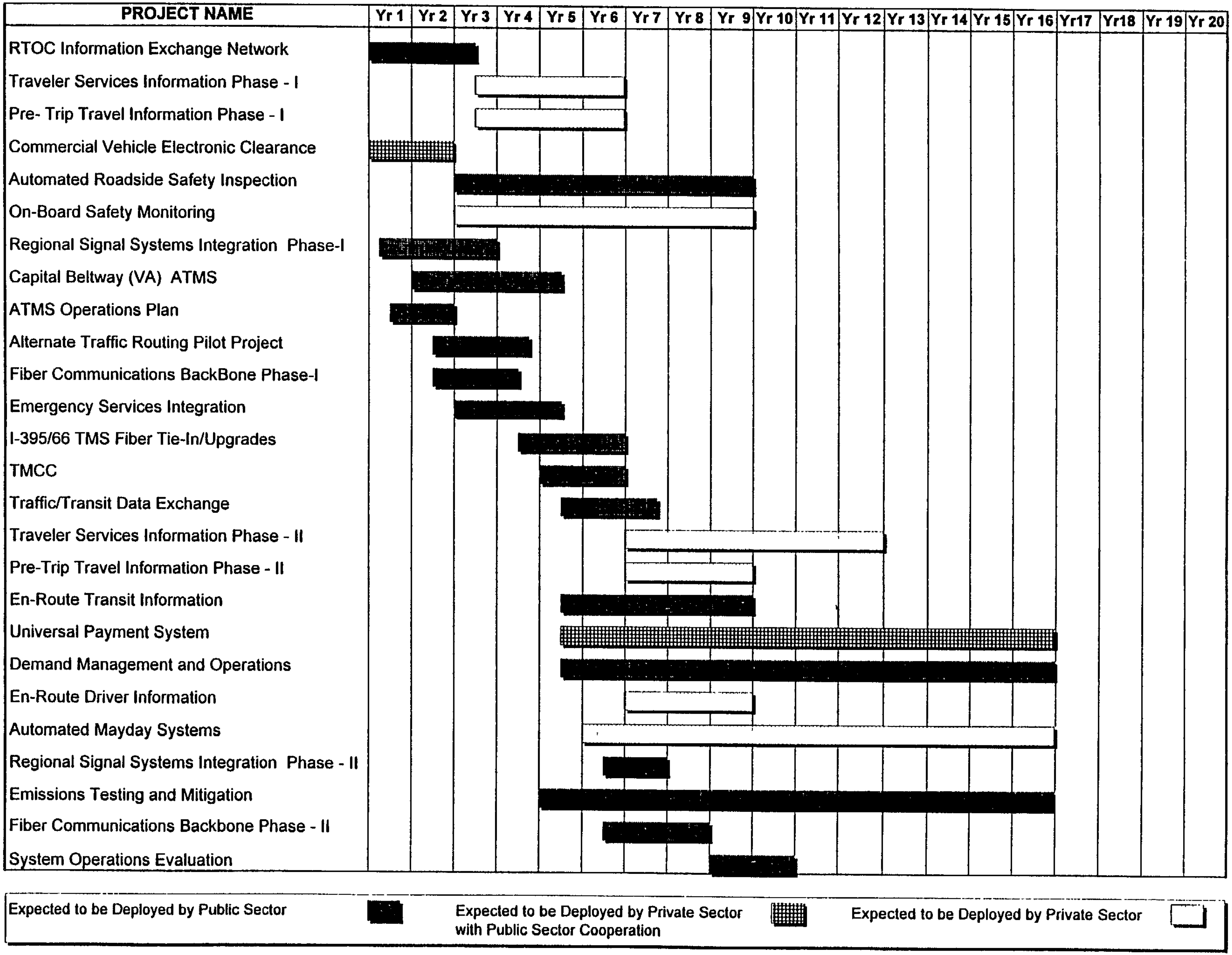


Figure - 7.7 Recommended Deployment Schedule

It is also desirable to incorporate this committee's activities with other on-going committee activities in the region relating to transportation programs and implementation of same. This committee would examine the potential methodology and institutional requirements by which present-day oversight of transportation programs are transformed from the typical project-oriented oversight approach to a systems-oriented, regional oversight program;

In summary, serves as the overall policy-setting body for ITS in the study area through the establishment of priorities, procurementcjoint-agency) policy, phased implementation coordination(projects), coordinates public/private ventures, promotes ITS at regional level, and guides all other committee activities.

The application of expertise to system developments in the study area is recommended to be guided by a subcommittees as required. The subcommittees should meet the following general criteria and/or functional requirements:

- Technical Subcommittee(s) are recommended to consist of key staff from selected transportation agencies in the study area having primary responsibility for design, operations, and maintenance of the transportation network subsystems.

- Provide a central technical coordination point, including technical expertise in traffic engineering, electronics, automation, expertise in human resource management, and transportation systems operation, maintenance and management relating to ATMS, ATIS, CVO, and APTS;

- Serve as a technical information clearinghouse to developments occurring in related areas on a regional basis. This would apply to non-related developmental areas regarding advanced technology applications that may not necessarily fall under the "ITS Umbrella" but may require integration;

- Provide technical oversight to achieve uniformity in tactical planning for the varying directions taken by the affected agencies for planning, design, construction, maintenance and operation including, but not limited to:

  - Developing a regional transportation center as a test bed for traffic modeling and technology transfer;
  - Developing a network-level traffic management program;
  - Integrating ITS concepts into a comprehensive transportation management plan that includes public transportation, demand management, etc.

- Developing an organized and consistent procedure for data collection, processing, and dissemination;
- Improving and upgrading existing agency programs for integration into the regional network;
- Assist in developing a public information and marketing program to increase public and legislative support for ITS;

7.4.2 Institutional Framework

As mentioned earlier in Section 2, the study team's preliminary analysis indicates that the complexity of resolving region-wide transportation issues is primarily driven by the enormous degree to which efforts are required to effectively and efficiently coordinate the development of strategies, improvement concepts, and resulting impacts on overall transportation system operations among a wide array of agencies and organizations. In all seventy nine agencies and organizations have been identified as having a key role in transportation in the region. For a listing of these agencies and their roles the reader is referred to the User Service Plan for this region which was a separate deliverable under this study. In order for ITS deployment to become a reality in Northern Virginia the institutional relationships between these agencies may need some changes. The recommended Institutional framework is shown in **Figure 7.8.**

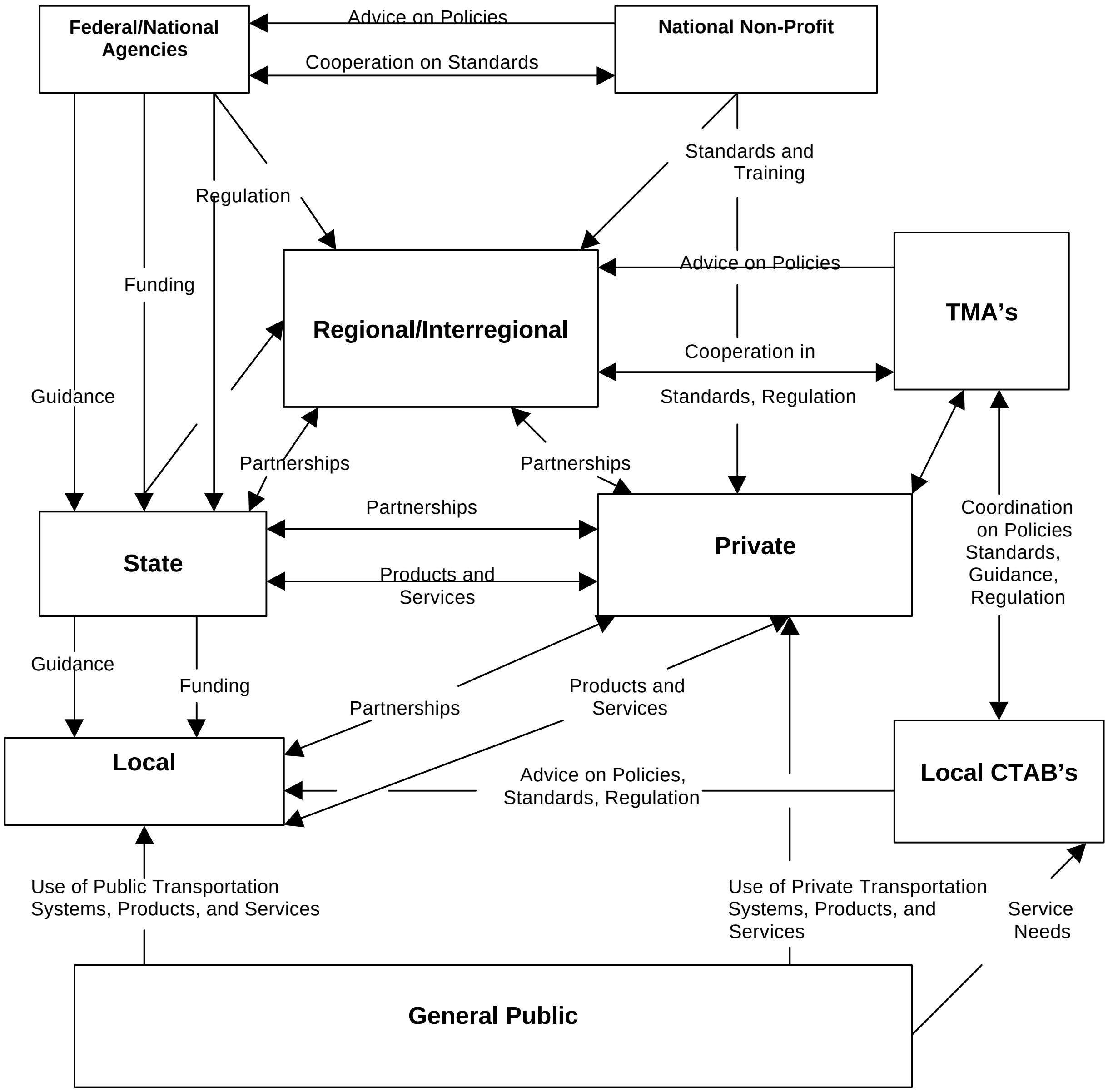


Figure – 7.8 Recommended Institutional Framework

SECTION 8.0 ESTIMATED POTENTIAL BENEFITS AND COSTS

8.1 INTRODUCTION

Over three decades ago, precursors to some of the user services included in today's Intelligent Transportation Systems (ITS) umbrella began appearing in America's urban areas. Implementations have since become more flexible, more capable, and more integrated. As examples, isolated ramp meters have developed into freeway management systems, incident management programs that began as courtesy patrols and CB monitoring have incorporated new technologies and are increasingly being integrated into transportation management centers to more effectively manage emergency response and services at regional levels.

More recently, ISTEA supported a national program both technically and financially to formally evaluate the potential for ITS applications. To move ITS from research, prototyping, and pilot projects into routine usage, decision makers at the corporate, state, regional, and local levels need reliable information about the contribution that ITS deployment can make toward meeting the demand for safe and efficient movement of people and goods.

8.2 BENEFIT DATA FROM OPERATIONAL TESTS PROGRAM

The experience of the US DOT with ITS research and development, operational tests, and deployment support programs over the past 3-5 years has led to the definition of an Intelligent Transportation Infrastructure (ITI) initiative. Recently announced in January 1996 by Secretary of Transportation Pena, the ITI program consists of traffic detection and monitoring, communications, and control systems required to support a variety of ITS products and services in metropolitan and rural areas, building on the prior US DOT ITS program efforts. Published in January 1996 by the MITRE Corporation and sponsored by the FHWA, *Intelligent Transportation Infrastructure Benefits: Expected and Experienced* summarized the potential benefits resulting from the early ISTEA programs that have focused on ITS. Potential early benefit data has been compiled in seven core areas:

- Traffic Signal Control Systems
- Freeway Management Systems
- Transit Management Systems
- Incident Management Programs
- Electronic Fare Payment Systems
- Electronic Toll Collection Systems
- Multimodal Traveler Information Systems

While the total picture remains unclear regarding how ITS user services deployment will relate to all transportation needs, partial results are available from early ITS projects and related deployments. Significant benefits have been recorded in areas such as accident reduction, time savings, transit customer service, roadway capacity, emission reduction, fuel consumption, vehicle stops, etc. Anaysis and simulation based on limited tests have predicted even greater potential for benefits with more extensive deployment of more mature products and total transportation management approaches.

The findings of the national effort are presented in this section, along with supplemental data from other similar efforts in which members of the study team were involved. These findings and data are used in the ITS deployment benefit analysis to estimate thepotential benefits for the Northern Virginia Region. These benefits are then related to the cost data made available to the study team to arrive at a benefit/cost ratio for ITS deployment at a regional level.

Freeway Management System Benefits

Freeway Management Systems monitor and control traffic flow along freeway corridors by collecting data through detector subsystems on the roadway and analysing them to detect incidents and implement demand management (e.g.,ramp metering) strategies to ensure the smooth flow of traffic. Advanced freeway management systems have been implemented in urban areas across the country and have yielded significant benefits.

▪ Travel Time	Decrease 20% - 48%
▪ Travel Speed	Increase 16% - 62%
▪ Freeway Capacity	Increase 17% - 25%
▪ Accident Rate	Decrease 15% - 50%
▪ Fuel Wasted in Congestion	Decrease 41%
▪ Emissions	Decrease CO emissions 122,000 tons annually
	Decrease HC emissions 1400 tons annually
	Decrease NO, emissions 1200 tons annually

The cost of installing a freeway management system compares favorably to the cost of adding physical capacity. For example, a four lane freeway installing a TMC could add approximately half the capacity of an additional lane at 1/8 the cost.

Traffic Signal Systems Benefits

Advanced Traffic Signal Systems, using algorithms, that can derive demand from detector data at intersections, adjust the signaling pattern for near-optimum traffic flow, thus reducing undue stops and delays. The benefits from Traffic Signal Systems are:

▪ Travel Time	Decrease 8% - 15%
. Travel Speed	Increase 14% - 22%
▪ Vehicle Stops	Decrease 0% - 35%
. Delay	Decrease 17% - 37%
. Fuel Consumption	Decrease 6% - 12%
▪ Emissions	Decrease CO emissions 5% - 13%
	Decrease HC emissions 4% - 10%

Incident Management Program Benefits

Incident management programs involve coordinating response to predictable (e.g. Lane Closures) and unpredictable (e.g. Accidents) conditions, so an incident can be cleared in a safe, speedy and efficient manner. Incident management programs typically evolve as part of a regional freeway management strategy, since incidents are mainly detected through the freeway monitoring systems. Incident management programs show tangible promise of reducing 50% - 60% of traffic congestion attributable to incidents.The benefits of Incident Management programs are:

▪ Incident Clearance Time	Decrease in 8 minutes for stalls
	Decrease wrecker response time 5 - 7 minutes
. Travel Time	Decrease 10% - 42%
▪ Fatalities	Decrease 10% in urban areas

MultiModal Traveler Information System Benefits

Traffic and traveler information systems help travelers reduce unnecessary delays by providing valuable route and traffic information both before (Pre-Trip) and during (En-route) their trip. Pre-Trip travel information is typically provided through kiosks and in-vehicle devices. These systems have shown benefits in reducing travel delay, travel time, emsissions, and fuel consumption. The benefits Traveler Information systems are:

▪ Travel Time	Decrease 20% in incident conditions Decrease 8% - 20% for equipped vehicles
▪ Delay	Decrease up to 1900 vehicle-hours per incident
▪ Fuel Consumption	Decrease 6% - 12%
▪ Emissions	Decrease VOC 25% from affected vehicles Decrease HC 33% from affected vehicles Decrease NO_X 1.5% from affected vehicles

Transit Management System Benefits

Safety and security are major factors in decisions to install transit management systems. Situations benefiting from vehicle location and communication systems include medical emergencies as well as threats and crimes involving passengers and those observed by transit vehicle operators. Available Transit Management benefit data includes:

▪ Travel Time	Decrease 15% - 18%
▪ Service Reliability	Increase 12% - 23% in on-time performance
▪ Security	Decrease incident response time to as little as one minute
▪ Cost Effectiveness	45% annual return on investment

Other

▪ Bus Operations/Maintenance	Decrease 9%
▪ Rail Operations/Maintenance	Decrease 20%
▪ Planning, Customer Service and Administration	Decrease 10%
▪ Missed Revenue Opportunity	Decrease 15%
▪ Vandalism, Claims, and Liability	Decrease 26%
▪ Engineering, Special Services, Marketing, etc.	Decrease 3%

Electronic Toll Collection (ETC) System Benefits

ETC benefits are based on operating cost to the toll authority, coupled with benefits of emission reduction and capacity increases. Electronic toll collection can greatly improve throughput on a per-lane basis compared with manually operated lanes. It should be noted that the frequency of toll plazas within various system varies and, thus, impacts the percentage change in the benefit factors listed based on actual operating conditions.

- Operating Expenses — Decrease up to 90%
- Capacity — Increase 250%
- Fuel Consumption — Decrease 6% - 12%
- Emissions — Decrease CO emissions 72% per affected mile
  Decrease HC emissions 83% per affected mile
  Decrease NO_X emissions 45% per affected mile

Electronic Fare Payment Benefits

Rail transit systems have been using stored-value magnetic stripe fare cards in the Washington, D.C. area since the 1970s. Several tests and pilot programs using newer electronic fare payment techniques are ongoing. The use of electronic media for bus transit is under development. In addition to the popularity of electronic fare payment, benefits have been noted in fare collection and data collection.

- Patron Popularity — Up to 90% usage where available
- Fare Collection — Increase 3% - 30%
- Data Collection Costs — Decreased $1.5 million - $5 million

8.3 ESTIMATED BENEFITS IN NORTHERN VIRGINIA

In a typical benefit/cost study, the actual gains and losses from a policy are listed, quantified and compared. However, due to the relatively nascent state of ITS deployment there is a shortfall of sufficient cost data to support such a detailed analysis at this time. Through interaction with the primary jurisdictions and agencies it was found that, in many instances, extrapolating detailed cost data from existing accounting systems would require substantial effort, effort that was considered beyond the scope of this project. Other cases indicated that existing performance data in the requisite areas was not extractable from agency/jurisdiction data.

Therefore, this analysis will simply explain the advantages of ITS deployment in the Northern Virginia region, with application of recorded potential benefit factors to the data that was readily available. With this approach, the estimated potential total benefit to the region presented herein then represents a minimum expected benefits relating to investment in ITS. It is important to note that with the guidelines provided in this report, the agencies/jurisdictions in the region will then have the benefit factors to apply to data once it is derived through their independent efforts. It is anticipated and recommended that this effort be put forth as each deployment recommendation of this study is considered by the collective group of agencies and juridictions in the furthering development of specific ITS projects or groups of ITS projects for deployment.

Since transportation system operations are primarily the responsibility of public sector agencies in the Northern Virginia Region, benefits to the primary service providers resulting from region-wide ITS deployment are defined as public sector benefits. For the primary service providers, the objective in deploying ITS is to increase the productivity of available transportation resources in a given service area and to reduce traffic congestion, energy usage, air pollution, and mobility problems in a cost-effective manner. A key to achieving this objective is in realizing that the transportation provider and the traveler are both the users, and that benefits accrue to both.

For the transportation providers, the participating public and major private agencies in any integrated deployment effort, the following top-level benefits to each are foreseen:

- Better operational control;
- Lower operating and maintenance costs derived from improved system efficiency;
- Improved management and reporting activities through increased automated data collection; and
- Improved productivity . . . stress reduction and increased job satisfaction.

Most importantly, it needs to be recognized that the potential benefits represent a substantial return to the agencies in the region, both qualitatively and quantitatively. With enhanced coordination, cooperation, and sharing of responsibilities and costs the benefits of region-wide deployment will accrue over a large base and across numerous modal boundaries. Maximizing the utilization of these modal interfaces, each agency will be able to:

- Improve service reliability, safety, information accuracy, and on-time performance (transit, aviation);
- Attract more discretionary users through greater service reliability and multimodal options;
- Provide significant economic benefit to those users with limited mobility and/or financial contraints that currently impact system usage; and
- Effectively address credibility problems with system operations, improve public image and foster continuing support for deployment funding.

In order to obtain estimates for the potential benefits from ITS deployment in Northern Virginia the study team conducted various analyses based on available information and knowledge from similar studies for other major agencies. The analysis for congestion cost is presented here. These and other benefit factors were used in the overall analysis to arrive at an estimated potential minimum value for benefits resulting from ITS deployment. The results are summarized in Table 8-2.

Travel Delay Costs

The main focus of most ITS deployments nationwide is on the Advanced Traffic Management Systems. The reason is because that the benefits from ATMS directly impact all the users of the system by reducing traffic congestion. In short, they are sure winners and hence are considered a safe investment. To present an order of magnitude estimate of the cost of congestion in Northern Virginia, the study team conducted a rudimentary analysis of the available traffic data. The contents of **Table 8-1** illustrate the delay in vehicle hours experienced everyday by drivers in Northern Virginia and the cost of such delay. The annual cost of congestion based on 260 workdays per year comes to $1,377,420,200 for 1996 and $1,802,488,480 for the year 2000. The cost of congestion shown is calculated assuming an $8.00 per hour value of time (this is a very conservative value considering that minimum wage is $4.25 per hour and the region has the highest average income in the country) and a vehicle occupancy of 1.00 (Average vehicle occupancy in the region is around 1.2).

TABLE 8-1
DAILY VEHICLE HOURS OF DELAY (VHD) IN NORTHERN VIRGINIA

	1996		2000	
	VHD	Cost	VHD	Cost
Major Arterials				
Arlington	25,625	$204,998	31,925	$255,400
Alexandria	44,029	$352,232	50,588	$404,704
Fairfax	330,685	$2,645,480	384,699	$3,077,592
Loudoun	18,124	$144,992	56,914	$455,312
Prince William	27,883	$223,064	139,683	$1,045,468
Freeways				
NoVA District	215,875	$1,727,004	211,771	$1,694,172
TOTAL	662,221	$5,297,770	866,580	$6,932,648

These assumptions are made to simplify the analysis as the above numbers are only meant to provide an order of magnitude estimate. Further, the costs above do not include the cost due to excess fuel consumption; the calculation of such costs will require a more complex data analysis. Assuming the NoVA ATMS can reduce the delays in the region by a meagre 10% the savings in delay costs comes to $ 180,248,848 annually for the year 2000.

Fuel Waste Costs

A research publication from the Virginia Transportation Research Council estimates that in the year 2000 about 251,609 gallons of fuel would be wasted on Northern Virginia's freeways everyday. Assuming the cost of fuel is $1.10 per gallon, the fuel waste on Northern Virginia's freeways alone will cost Northern Virginia drivers approximately $71,960,200 per year. Assuming that an advanced traffic management system in the Northern Virginia Region can reduce the excess fuel consumption by 10 percent, the annual savings in the year 2000 alone would be approximately $7,196,020.

The benefits in Table 8-2 represent minimum potential benefits. The actual benefits observed will be higher due to the synergy in common functions and information sharing due to system integration. These additional benefits will accrue from:

- ***Data/Information Sharing for System Management and Planning*** - Through the many data flows and interfaces, the architecture identifies how organizations can share data and information. In many cases, such information sharing is necessary to provide particular user services. Perhaps more importantly, these data and information can be used for better transportation system management and operations. Hence, the sharing of transportation performance data through the architecture may lead to more effective use of scarce transportation resources and better system-wide planning (e.g. with traffic and transit management, multi-modal coordination, etc.).

- **Common Functions and Functional Integration** - There are many functions within the architecture that either 1) are common to several user services or 2) may be integrated with functions in other user services to provide higher benefits. By sharing certain functions between user services, cost savings and operational efficiencies may be realized by the end users of these services. In addition, integrating particular user services allows higher benefits to be achieved. For example, route guidance can be connected with regional traffic control. This integration allows an ISP to provide better routing advice, given that they know the arterial and freeway signal plans. In turn, if the traffic managers know how vehicles will be routed, they can better time their traffic signals to accommodate this traffic.

- **Common Technology - Data flows and** functions specified in the architecture may be combined, in a specific system design, to leverage common communications and other technology. Dedicated short-range communications devices can be used both for roadside toll collection, CVO vehicle check/clearance, and vehicle probe surveillance data. A single credit or debit card technology could be used for transit fare payment, toll and parking charges, or even non-ITS purposes. Software and hardware for map databases, as well as for position referencing systems (e.g. GPS), are needed for a broad range of ITS user services, and can leverage system standards in these areas.

TABLE 8-2
ESTIMATED MINIMUM POTENTIAL ANNUAL BENEFITS
IN NORTHERN VIRGINIA

Cost Area		**Estimated Potential Annual Benefits ***
TRANSIT	Bus (Operations & Maintenance)	$ 5,884,000
	Rail (Operations & Maintenance)	$ 7,807,000
	Bus / Rail (other)	$ 7,364,000
TRAFFIC	Travel Delay	$ 134,699,964
	Excess Fuel Consumption	$ 5,337,586
Total		**$161,092,560**

* 1995 dollars

8.4 COST ANALYSIS

In order to estimate the cost of a system accurately, the following need to be considered:

- System Design
- Equipment Cost Estimates
- Existing System Components

System Design

A system design provides the type of hardware and software and quantities required to develop a desired system. Without knowledge of the equipment and the quantities, the system cost cannot be estimated. For example, to cost the elements of a traffic management system one must define the number of intersections, the type of controllers, and the proposed communications that will be used. For the Northern Virginia ITS, a clearer picture of the system design will emerge when the deploying agencies decide on the type and extent of the systems they foresee the region having. The architecture recommendations, presented in the Final Report: *ATMS Implementation Plan,* provide the framework for these decisions. However, for the purpose of costing the NoVA ITS the study team relied on its knowledge of the area and experience from previous projects of similar nature.

Equipment Cost Estimates

Unit price ranges for various pieces of hardware and software equipment along with operations and maintenance requirements should be considered. If possible, the price ranges should be from state-of-the-practice equipment using installed construction bid prices. In the cost analysis for the Northern Virginia ITS the study utilized equipment cost estimates from prior experience in previous projects of a similar nature. Annualized costs assume an annual interest rate of 6% . An average system life of 15 years, annual operating cost at 4%-5% of base capital cost and maintenance costs at about 10% of base capital cost were assumed.

Existing System Components

Costs would not only depend on the selected system design, but also on the existing system. For example, the cost of installing a complete Intelligent Transportation Infrastructure (ITI) for Washington, DC is estimated to be approximately $277 million (Source: *ITS Implementation Strategy,* USDOT). The actual costs would be lower since the existing infrastructure can be used as a basis for the ITI. However, in the absence of a system design the amount of existing infrastructure that can be used cannot be arrived. Therefore, for the purpose of costing the NoVA ITS the study team relied on its knowledge of the area and experience from previous projects of similar nature.

Table 8-3 shows the Estimated Deployment Costs for the NoVA ITS.

8.5 SUMMARY

In a typical benfit/cost study, the actual gains and losses from a project are listed, quantified and compared. However, in the case of ITS the benefits information available cannot be attributed to any single project. ITS benefits accrue due to synergies obtained from system integration. Hence a benefit/cost ratio can only be calculated by comparing the general area of operations in which

TABLE 83
ESTIMATED ANNUAL COSTS FOR ITS DEPLOYMENT IN NORTHERN VIRGINIA

	Project Name	Upper-Limit Cost (x 1,000)	Annual Capital Recovery Cost (x 1,000)	Annual O & M Cost (x 1,000)
TRAFFIC	Regional TOC Information Exchange Network	27,705	2,852	1,299
	Regional Signal Systems Integration - Phase I	6,427	662	278
	Capital Beltway (VA) ATMS	15,909	1,638	1,209
	ATMS Operations Plan	623	64	0
	Alternate Traffic Routing/Diversion Pilot Project	1,058	109	0
	Transportation Management Coordination Center	5,284	544	249
	Regional Signal System Integration - Phase II	17,102	1,761	888
	Emergency Services Integration	25,124	2,587	1,440
	Traveler Information Systems (Rdwy. & Center Components)	11,208	1,153	800
	Emissions Monitoring and Management	13,550	1,394	600
	Demand Mangement (Traffic Component)	10,204	1,050	500
	Subtotal for Traffic	**134,194**	**13,814**	**7,263**
	Estimated Annual Cost for Traffic			**$21,077**
TRANSIT	Traffic/Transit Data Exchange	29,834	3,072	2,135
	En-Route Transit Information	2,439	251	95
	Demand Management (Transit Portion)	875	90	0
	Subtotal for Transit	**33,148**	**3,413**	**2,230**
	Estimated Annual Cost for Transit			**$5,643**
COMM	FO Communications Backbone Expansion - Ph. I	11,527	1,187	945
	I-395/66 TMS FO Tie-In/Upgrades	6,691	689	548
	FO Communications Backbone Expansion - Ph. II	30,012	3,090	2,460
	Laterals from local centers (Fiber)	52,973	5,450	556
	Subtotal for Communications Infastructure	**101,203**	**10,416**	**4,509**
	Estimated Annual Cost for Comm. Infrastructure			**$14,925**
TOTAL	**TOTAL COST FOR ITS DEPLOYMENT**	**$268,545**	**$27,643**	**$14,002**
	ESTIMATED ANNUAL COST FOR ITS			**$41,645**

the benefits occur (e.g. traffic and transit) with the projects that directly impact that area of operations. Table 8-4 shows the benefit/cost ratios for the NoVA ITS deployment in the areas of traffic and transit. While Emergency Services constitute a significant part of the NoVA ITS, it is difficult to quantify the likely benefits in Northern Virginia as it would require a detailed analysis of the accident statistics. Further, a significant benefit from Incident Management is the reduction in congestion due to incidents, therefore, the cost of the Incident Management program was combined with other projects that impact traffic operations, for the purpose of this study's evaluation.

TABLE 84

BENEFIT I COST RATIOS FOR NoVA ITS DEPLOYMENT

Cost Area	Estimated Annual Benefits	Estimated Annual Costs	B/C Ratio
Traffic	$140,037,560	$21,077,000	6.64 : 1
Transit	$21,055,000	$5,643,000	3.73 : 1
Total System	$161,092,560	$41,645,000	3.67: 1

Note: Estimated Annual Cost for the total system includes $14.925000 annually cost of supporting region-wide communications infrastructure applicable to both traffic and transit susbsystems. All estimated dollar values are in 1995 dollars.

APPENDIX A

APPENDIX A REFERENCES

1. Federal Highway Administration, National ITS Program Plan, U.S. Department of Transportation, Washington, D.C., March 1995.

2. Federal Highway Administration, IVHS Planning and Project Deplovment Process, Version 1.0, U.S Department of Transportation, Washington, D.C., April 1993.

3. Federal Highway Administration, Intelliaent Transportation Svstems User Services Summary, US. Department of Transportation, Washington, D.C., January 1995.

4. Federal Highway Administration, National ITS Program Plan - Intelligent Transportation Systems Synopsis, March 1995.

5. Federal Highway Administration, National Strategic Plan 1996 - Highwavs Make the Connection, 1996.

6. Federal Highway Administration, Rebuilding America: Partnership for Investment - Innovative Financing Handbook - Test Evaluation 045 (TE-045). U.S.DOT, October 1995.

7. National Capital Region Transportation Planning Board, Long-Range Transoortation Plan for the Northern Virginia Region., Metropolitan Washington Council of Governments, Washington, D.C., September 1994.

a. Virginia Department of Transportation, Virginia Connections, Strategic Plan for Transportation, Virginia Department of Transportation, Richmond, Virginia, December 1994.

9. Northern Virginia Transportation Commission, Eleventh Annual Report. Transportation Service Coordination Plan, Northern Virginia Transportation Commission, Arlington, Virginia, September 1995.

10. Tyndall, G.R., Cameron, J., and Taggart, C., Strateaic Planning and Management Guidelines for Transportation Agencies, Transportation Research Board, National research Council, Washington, D.C, December 1990.

11. Arlington County Department of Public Works, Planning and Engineering Division, Virginia, Master Transportation Plan-Part I. Adopted 1966, Arlington, Virginia, September 1967.

12. Fairfax County Office of Transportation, Transportation Characteristics: Existing Conditions and Trends Report, , Fairfax, Virginia, July 1995.

13. Loudoun County Board of Supervisors, Countywide Transportation Plan, Loudoun, Virginia, July 1995.

14. County of Prince William, Six Year Secondarv Road Plan FY 1994-2000, Prince William, Virginia, April 1994.

15. City of Alexandria, Transportation-1992 Master Plan, Alexandria, Virginia, 1992.

16. City of Fairfax, Tradition with Vision-Fairfax 2020 Commission Report, Fairfax, Virginia, March 1994.

17. City of Falls Church Planning Department, Falls Church Master Plan, Falls Church, Virginia, April 1966.

18. City of Manassas, Comprehensive Plan for The City of Manassas, Manassas, Virginia, February 1969.

19. Town of Herndon Department of Public Works, Herndon 2010 Comprehensive Plan, Herndon, Virginia, February 1990.

20. Benton, K., Investment Analysis-Virainia Railway Express Versus Equivalent Highway Capacity, Northern Virginia Transportation Commission, April 1995.

21. Federal Highway Admitiistration, Intelligent Transportation Systems Implementation Strategy, U.S. Department of Transportation, Washington, D.C., April 1996.

22. Federal Highway Administration, Commercial Vehicle Information Systems and Networks(CVlSN) Architecture Specification, The Johns Hopkins University Applied Physics Laboratory, February 1996.

APPENDIX B

APPENDIX B ACRONYMS

APTA	American Public Transit Association
APTS	Advanced Public Transportation Systems
ARTS	Advanced Rural Transportation Systems
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
AVCS	Advanced Vehicle Control Systems
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
CCTV	Closed Circuit Television
CMS	Congestion Management System
CVISN	Commercial Vehicle Information Systems and Network
CVO	Commercial Vehicle Operations
DMV	Department of Motor Vehicles
DSRC	Dedicated Short Range Communication
EIS	Environmental Impact Statement
EOC	Emergency Operations Center
FHWA	Federal Highway Administration
FO	Fiber Optic
FTA	Federal Transit Administration
GIS	Geographical Information System
GPS	Global Positioning Systems
GPS	Global Positioning Satellite
HAR	Highway Advisory Radio
HOV	High-Occupancy-Vehicle
ISTEA.	Inter-modal Surface Transportation Efficiency Act
ITS	Intelligent Transportation System
MIS	Major Investment Study
MOE	Measure of Effectiveness
MPO	Metropolitan Planning Organization
MWAA	Metropolitan Washington Airport Authority
MWAQC	Metropolitan Washington Air Quality Committee
MWCOG	Metropolitan Washington Council of Government
NHS	National Highway System
NoVA	Northern Virginia

NVTC	Northern Virginia Transportation Commission
OOD	Object Oriented Design
PRTC	Potomac and Rappahannock Transportation Commission
SONET	Synchronous Optical Fiber Network
TCC	Transportation Coordinating Council
TEMPO	Transportation and Environmental Management and Planning Organization
TMA	Transportation Management Associations
TMCC	Transportation Management Coordination Center
TMS	Traffic Management System
TOC	Transportation Operations Center
VAN	Vehicle-Area Networks
VDOT	Virginia Department of Transportation
VDRPT	Virginia Department of Rail and Public Transportation
VMS	Variable Message Signs
VPA	Virginia Port Authority
VRE	Virginia Railway Express
VTRC	Virginia Transportation Research Council
WIM	Weight-in-Motion
WMATC	Washington Metropolitan Area Transit Commission

APPENDIX C

APPENDIX C TRANSPORTATION SYSTEM OBJECTIVES SUMMARY

NATIONAL ITS PROGRAM PLAN USER SERVICE OBJECTIVES

- **Travel and Transportation Management**
  Provide a comprehensive travel and transportation management system to collect and process information about the surface transportation system, provide commands to various traffic control devices, and disseminate this information to the traveler.

- **Travel Demand Management**
  Support policies and strategies that are aimed at reducing vehicle demand by developing and encouraging modes of travel other than the single occupant vehicle.

- **Public Transportation Operations**
  Implement systems that are better capable of managing the public transportation system and providing improved transit services and mode choice information.

- **Electronic Payment Services**
  Foster intermodal travel by providing a common electronic payment medium for all transportation odes and functions, including tolls, transit fares, and parking.

- **Commercial Vehicle Operations**
  Support the goals of improving efficiency and safety of commercial fleet operations, to the benefit of both the States and the motor carrier industry.

- **Emergency Management**
  Enhance emergency management services to improve the management of police, fire, and rescue operations and response to emergency situations.

- **Advanced Vehicle Control and Safety Systems**
  Improve vehicle safety by reliance on self-contained systems within the vehicle and enhance the on-board capabilities with interfaces to additional infrastructure improvements.

TRANSPORTATION AND LAND DEVELOPMENT OBJECTIVES

- Foster transportation strategies that encourage shorter trip lengths through balanced development of jobs and housing for different income and cost levels.

- Use transportation strategies to encourage local plans which promote concentrated development along existing transportation corridors and in close proximity to transportation centers.

- Encourage “pedestrian-, bicyde-, and transit-, friendly” site designs at regional and sub-regional centers.

- Consider the likely effect of transportation policy decisions on land use and development and the consistency of trans. plans and programs with the provisions of all applicable short- and long-term land use and development plans.

TRANSPORTATION, ENVIRONMENTAL, AND ENERGY OBJECTIVES

- Develop and implement regional bicycle and pedestrian facilities to promote walking and bicycle use as a means of transportation.

- Develop and manage the transportation system to meet the requirements of the Clean Air Act Amendments of 1990.

- Manage, operate, and expand the transportation system in a manner that protects critical watersheds and helps to preserve the region’s farmlands, forests, open space, and other valuable natural resources.

- Promote “clean” travel options by developing a greenway system that includes electric or other non-polluting high occupancy vehicles (HOV), bicycle, and pedestrian facilities.

- For all transportation projects, consider implementing the transportation enhancement activities as defined by federal regulations, which include activities such as acquiring scenic or historic sites, landscaping and other scenic beautification, historic preservation, rehabilitation and operations of historic transportation facilities, preservation of abandoned railway corridors, and other activities.

- Ensure that the region's transportation planning is consistent with federal, state and local energy conservation programs, goals and objectives.

CONGESTION MANAGEMENT OBJECTIVES

- Manage the operation of the existing transportation system to improve safety and reliability, and to serve the trans. needs identified through the state highway safety management systems.
- Improve the flow of traffic on existing arterial highway facilities by using traffic management and enforcement measures.
- Reduce transit travel time for buses and other high-occupancy vehicles through the use of exclusive lanes or priority treatment.
- Improve and expand regional tidesharing activities by promoting Carpool, Vanpool, and other high-occupancy vehicle programs, including providing preferential treatment for such vehicles.
- Reduce congestion and improve traffic flow on the existing transportation system by developing and implementing complementary demand management strategies, including alternative work hours, telecommuting, and parking pricing.
- Create areas of pedestrian, bicycle, and transit priority in residential and commercial areas to enhance mobility choices and protect community quality of life.
- Give car and van pools priority in the utilization of long-term parking spaces.
- Implement taxing and pricing policies that favor employer subsidies for transit and other HOV services over employer-subsidized parking.
- Implement the region's congestion management system.

OBJECTIVES RELATED TO TRANSPORTATION FOR PERSONS WITH LIMITED MOBILITY

- Improve transit services to persons with disabilities, including meeting the requirements of the Americans with Disabilities Act of 1990.

- Improve transit services to isolated communities and to other persons without convenient access to automobiles.

INTERREGIONAL TRANSPORTATION OBJECTIVES

- Provide for the safe, orderly, and timely development of the region's airports to meet present and future air transportation needs in accordance with the region's land development, economic, environmental, and transportation goals

- Integrate the airport system with the region's other transportation systems, including maintaining and improving airport access and coordinating with high-speed rail services

- Accommodate general aviation to the extent compatible with the airports' primary **air** carrier service role

- Minimize the adverse environmental impacts associated with air transportation, including aircraft noise

- Ensure that the roads and highways within the Washington metropolitan area provide effective connectivity with the roads outside the metropolitan area

TRANSPORTATION SYSTEM OBJECTIVES

- Expand & enhance transit services and increase the use of such services.

- Provide sufficient revenue to operate, maintain, and expand an efficient public transportation system.

- Provide transit services in the most cost-effective manner possible, including the involvement, where applicable, of private transit providers.

- Develop & implement a coordinated system of transit and HOV facilities, connecting the region's activity centers...radial and circumferential travel.

- Improve pedestrian and bicycle access to the transit system.

- Maintain & improve existing roads and bridges, and serve transportation needs identified through the state pavement and bridge management systems.

- Encourage transportation system improvement based on how well they advance the overall development, transportation, and environmental goals for the region.

- Provide additional park-and-ride facilities throughout the region:

- Manage the supply of parking to support development and environmental objectives and to encourage HO travel.

- Serve the region's transportation needs identified through the state intermodal facilities and systems management systems.

- Assess the effects of all transportation projects to be undertaken, without regard to whether such projects are publicly funded.

- Improve, where necessary, access to the region's ports, airports, intermodal facilities, major freight distribution routes, national parks, recreation areas, monuments and historic sites, and military installations.

- Preserve rights-of-way for future transportation improvements, including identification of unused rights-of-way needed for future transportation corridors and identification of those corridors for which action is most needed to prevent destruction or loss.

- Implement methods to enhance the efficient movement of freight.

- Consider operating and maintenance costs in analyzing transportation alternatives, and use life-cycle costs in the design and engineering of bridges, tunnels, or pavement.

- Maintain the high level of security in the region's transit systems.

- Serve the region's transportation needs identified through the state public transportation facilities and equipment management systems.

REGIONAL ITS DEPLOYMENT OBJECTIVES

- Provide a common framework for interagency communications and coordinated management of transportation network.

- Enhance credibility of system operations through improved information processing and dissemination to system users.

- Provide capability for comprehensive data capture and exchange to improve the comprehensive planning process.

- Expand data collection and analysis to provide the capability to consider "echo effects" of incidents in network-level analyses.

- Improve the availability of, and ease of access to, static information relating to public transportation services.

- Provide the capability to disseminate information in different languages and formats.

- Ensure that safeguards are implemented to prevent major disruptions to local road/street network in residential areas.

- Establish protocols and pre-determined transportation network control plans for specified special events through interjurisdictional agreements.

- Establish automated inter-jurisdictional information exchange capabilities.

- Provide capabilities for advanced information dissemination to various agencies regarding maintenance plans and schedules.

- Consider community to community information exchange needs in development of advanced information dissemination,

- Examine methods by which independent GIS development activities in the region can be integrated to reduce maintenance intensive efforts to continuously update system(s).

- Provide system capability to collect and disseminate information on the type and severity of incidents.

- Enhance existing information dissemination through better utilization of information available through the police departments.

- Consider the extent to which fleet management principles can be applied to ground transportation service management at region's airports. Continued on next page

- Provide integrated, multi-jurisdictional database as regional resource.

- Determine the benefits and costs of information distribution.

- Identify costs to transit operating centers and costs to others resulting from implementing transportation control measures such as adjusting signal timings when buses get behind schedule.

- Consider the extent to which expert or predictive system(s) can be utilized to provide decision support in implementing transportation system operation plans.

- Examine methods by which freight and other commercial vehicle operators and service providers can be encouraged to participate in the development of an ITS plan for the region.

- Consider the development of maintenance management system applications to enhance and improve the efficiency of maintenance activity scheduling and management.

- Consider impacts of "holds" for bus to bus transfers or bus to rail transfers on the total surface system operations.