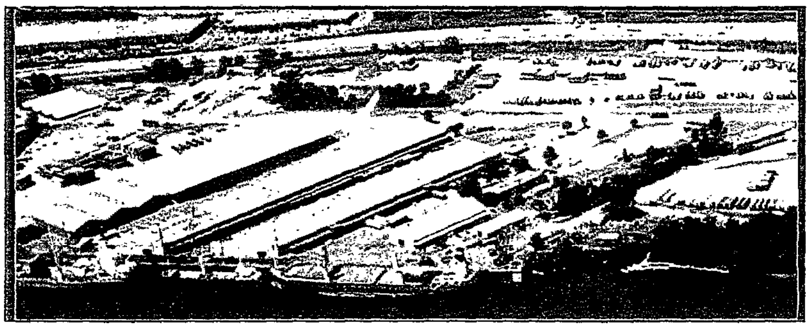
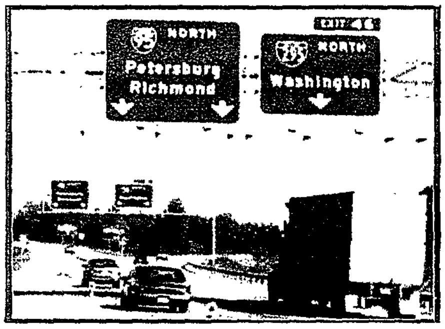
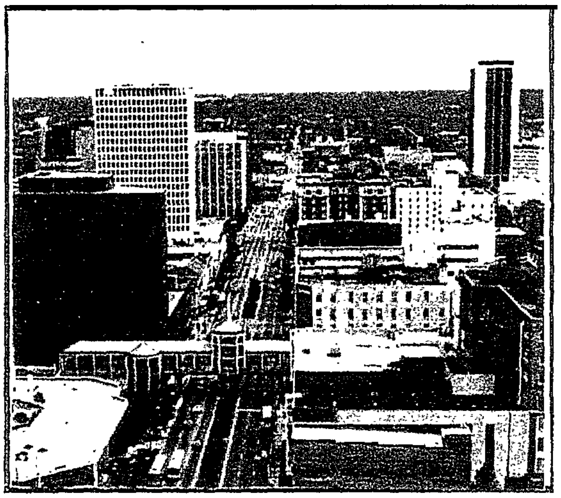
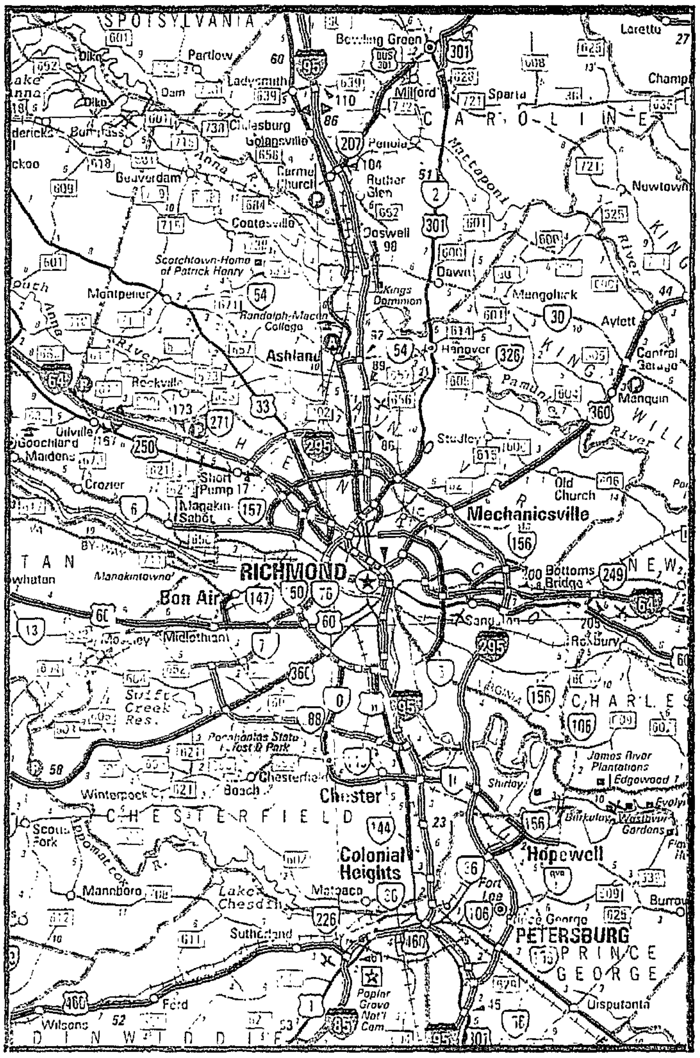
Virginia Department of Transportation

ITS Early Deployment Study
Richmond/Tri-Cities Area
Strategic Deployment Plan









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Frederic R. Harris, Inc.
Fairfax, Virginia

October 1996

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SECTION 1
INTRODUCTION AND OVERVIEW

Planning for the early deployment of intelligent transportation systems (ITS) in the Richmond/Tri-Cities area has followed the evolving guidelines of the Federal Highway Administration. The eight-step process, from problem definition through strategic deployment, has served as a guide to this important effort. The products of this study are a series of specific projects and a long-term direction for integrating ITS operations with the existing transportation systems, and for combining new and existing intelligent transportation features into a cohesive, region-wide system.

This report represents the culmination of a twelve-month planning process that commenced in October, 1995. The consulting firm of Frederic R. Harris, Inc. (FRH), leading a team of engineers, planners, and other specialists, formulated this plan. The project team worked closely with a steering committee comprised of representatives of more than three dozen local and state agencies, public, private, and quasi-governmental agencies. The Virginia Department of Transportation, through the ITS group within the Central Office's Traffic Engineering Division, supplied. the project management staff and direction, and facilitated much of the agency coordination. VDOT also served as a reference source, and supplied both information and direction on where to find data essential to the conduct of this study.

This report also represents the commencement of the implementation program-one that is envisioned to extend more than two decades into the future. ITS projects that are warranted today and would benefit current motorists and freight movers are articulated in this report. Projects that will be warranted beyond the three to five year time frame, or that are less urgent, are described in less detail.

Within the context of the ITS planning guidelines, this report represents the conclusion of the planning process, This report recommends specific ITS projects, needs, and directions. It identifies the most important requirements for the Richmond/T&Cities area, and also other considerations that should be taken into account over the next twenty years. What these projects are and who should plan, build, operate, and maintain them are described in this report. Funding and institutional issues are also discussed in this document. ITS is unique in the transportation field in that no single agency currently has responsibility for its implementation. Being relatively new, establishment of relationships and a place within the greater arena of transportation planning and operations are still being formulated.

This report also presents the system architecture and technology guidelines that will need to be considered with respect to both the projects specifically referenced and those inferred for the future. Again, as an evolving field, the system architecture can only be used as a guide to insure that as new features come "on line," they can be incorporated into the proposed system. Because technology is always evolving, the material in this report is descriptive rather than prescriptive.

The format of this report mirrors the eight-step planning process through which it was devised; Each chapter is intended to describe the efforts surrounding a specific task. The chapters are intended to be a summary of that work, describing the information used, the processes followed, and the results of the analysis. Further details on each task can be found in one or more companion documents. These technical memoranda, meeting handouts, and other documents, are described in the bibliography, and can be obtained from the VDOT.

1.1 MAJOR FINDINGS AND RECOMMENDATIONS

This strategic deployment plan recommends a series of ten specific projects, intended to be implemented within the next three years. The rationale for this time frame and the selection process that produced this list are described in subsequent sections of this report. But the most important, most easily implemented, and most needed projects for the region are itemized here. Beyond this "short list" are many other projects and needs (more frequently referred to as user services), that should also be considered over the next two decades. This distinction, short-term versus longer term, is not intended to limit the placement of improvements on the transportation system. Rather, the intent is to create a context into which improvements can be implemented as they come on line, are funded, or are produced, perhaps as a by-product of some other project.

This plan also addresses some global issues that underlie the entire Richmond/T&Cities ITS program. These are presented below and discussed both here and elsewhere in this document, particularly in Section 8, as they pertain to specific projects.

1.1.1 ITS Leadership

While there is no existing, central agency responsible for ITS, nor even a full responsibility within either the public or private sector for ITS, this study does not recommend such an agency. Instead, the multitude of agencies having ITS-related responsibilities should assume responsibility for regional coordination as an extension of their existing charge. ITS planning is a logical extension of the regional transportation planning that occurs within the metropolitan planning organizations of the Richmond/T&Cities area. A technical sub-committee, working under the direction of the existing MPO management structure, would be well-equipped to plan a growing intelligent transportation system. Similarly, it might be more appropriate for agencies currently conducting design, operations, or maintenance functions to extend their responsibility, by legislative act if necessary, rather than create a new, regional organization.

1.1.2 Funding

Funding for the proposed projects and those that develop out of these recommendations should be expected from a variety of sources. There will be a partnership of existing public sector funds and private sector sources. Funds should be offered in a cooperative manner based on the following, guiding principles:

- ITS projects offer genuine benefits to the travelers of the region. Transportation agencies are charged with providing service to these travelers and so should view ITS as a complementary means of delivering those services rather than as an additional burden. Use of existing budgets is consistent with this philosophy.
- ITS projects, when delivered on a region-wide basis, offer an economy of scale, thereby reducing the cost of delivering services to travelers. While increased service does incur increased cost, the increased cost comes at a discount to each constituent transportation-provider-a win-win situation for both the transportation-provider and user.
- ITS projects improve travel within the region and have a value. Travelers should, therefore, expect to pay for these projects. Additional funds, such as those derived from user fees, could come from traditional sources. Some examples of these sources may include gasoline, battery, and tire excise taxes.
- The private sector should be encouraged to participate in ITS projects but not expected to advance projects at the direction of government agencies. Projects that will make money will likely be assumed by the private sector. Just as private organizations have found a way to generate revenues through disseminating traffic information, other ITS projects will naturally be advanced if the private sector sees an opportunity. Public-private cooperation such that the private sector can participate, rather than be expected to operate alone, should be encouraged. Permitting the private sector a role as an adjunct, while funding the majority of the project through public sector funds, will continue to offer a net benefit to the region's travelers.

1.1.3 Regional ITS Projects

The region's travelers have a need for information. While management of traffic operations is a consideration in some cases, there is a general recognition that information on traffic and travel conditions is most important. The Richmond/Tri-Cities area is generally not operating in a congested environment. Most commuters can drive to work with relative case; freight moves about the roadway network with limited delay; parking is generally ample and affordable; and options for travel are limited, but seem to meet most of the needs of the region's travelers. Over time, this situation can be expected to change. The short-term needs, therefore, call for the 'broadest level of information dissemination. The system architecture, however, should be formulated to permit management and control in the future. The ITS project should also serve as a bridge, prepared to span the relatively high level of personal mobility today and the anticipated, more congested conditions that warrant greater emphasis on alternative modes, in the future.

1.2 CONTENTS OF THIS REPORT

This chapter summarizes the work of the past twelve months in a format that mirrors the FHWA ITS Planning Process. Generally, Sections 2 through 6 summarize work that was reported in separate technical memoranda and summary reports. A list of those reports is presented in the bibliography at the end of this document. Section 7 summarizes the existing, candidate technologies that would be appropriate for the ITS projects for this study area. This work is not described in a separate technical memorandum and so the appendix to the chapter (Appendix A) is more extensive than might otherwise be included in a report of this nature.

The "heart" of this report is Section 8, the deployment plan. Each of the ten projects is explained along with the institutional, funding, and other issues, the systems architecture and technology context, and the general need and priority of the projects. The other projects considered for deployment are described ***in the Steering Committee Number 9 Meeting Agenda (16).*** While they are not "featured" to the extent of the short-term projects, all are important in the long-term planning for the Richmond/Tri-Cities area.

1.3 PROJECT STEERING COMMITTEE

This project was conducted in cooperation with a project Steering Committee. That committee included personnel responsible for the planning, design, construction, and maintenance of transportation infra-structure in each of the jurisdictions, the terminal facilities (e.g., Port of Richmond, Richmond International Airport), and for specialized facilities (e.g., Powhite Parkway) and services (local public transit and inter-city rail). Table l-l lists the membership on the committee.

TABLE l-l

STEERING COMMITTEE MEMBERSHIP

Federal Organizations	
Amtrak *Mr. Danny W. Best, Service Manager*	*Federal Highway Administration* *Mr. Thomas Jennings, Transportation Management Engineer*
Metropolitan Planning Organizations/Planning District Commissions	
Crater Planning District Commission *Mr. Joe Vinsh, Regional Planner*	*Richmond Regional Planning District Commission* *Mr. Dan Lysy, Director of Transportation*
State Organizations	
Virginia Department of Transportation *Mr. J. R. Robinson, Director ITS Programs, Traffic Engineering Division* *Mr. Robb Alexander, Transportation Engineer Sr., Traffic Engineering Division* *Mr. Travis Bridewell, District Traffic Engineer, Richmond District* *Mr. Herbert Pegram, Transportation Engineer Senior, Transportation Planning Division* *Mr. Reggie Beasley, Jr., Urban Programs Engineer, Urban Division* *Mr. Jay Allen, Division Informa tion Systems Manager, Maintenance Division*	*Virginia State Police* *Captain Dave Conklin, First Division Headquarters* *Virginia Department of Rail and Public Transportation* *Mr. Mark Rickards, Transportation Engineer, Senior*
Commissions and Authorities	
Capital Region Airport Commission *Mr. Todd D. Sheller, Richmond International Airport* *Port of Richmond Commission* Mr. *Marty Moynihan, Executive Director*	*Richmond Metropolitan Authority* *Mr. Jim Kennedy, Director of Operations*
Not for Profit Organizations	
Greater Richmond Transit Company *Mr. Keith Parker, Assistant General Manager* *Mr. Greg Thompson, Project Manager* *Metropolitan Richmond Visitor Centers* *Ms. Betsy Langhorne, Manager*	*Ride finders* *Mr. Ho ward Jennings, Executive Director*

TABLE l-l (Continued)

STEERING COMMITTEE MEMBERSHIP

Local Organizations	
Town of Ashland *Mr. H. Stephen Yarus, P.E., Town Engineer*	*County of Henrico* *Mr. Edward L. Priestas, P.E., Traffic Engineer*
County of Charles City *Mr. Harrison Jones* *Mr. William R. Britton, Jr., Director of Planning* *Ms. Gail Clayton, County Administrator*	*City of Hope well* *Mr. Clinton H. Strong, City Manager*
County of Chesterfield *Mr. R. J. McCracken, Director, Transportation Department*	*County of New Kent* *Mr. Larry Gallaher, Director of Public Works*
City of Colonial Heights *Mr. Robert E. Taylor, City Manager*	*City of Petersburg* *Mr. Michael D. Briddell, City Engineer*
County of Dinwiddie *Mr. Charles W. Burgess, Jr., County Administrator*	*County of Powhatan* *Mr. Paul Grasewicz, AICP, Director of Planning*
County of Goochland *Mr. Doug Harvey, County Engineer*	*County of Prince George* *Mr. John G. Kines, Jr., County Administrator*
County of Hanover *Ms. Rebecca Draper, County Engineer, Department of Public Works*	*City of Richmond* *Mr. Ralph H. Rhudy, P.E., Assistant Traffic Engineer* *Mr. R. L. Lenhart Traffic Engineer* *Mr. Matt Miller, Traffic Engineer*
Consultants	
Frederic R. Harris, Inc. *Mr. Stephen D. Hetrick, Project Manager*	*Parsons Transportation Associates* *Mr. Robert E. Parsons, Principal*

SECTION 2
EXISTING AND PLANNED SYSTEMS

2.1 GENERAL BACKGROUND

2.1.1 Geography

The Richmond/Tri-Cities area has unique geographic characteristics that define the transportation system. The Richmond/Tri-Cities area is located in the Mid-Atlantic region of the United States and is directly in the path of Interstates 64, 85, and 95. Interstate 64 runs from Interstate 81 in western Virginia to the Norfolk/Virginia Beach area and provides a direct connection between the metropolitan areas of Charlottesville, Richmond, and Norfolk. Interstate 95, the busiest route of the National Interstate Highway System, connects the Richmond/Tri-Cities area with major eastern cities from Boston, Massachusetts to Miami, Florida. Interstate 85 terminates within the study area at Interstate 95 in Petersburg and serves as a link between the Richmond/Tri-Cities area, Raleigh and Charlotte, North Carolina, and Atlanta, Georgia. In addition to these major interstate routes, the Richmond/Tri-Cities area is served by U.S. Routes 1 and 301 to the north and south, and U.S. Routes 60,360 and 460 west to Lynchburg, Roanoke, and Danville.

Both Norfolk Southern and CSX have rail lines that ship coal to the Norfolk/Hampton Roads area and pass directly through the study area. Additionally, CSX who is the major rail shipper along the Eastern U.S., has major rail lines serving north-south commerce passing directly through the study area.

The Richmond/Tri-Cities area is situated along the general boundary of eastern Virginia and the Piedmont region. Eastern Virginia is generally defined by the Chesapeake Bay and its tributaries on the east and the “fall line,” a noticeable drop in elevation across the state, to the west. Because of environmental and cost constraints, the roadway network in eastern Virginia is oriented primarily toward a few major routes and river crossings. These constraints also affect areas west of Richmond, with the James River dividing the study area into northern and southern portions.

The socioeconomic growth of Virginia is also dictated by its geography. The Chesapeake Bay and ‘its tributaries provide water resources and convenient ocean access. The mountainous western portions of the state make large scale commercial development difficult. The transportation system of the Piedmont region is generally defined by the constraints of eastern and western Virginia and the interactions between the regions. This limits the transportation network in the Piedmont relative to its overall land area. As a result, the vast majority of the growth activity in Virginia, both currently and in. the future, is focused in a corridor defined by the Norfolk/Hampton Roads area at the southeast, the Richmond/Tri-Cities area in the center, and the Metropolitan Washington/Northern Viiginia area in the north. This corridor has been nicknamed the “Golden Crescent of Virginia,” due to its shape and the extensive amount of high quality development that has moved to the corridor, The Richmond/T&Cities area is an integral part of the "Golden Crescent." Most road and rail transportation networks pass through this region.

The importance of Virginia's activity on the Richmond/Tri-Cities area's transportation system is further emphasized by the substantial number of military facilities and tourist attractions. The numerous military bases in the state, as well as those in neighboring states, have operations that require the use of the Golden Crescent road network. The tourist trade in Virginia, both historical (Williamsburg, Richmond, Petersburg and Washington) and contemporary (Virginia and North Carolina beaches, amusement parks and state and national capitals), relies heavily on the roadway network of both the Golden Crescent and the Richmond/Tri-Cities area.

Airport activity in the study area is defined by regional and statewide needs. The study area offers direct airline connections to Tidewater and the Metropolitan Washington Region. The air transportation activity in the study area, while sizeable, is locally oriented and serves as a terminus rather than a hub for interstate or international activity, which are served by the Tidewater and Metropolitan Washington airports.

One last major component of the Richmond/Tri-Cities area transportation system defined by its geography is the Port of Richmond. The James River offers a waterway to support ocean-going vessels that provide some provincial shipping for various business activities in the study area.

2.1.2 Jurisdictions

The Richmond/Tri-Cities area consists of urban, suburban, and rural components governed by city, town and county governments (the term "Tri-Cities" refers to the cities of Petersburg, Hopewell, and Colonial Heights). Some are fully developed urban areas, such as the cities of Richmond, Petersburg and Hopewell. Some are only partially developed with both urbanized and open spaces such as the City of Colonial Heights and the Town of Ashland. Some are fast growing such as Henrico and Chesterfield Counties. Some are partially developed but are beginning to grow faster, such as Hanover and Prince George Counties. On the other hand, Powhatan and Charles City Counties are undeveloped and are growing very slowly.

While the jurisdictions share common interests in relation to geography and national commerce, they vary widely in their perception of how best to serve their constituency. They also must conform to the laws of the State of Virginia regarding the rights and responsibilities of cities, towns and counties.

The State of Virginia takes a leading role on issues that cross jurisdictional boundaries, such as transportation. Each jurisdiction has some authority and responsibility for strictly local issues. The key state departments that regulate transportation in the study area include the Departments of Transportation, Aviation, Rail and Public Transportation, Emergency Services, and Motor Vehicles as well as the State Police.

Additionally, regional agencies and commissions exist that coordinate the activities among the jurisdictions regarding transportation, These include the planning district commissions (PDC's), the metropolitan planning organizations (MPOs), the Capitol Region Airport Commission, the Richmond Metropolitan Authority (RMA) and the Greater Richmond Transit Company (GRTC) and Petersburg Area Transit Authority. Each of these agencies/commissions have charters developed to address specific issues. As previously discussed, the jurisdictions vary widely as to what is important to their constituency and, as a result, none of these agencies serve all the jurisdictions that make up the study area.

The Virginia Department of Transportation (VDOT) has a larger presence in the study area. VDOT's Richmond District operations cover fourteen counties, many of which are within the study area. As a part of these district-wide operations, VDOT has transportation responsibilities within the counties.

The cities of Richmond, Petersburg, Hopewell and Colonial Heights are in complete control of all operations on the roadways that are within their jurisdictional boundaries. The only notable exception to this is the interstate system that is the responsibility of VDOT. City responsibilities include design construction, maintenance and operations of roads, signs, pavement markings, traffic signals (except rail-highway crossing signals), driveway access and snow removal. City residents are the sole recipients of local taxes generated within their boundaries.

The Town of Ashland is also in control of all operations and maintenance on the roadways within its boundaries. The Town does not have responsibility for interstate operations. Local tax revenues generated by its residents must be shared with Hanover County for some services provided by County agencies. Currently, no revenue sharing arrangements between Ashland and Hanover pertain specifically to transportation.

The County of Henrico is one of only two counties in Virginia that operates and maintains its own secondary roadways (VDOT controls the primary roads, which includes the interstate system and U.S. routes). Where a primary road intersects a secondary road, VDOT's responsibility extends up to the right-of-way line on the primary road alignment. The County is responsible for intersection traffic control on secondary roads, except traffic signal system equipment, such as the placement of, and maintenance of, lane lines, stop bars, some movement restriction signs and raised median treatments. These are under the control of the County, whether they are on the County's or State's right-of-way.

The remaining jurisdictions within the study area are the Counties of Hanover, Goochland, Powhatan, Chesterfield, Dinwiddie, Prince George, Charles City and New Kent. These jurisdictions do not have responsibility for the transportation system within their boundaries. Hanover and Chesterfield, by agreements with VDOT, have implemented policies that allow for some design and construction activity to take place under the auspices of the Counties themselves. While this gives them more refinement capability and responsiveness in spending funds for their secondary roads, it does not usurp VDOT responsibility for all of their County roadway infrastructure. The military installations within the study area, Defense General Supply Center (DGSC) and Fort Lee army base, control transportation facilities within their boundaries.

Hanover, Dinwiddie and Chesterfield Counties own municipal airports. Control of their transportation operations is directed by agreement between local, regional and state agencies.

The Port of Richmond Commission, as an agency of the City, controls and operates the deep water terminal within Richmond.

The Richmond Metropolitan Authority operates the Powhite Parkway, the Downtown Expressway, the Boulevard Bridge and several parking garages, along with the professional baseball stadium, located in Richmond.

The MPOs for Richmond and the Tri-Cities area work under federal mandates that require jurisdictional involvement in order to secure federal funds. The staff for these organizations is supplied by the Richmond Regional and Tri-Cities Planning District Commissions. Much of these funds are earmarked for transportation infrastructure planning and coordination. This has recently become much more prominent with the Intermodal Systems Transportation Efficiency Act (ISTEA) of 1990 and the mandated designation of a National Highway System (NHS) adopted in early 1996.

2.1.2.1 State Agencies

The State Departments of Motor Vehicles, Emergency Services and Police provide for and control the movement of people and goods along the study area roadways through licensing, permitting and regulation. Additionally, the DMV and State Police have an information gathering and distribution system coordinated with the State Information Technology Department.

2.1.2.2 Freight Transportation Infrastructure

CSX and Norfolk Southern Railroad companies own the rail lines, rail spurs and road crossings within the study area. Additionally, they and Amtrak own and operate the vast majority of the rail cars that move goods and people along the tracks in the study area.

The trucking industry is an important element of the transportation system in the study area. Trucking companies contribute revenues through taxes and user fees and required services such as roadway assistance and safety inspections.

2.1.3 Demographic Information

This subsection provides income-related demographic data and discusses its relationship to travel patterns in the twelve jurisdictions making up the study area. The data was derived from "The 1990 Census Transportation Planning Package" (CTPP), which tabulates the 1990 census data and tailors the results to meet the needs of transportation planners. A discussion of other demographic data and employment characteristics of the study area is included in Section 2.3 and Section 2.4 of the User ServicePian.(20)

Earnings of workers can have an impact on travel patterns. The actual number of persons working in the study area in 1990 was approximately 436,400, of which almost 28% earn between $10,000 and $20,000. Those earning less than $10,000 make up 20.4% while 22.1% of the working population earns between $20,000 and $30,000. A significant number of workers, 19.8%, earn between $30,000 and $50,000. The remaining workers earn more than $50,000, with a small percentage having no earnings.

The mode of transportation used to get to places of employment typically changes according to earnings. While driving alone is clearly the most frequently used mode of transportation, it increases steadily as earnings rise. Single drivers make up 64.3% of those workers earning less than $10,000, while 86.5% of those earning between $30,000 and $50,000 drove alone. Bus ridership decreases steadily as earnings rise, from 6.9% of those earning less than $10,000 to less than 1% of those earning between $30,000 and $50,000. Carpooling shows a decrease as earning rise as well, but not so dramatic a change as that for bus riders. The number of persons working out of their homes does not appear to have any correlation to earnings. Table 2-l shows the average household income by mode of travel.

TABLE 2-l

HOUSEHOLD INCOME BY MODE OF TRAVEL

MODE\HOUSEHOLD INCOME fin $s)	< 10,000	10,000-19,999	20,000-29,999	30,00049,999	50,000-74,999	>75,000	No earnings reported
Total, all means of transportation	88,887	120,843	96,322	86,312	22,646	11,574	9,840
Drove alone	57,192	89,797	79,739	74,689	19,843	10,504	5,261
In 2-person Carpool	11,478	14,600	10,114	7,402	1,550	543	1,494
In 3-person carpool	1,682	2,644	1,558	952	139	42	202
In 4-or-more-person Carpool	996	1,179	638	580	139	26	200
Bus or trolley bus	6,093	5,952	1,779	763	125	37	874
Streetcar, trolley car, subway, or elevated	17	49	20	24	12	0	0
'Railroad	4	6	9	13	0	13	0
Bicycle or walked	6,266	3,288	944	702	244	95	738
Taxicab, ferryboat, motorcycle, or other means	1,282	1,337	469	263	115	79	266
Worked at home	3,877	1,991	1,052	924	479	235	805

2.2 TRANSPORTATION AND ANCILLARY INFRASTRUCTURE

This section provides a summary of the transportation and ancillary infrastructure in the study area. A more thorough discussion is presented in Section 2.9 of the User Service Plan. (20)

2.2.1 Highway System

The major transportation infrastructure that affects both the region and the State the most is the roadway network. The Richmond/Tri-Cities area has many interstate roads, including Routes 64, 85, 95 and 295. Interstates 95, 64, and 85 have already been discussed. Interstate 295 is a bypass route for Interstate 95 and bypasses Petersburg, Colonial Heights and Richmond. Interstate 295 was built to mitigate congestion on Interstate 95 through Richmond, improve safety and promote commercial development.

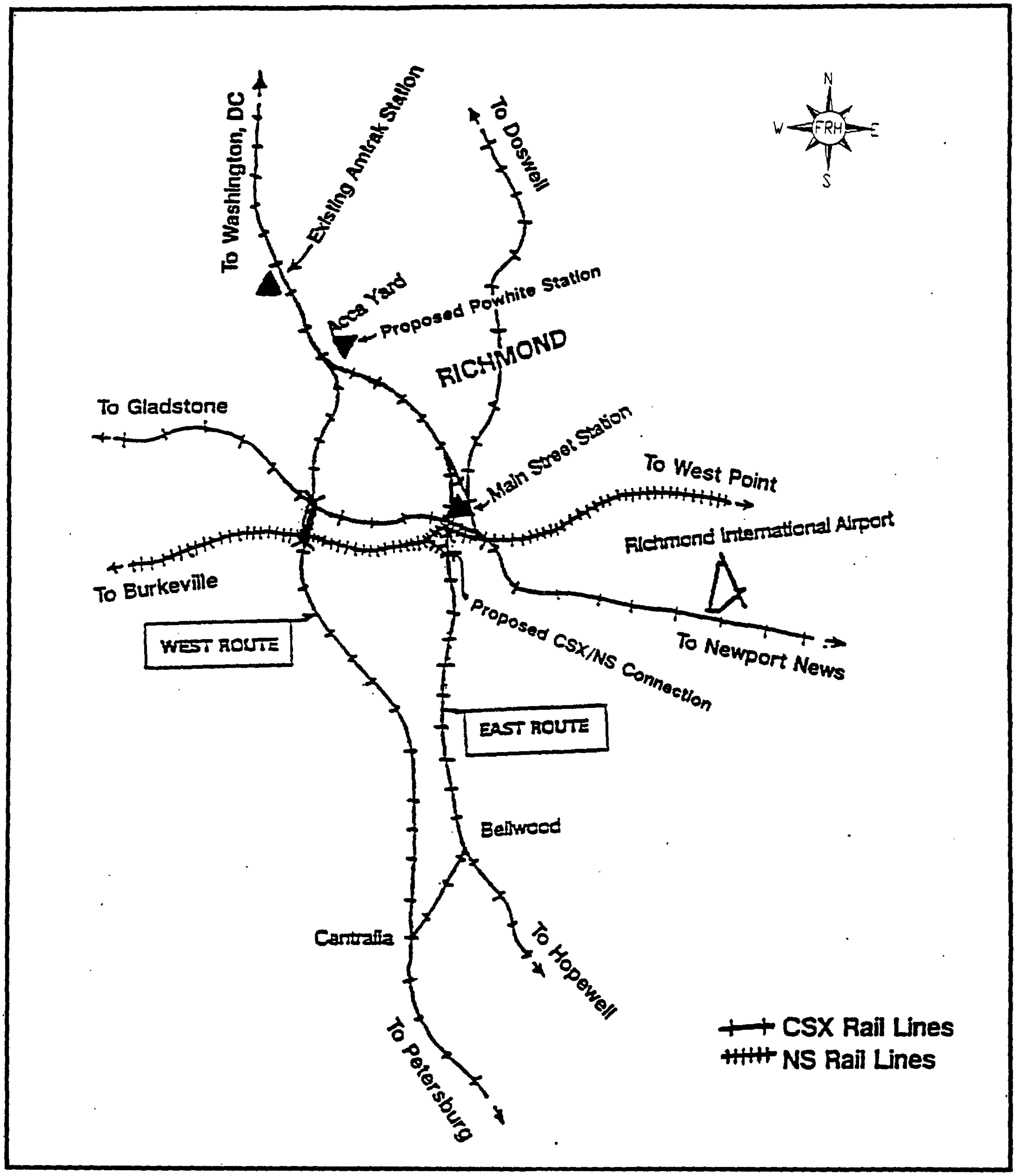
Additionally, Interstate Route 895 is a corridor planned south of Richmond which will connect Interstate 295 to Chippenham Parkway (SR 150), which is a circumferential route around Richmond to the west. Interstate 895 will also provide a new and strategic crossing of the James River.

As important as the interstate system is, other components of the road network are equally important. As previously discussed, a National Highway System has been adopted by the federal government, which considers all important roadways from a regional as well as a state and interstate basis. From the perspective of accessibility for commercial operations, tourism, and local transit, the Richmond/Tri-Cities region contains some of the most important and heavily utilized roadway systems along the East Coast. These roadways range from local roads which provide intra-regional accessibility to state and major interstate highway systems, both of which provide coastal access for freight operations and seasonal tourists. US Routes 1 and 301 have been identified in. the National Highway System as promoting such interstate accessibility. US Routes 360 and 460 offer intrastate accessibility, and State Routes 150 and 288 offer access on an intra-regional basis. Some routes, such as Parham Road in Henrico County and the Downtown Expressway in the City of Richmond, provide inter-regional access even though the systems are wholly located in one jurisdiction. Appendix B summarizes the growth in 'traffic volumes on major freeways in the metropolitan area,

2.2.2 *Rail System*

RaiI represents another important transportation component in the study area. CSX and Norfolk Southern are major carriers of raw material and finished goods in the eastern U.S. Amtrak is the sole rail passenger carrier. Rail transportation is heavily utilized in the study area.

Figure 2-l shows the major rail system in place, not including the lesser spur lines used for local business use. CSX not only owns and operates rail lines going north-south and east-west through the study area, but also provides the lines that Amtrak uses for passenger service. Amtrak



To Washington, DC
Existing Amtrak Station
To Doswell
Acca Yard
Proposed Powhite Station
RICHMOND
To Gladstone
Main Street Station
To West Point
Richmond International Airport
To Burkeville
Proposed CSX/NS Connection
To Newport News
WEST ROUTE
EAST ROUTE
Bellwood
Centralia
To Hopewell
To Petersburg
CSX Rail Lines
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provides passenger service from the Staples Mill Station, north of Richmond in Henrico County. Service operates between the Richmond area and Washington, DC; Raleigh and Charlotte, North Carolina; Florida; Williamsburg and Newport News. Through connections at these termini, passengers can travel throughout the entire Amtrak system. More than a dozen trains stop at the station daily. Service to the Tri-Cities area is offered through a station in Colonial Heights, adjacent to Virginia- State University. Eight trains a day serve similar destinations north and south of the region. Tidewater service is available through connections in Richmond. CSX also owns and maintains the rail yards in Richmond. These yards are used to collect and distribute rail cars from one engine and route to another. They are also the collection point for freight cars that originate north of Richmond which then continue eastward toward Norfolk/Hampton Roads. Overseas container cargo is an important component of this traffic.

Richmond is also part of a High Speed - passenger rail service designated by the U.S. Department of Transportation, running between Washington D.C. and Charlottte, NC. This will permit new opportunities to interface rail and highway facilities.

Rail crossings of roads are maintained by the track owners (CSX and Norfolk Southern) and regulated by the State Department of Rail and Public Transportation. Depending upon the level of traffic on the road and the rail line, the type of crossing is then determined, along with the type of traffic control. In situations where a road crosses a rail line and a downstream traffic signal could potentially queue the motor vehicles back onto the tracks, a traffic signal preemption plan may be established for the signal. The plan is implemented when a train is approaching the crossing. It assures that the signal provides sufficient green time for the queued movement to clear the tracks of motorists before the train arrives at the crossing. This preemption plan, which is a part of the traffic signal control, is usually designed and maintained by the traffic signal maintenance jurisdiction. However, the actual preemption hardware is owned and maintained by the track owners.

2.2.3 Parking Systems

As the motor vehicle is the dominant mode of travel in the study ‘area, parking is therefore an important ancillary function. Since the majority of the study area is suburban or undeveloped in nature, parking is mostly dispersed along the road network, via either on-street parking or off-street parking, such as private driveways or separate parking lots for individual developments.

There is no central parking authority for the Richmond/Tri-Cities area. The majority of the organized parking lots not associated with individual building developments are owned and operated by private enterprises. The notable exception to this is the downtown Richmond parking deck over the downtown expressway, which is owned and operated by the Richmond Metropolitan Authority, and the Richmond International Airport parking lots at the terminal, which are under , the jurisdiction of the Capitol Region Airport Commission.

Other organized parking systems are the park and ride lots owned and maintained by VDOT and Henrico County. These lots are used by the motorists to then either car/van pool to their destinations (usually work) or catch an express bus to downtown Richmond. These lots, while popular, are currently more important to the convenience of the individuals using the lots than to the overall study area transportation system. They hold potential as one element of any travel demand management program that might be implemented.

2.2.4 Transit

The Richmond/Tri-Cities area is served by two transit agencies, the Greater Richmond Transit Company (GRTC) and the Petersburg Area Transit Authority (PAT). The GRTC serves the City of Richmond and Henrico County with a fleet of 181 buses that operate on 53 routes. The PAT currently provides transit service to the, City of Petersburg and the Ettrick portion of Chesterfield County with eight fixed-route buses.

With regard to paratransit, residents in the City of Richmond and Henrico County are served by the Specialized Transportation Assistance for Richmond (STAR) paratransit program under contract to GRTC. This is a' fully ADA-compliant curb-to-curb service for qualified citizens. Citizens in the Petersburg area receive complementary paratransit services through a local church that operates on subsidies from the City of Petersburg.

2.2.5 Air

There are four separate airport facilities in the Richmond/Tri-Cities area: the Richmond International Airport and the three municipal airports in Chesterfield, Dinwiddie and Hanover Counties.

The majority of the airport activity is centered in the Richmond International Airport located in eastern Henrico County. All on-site facilities, including planning and construction, are the responsibility of the Capital Region Airport Commission, which also is in charge of operations. The commission is chartered by the State and directed by an appointed board of elected officials in 'the region. Off-site facilities, however, are either privately owned and operated, or owned, maintained, and/or regulated by Henrico County. The exception to this is the National Guard Air Reserves, 'which has an operation at the airport.

The other airports are general aviation, municipal ownership and are very locally service oriented. Hanover's airport, however, is designated as the overflow destination for air travel originally destined to the Richmond International Airport. Additionally, there are plans underway to expand their facilities to better serve the adjacent industrial park and future development. As was previously discussed, Richmond International Airport serves as the major air destination point for the region. Some of the air activity is oriented outside of the study area toward Norfolk and the Metropolitan Washington area, which has regional hub activity. However, the vast majority of air usage for the study area is focused towards Richmond.

2.2.6 Port

The City of Richmond has a shipping port on the James River that allows direct shipping via the Atlantic Ocean While the major port activity in the State is located in the Norfolk/Hampton Roads area, Richmond's port serves the area's commerce. Some local shipping utilizes the James River. Ships move raw material for the heavy industrial and manufacturing activity in South Richmond and Hopewell. Other transportation modes are then used for delivery of the finished product.

2.2.7 Virginia State Police

The Virginia State Police (VSP) consists of seven divisions throughout the State, each of which has jurisdictional boundaries over a specific geographical area. Each of these areas consists of several counties and/or cities and towns. The First Division has responsibility for the City of Richmond, the Tri-Cities and 21 surrounding counties.

The VSP is responsible for law enforcement, compliance with traffic laws, incident management, the Virginia Criminal Information System (VCIS) and commercial vehicle inspections on all interstate highways within the Commonwealth of Virginia.

The First Division of VSP consists of approximately 240 officers and supervisors. Each officer is assigned duty to a specific geographic area within a county or city, with at least four on-duty officers on patrol in each county at all times. In more urbanized areas, six or more on-duty officers are always on patrol. Patrol coverage is present from 16 to 18 hours a day-24 hours in areas having interstate highways.

The VSP operates emergency call centers, which are located in each county throughout the study area. Each county and city has its own call center and is responsible for processing and directing emergency calls. After calls are processed, the centers then dispatch local respondents to incident locations. All cellular phone 911 calls are answered by the First Division communications center, which is staffed and operated 24 hours a day, 365 days a year. These calls are then directed to the' local police jurisdictions as applicable. All local phone calls, originating from homes and other fixed locations, are handled directly by the local police jurisdictions.

The VSP operates a motorist assistance patrol program, which is funded by VDOT. Motorist assistance patrol cars are white and are configured with yellow flashing warning lights, as opposed to the blue cruisers configured with flashing emergency lights. The motorist assistance vehicles patrol Richmond area highways in search of stranded motorists. Patrollers are required to be somewhat mechanically inclined, to attempt to assist the motorist, and to call a wrecker and/or use bumper pads configured on their vehicles to push disabled vehicles to a safe location. The VSP also maintains a tow truck/wrecker service rotation list for dispatching to incidents. Currently, any service can be added to the rotation list provided that they can pass an inspection conducted by VSP.

A computer-aided dispatch (CAD) system is anticipated to be operational by the end of Summer 1996, the first in the State. Other VSP Divisions throughout the State will be brought on-line over a period of 20 months, commencing with the completion and testing of the First Division CAD system. Local police jurisdictions will have dedicated line access to the CAD system for retrieving information.

2.2.8 Local Police (County, City, and Town)

The Richmond/Tri-Cities area is a typical Virginia metropolitan area, with a complex government structure as a result of having both towns and cities located within counties. Each county, as well as each town and city, operates its own administration. Agreements have been established for the purposes of providing emergency services to neighboring cities, towns and counties when necessary. For example, the Town of Ashland is an independent political entity within Hanover County. Even though these areas are politically' and jurisdictionally separate from one another, a situation may occur within the Town of Ashland that would necessitate the assistance of Hanover County Police. Depending upon the severity of the situation, such as a hostage crisis or a multi-vehicle accident on a major roadway, it may also be necessary for the State Police to get involved. Cooperation during times of inter-jurisdictional emergencies has been noted as good.

All local police operations have some variation of a 24-hour rotating shift. Some administrations operate on an overlapping, g-hour, 3-shift sequence. Others incorporate two 12-hour shifts. Either way, at least two officers are always on patrol.

2.2.9 Fire and Rescue Service

Volunteer and professional fire and rescue services are available throughout the study area, with volunteer services more commonly located in rural areas. Each county, city, or town staffs and operates its own emergency call center and dispatches rescue services as needed. Most county fire and rescue services will respond to incidents within cities and towns when necessary; however, inter-jurisdictional cooperation can be mdre difficult. This is due to the variance of some fire fighting equipment from county to county, which makes systems incompatible. It was reported that policy stipulates that all ambulances operating in the study area are tied to the nearest hospital in need of immediate services.

2.3 TRANSPORTATION RELATED ISSUES

This section presents the problems and opportunities that the Richmond/Tri-Cities area faces in meeting the needs of the regional transportation system. The discussion focuses on traffic congestion and incident management, which were identified as 'some of the major transportation problems for the region, and provides an informed basis for evaluating the usefulness of the ITS User Services in. addressing the needs of the Richmond/Tri-Cities area. Other transportation related issues, and a thorough discussion of the synthesis of problems and opportunities is contained in Section 2.8 of the User ***Service Plan. (20)***

2.3.1 Traffic Congestion

Interstate Highways. The interstate highways that provide regional access to the Richmond/T&Cities area include I-64, I-85, I-95, I-195 and I-295. The congestion on these interstates can be classified into two categories: recurring congestion and non-recurring congestion. Recurring congestion is traffic congestion that occurs at a given location on a frequent basis. Non-recurring congestion is traffic congestion that is caused by unpredictable or infrequent circumstances – for example, incidents on the road, special events, construction/maintenance activities, severe storms, or any other event that severely reduces the flow of traffic.

(1) *Recurring Congestion.* A number of locations on the interstates, where recurring congestion is a problem,, were pinpointed by responsible officials and project staff. Table 2-2 provides a summary of recurring congestion on the interstate highways in the Richmond/Tri-Cities area as indicated by the total number of spots pinpointed for each highway. A more detailed description and location for each spot is provided in Appendix C of the User ***Service Plan. (20)***

TABLE 2-2

RECURRING CONGESTION ON INTERSTATE HIGHWAYS

HIGHWAY	NUMBER OF RECURRING CONGESTION SPOTS
Interstate 64	9
Interstate 85	1
Interstate 95	17
Interstate 195	1
Interstate 295	3

(2) *Non-recurring* Congestion. Most of the reports of non-recurring congestion on the Interstate highways pertain to I-64 and I-95. This makes sense in light of the fact that the recurring congestion reports tabulated in Table 2-2 show that I-64 and I-95 have the most congestion. Incidents and other traffic induced events are more likely to occur on facilities that experience heavier recurring traffic congestion. Non-recurring congestion was also noted on I-85 in Petersburg; however, this non-recurring congestion is less frequent than that in Richmond.

Primary and Secondary Routes.

(1) *Recurring Congestion. The* recurring congestion problems on primary and secondary routes are generally caused by demand that exceeds current capacity. This is especially prevalent in surrounding counties and other areas that are experiencing rapid residential and/or commercial development. For a comprehensive list of specific primary and secondary routes tbat have recurring congestion, see Appendix C of the User *Service Plan.* (20) This appendix contains two tables that list the congested links on primary and secondary routes in the Richmond Regional Planning District and the Crater Planning District.

(2) *Non-recurring Congestion*. The non-recurring congestion on primary and secondary routes is generally caused by incidents,, special events, train crossings, and other events that may not be a factor on the Interstates. Aside from accidents and other emergencies, each jurisdiction has its own special events, railroad crossings, and other unique features that are responsible for non-recurring congestion.

2.3.2 Incident Management

Incident management issues are one of strongest concerns according to the number of comments received during interviews with responsible officials. In general, the comments seemed to point out a number of potential areas for improvement in the way incident management is conducted. These improvements represent opportunities for more efficient incident response, resulting in reduced congestion, reduced operating costs, and fewer injuries and fatalities. Table 2-3 lists the improvement areas and the suggested solutions as presented by the interviewees.

2.4 COORDINATION WITH EXISTING AND PROPOSED ITS PROJECTS

Although the ITS architecture for the Richmond/T+Cities area is mainly concerned with transportation activities that take place in this region, the functions of this architecture should be coordinated with the functions of the Traffic Management System (TMS) centers located in Northern Virginia and Hampton Roads. The rationale for this coordination, and a mechanism that is currently being implemented which can help achieve coordination, is briefly presented in this section.

2.4.1 Coordination Needs with Other Traffic Managements Systems

I-95 and I-295 are essentially parallel and function as diversion routes for'each other. Major incidents which occur north or south of I-295 will result in diversions to Route 1 and Route 301,

TABLE 2-3

POTENTIAL INCIDENT MANAGEMENT IMPROVEMENTS

IMPROVEMENT AREA	RECOMMENDED SOLUTION
Cooperation	(1) Can improve cooperation and efficiency at incident scenes by holding regular meetings to get all incident response parties acquainted and to share information; (2) Create a coordinated policy or procedure that addresses incident response parties and their respective responsibilities in incident response.
Wrecker Services	(1) Need to develop a heavy-duty wrecker service list that includes only those providers that meet minimum standards; (2) Improve dispatch and communications to provide more accurate information about the incident to prevent erroneous requests.
Load Limits on Bridges Along Diversion Routes	Need to review bridge and road capacities to ensure that diversion routes can accommodate the trucks that get diverted from major routes.
911 Phdne Line Capacity	Provide a separate cellular call number to handle all non-emergency police calls so that more capacity on the 911 line is reserved for the life threatening situations.
Secondary Incidents	Clear incidents more quickly
Coordination of Resources	(1) Coordinate joint emergency response exercises; (2) Promote compatibility of equipment between jurisdictions; (3) Investigate a common communications frequency and media; (4) Develop joint operating practices and procedures
Information Sharing/Management	Develop a network for sharing incident data and other information resources.
Opirational Support	Develop resources and management practices that will provide traffic engineering and traffic operations support on a full-time 24-hour, 365-day per year basis.
Vehicular Carrying Capacity of Diversion Routes	(1) Coordination and incident timing plans; (2) Advanced signing; (3) Highway Advisory Radio
Incident Detection	(1) CCTV; (2) Loop detectors; (3) Cellular phones

signalized arterials which have substantially lower capacities than these interstate highways. This lack of high capacity alternate routes on some sections of I-95 makes it very important to decrease the demand volume on I-95 when major incidents occur.

Although the degree of volume reduction that can be achieved is subject to a variety of influences and difficult to estimate, some change in volume will result from communicating the facts concerning major incidents in the Richmond/Tri-Cities area to the TMS centers in Northern Virginia and Hampton Roads. For example: traffic from Northern Virginia heading to points west on I-85 via I-95 could be advised of the delays through the Northern Virginia TMS and encouraged to use I-66 west to I-81 south. Similarly, traffic moving between Northern Virginia and the Hampton Roads area could be advised to use Route 17.

Of course, this type of advisory would only be issued when there is a major incident which is anticipated to have I-95 closed. for several hours or more. It is questionable whether this type of message would be provided over the standard VMS or HAR systems in Northern Virginia and Hampton Roads since it would be of interest to a small fraction of the people viewing the message. However, it is entirely appropriate to use these other TMS centers as contact points for private sector information service providers who can broadcast this data to the market sectors that are interested in receiving the information.

The periodic need to evacuate the Tidewater area when there is an approaching hurricane is another important reason for linking a future TMS center in the Richmond/Tri-Cities area with the Hampton Roads TMS. Under these conditions it is extremely important to post appropriate messages on the VMS and HAR systems in the Richmond/Tri-Cities area. These messages can discourage traffic from traveling to the Hampton Roads area, and can help keep the I-64 eastbound lanes available for emergency vehicles. These messages are important during an evacuation, and continue to be important during the disaster recovery efforts that follow in the aftermath of a major storm.

2.4.2 Coordination Via the I-95 Corridor Coalition Information Exchange Network

The Information Exchange Network (IEN) that is currently being developed and implemented by the I-95 Corridor Coalition is a strong candidate for coordinating the communications between a future TMS serving the Richmond/Tri-Cities area and the existing Northern Virginia and Hampton Roads TMS centers. This IEN will eventually interconnect the member agencies of the I-95 Corridor Coalition. This will include the TMS centers in Hampton Roads and Northern Virginia, as well as TMS centers further north. When completed, the system will include several workstations for each agency using text messages and a GIS (geographic information system) to display current operational information in the corridor. Approximately 60 workstations are envisioned for deployment throughout the I-95 corridor.

The April 1996 edition of *the I-95 Corridor Clipboard* contained a brief summary of the status of the IEN. For the foreseeable future, the IEN is based on dial-up telephone lines for communications. When an incident is input at an IEN workstation, the server is dialed via an 800 number. The information is then relayed by the server to the other IEN workstations using a single phone line, allowing only one workstation to receive information at a time. An upgrade that is now being made will provide an 8-line “hunt group”. This will allow the server to dial, connect and transmit messages to multiple workstations concurrently while continuing to receive information from other workstations. The use of multiple servers is also being considered to expedite the transmission of messages.

Other changes anticipated in the future will replace the manual data entry requirements with an interface which will extract the required information from the local TMS center’s database, convert the data to the appropriate protocol and transmit the information to the server supporting the IEN workstation.

Currently there are eight existing IEN sites, one of which is located at VDOT’s Transportation Emergency Operations Center (TEOC) in Richmond. It is anticipated that additional workstations will be deployed at the Hampton Roads and Northern Virginia TMS centers as part of the future deployment.

SECTION 3
PROBLEM DEFINITION AND OPPORTUNITIES

The proper identification of problems affecting, and opportunities available to, the Richmond/Tri-Cities area is an important step in the development of a Strategic Deployment Plan for the region. By defining the current deficiencies as well as the potential opportunities in the transportation system, several things are accomplished:

- The need for various ITS user services can be gauged.

- ITS user services can be selected to maximize the extent to which current deficiencies are addressed and the extent to which opportunities are utilized to improve the transportation system.

- Measures of Effectiveness (MOEs) can be identified for gauging progress towards objectiveness and maximizing operating efficiency of ITS investments.

3.1 PROCESS

In order to arrive at the optimal solution to any problem , a thorough understanding of the problem itself and related parameters must be obtained. As such, a major component of the work FRH performed on the project was the identification of key problem areas and issues that could be addressed through the deployment of ITS technologies and systems.

The first step in identifying these key problem areas and issues was to develop an understanding of the transportation systems in the Richmond/W-Cities region. This initial step consisted of gathering and assimilating current data regarding these systems.

During the various information gathering processes, the data collected was shared with the Steering Committee in order to expose the Committee to the reported issues, and allow the Committee to provide feedback and guidance on what was reported.

3.1.1 Public Sector Stakeholders

The data review established the' basis for collecting additional information, through meetings, interviews, and, focus group sessions with individuals and groups associated with the regional transportation systems. The objective was to identify the key problems and issues to be addressed in this project. Data collection from the public sector included in-depth interviews with the following stakeholder groups:

- Federal Transportation Agencies.
- State Transportation Agencies.
- VDOT District Staff and Other Agencies.
- Local Government.
- Authorities and Commissions.

Table **3-1** summarizes the public sector stakeholder participation and sources of input.

TABLE 3-l

PUBLIC SECTOR TRANSPORTATION STAKEHOLDERS

Sector	Agency
Federal	• Federal Highway Administration • Amtrak
State	• Virginia Department of Motor Vehicles • Virginia Department of Rail and Public Transportation • Virginia Transportation Research Council • VDOT - Central Office, Maintenance Division • VDOT - Richmond District, Traffic Engineering Division • VDOT - Traffic Engineering Division • VDOT - Transportation Planning Division • VDOT - Urban Division • VDOT - Powhite Parkway Extension • Virginia State Police
Local	• Charles City County Government • Chesterfield County Government • City of Colonial Heights • Dinwiddie County Government • Goochland County Government • Greater Richmond Transit Company • Hanover County Government • Henrico County Government • New Kent County Government • Powhatan County Government • Prince George County Government • City of Hopewell • City of Petersburg • City of Richmond • Town of Ashland • Town of Ashland Police

TABLE 3-1 (Continued)

PUBLIC SECTOR TRANSPORTATION STAKEHOLDERS

Sector	Agency
Authorities and Commissions	• Richmond Metropolitan Authority • Capital Region Airport Commission • Crater Planning District Commission • Port of Richmond Commission • Richmond Regional Planning District Commission

Additional information on these interviews and public sector data collection activities can be found in the *Synthesis of Problems and Opportunities (17)*, and *User Service Plan (20).*

3.1.2 Private Sector Stakeholders

FRH also conducted in-depth interviews with representatives from private sector organizations. Table 3-2 summarizes the private sector stakeholder participation and sources of input.

TABLE 3-2

PRIVATE SECTOR TRANSPORTATION STAKEHOLDERS

Organizations
• AAA of Virginia
• CSX Corporation
• Metro Traffic Control
• Norfolk Southern Corporation
• Overnight Transportation Company Freight Line
• Ridefinders
• Robinson Transportation Company
• Old Dominion Freight
• VSPI Commuter Vanpools
• Acton Cab
• Veterans Cab
• Manhattan Cab
• Yellow Cab
• Boulevard Cab
• A All Around Cab

Additional information on these interviews and public sector data collection activities can be found in the *Synthesis of Problems and Opportunities (17),* and *User Service Plan (20).*

3.1.3 Public Outreach Effort

FRH implemented a public outreach effort by conducting interviews and holding focus group sessions with community and civic groups. Table 3-3 summarizes the public outreach participants and contributors.

TABLE 3-3

PUBLIC OUTREACH PARTICIPATION

Group	Representative
Community and Civic	• Goochland County Planning Commission Comprehensive Plan Transportation Committee • MPO Citizens' Transportation Advisory Committee • Richmond Highway Safety Commission • Virginians for Better Transportation/Virginia Road and Transportation Builders Association • City of Hopewell Transportation Safety Commission • Huguenot Neighborhood Team Process Group • Henrico County Highway Safety Commission • Colonial Heights Chamber of Commerce • Midlothian Neighborhood Team Process Group • East District Neighborhood Team Process Group • Far West Neighborhood Team Process Group • Petersburg Chamber of Commerce

Additional information on these interviews and focus group activities can be found in the *Synthesis of Problems and Opportunities (I 7),* and *User Service Plan (20).*

3.2 SPECIAL INVESTIGATIONS

There are two ITS user services, as defined in the National Program Plan for ITS, which are particularly important to the Richmond/'Tri-Cities area transportation system. Specifically, the Freight Mobility and Personalized Public Transit user services impact the performance of the region's current transportation system, and are expected to play increasingly more important roles in the future. FRH performed special investigations to properly identify and address problems and opportunities related to each of these user services. This analysis is outlined below.

3.2.1 Freight Mobility

Freight Mobility is a user service developed specifically to address the needs of freight transportation. Freight mobility services are generally intended to enhance the movement of freight by supplying dispatching operations with realtime traffic information and freight locations; assisting truck drivers in avoiding congestion; and improving the efficiency and reliability of trucking operation.

The Richmond/Tri-Cities area is an important industrial and transportation center within Virginia. Both from a local and national perspective, a substantial amount of freight activity centers around The City of Richmond specifically, and the Richmond/Tri-Cities area, in general. The City of Richmond and the surrounding counties are home to a broad range of manufacturers which continue to generate a substantial amount of local freight activity.

The area is also a transportation center, not only for the Commonwealth of Virginia but also for the east coast and along corridors leading into the rest of the country. The region is connected to the rest of the country through a network of major highways, rail lines, an international airport, and a port. Inter-modal activity, that is, freight movement involving more than one mode, is also prevalent in the region.

The project team in cooperation with the project Steering Committee identified Freight, Mobility as a user service. that should be examined with an eye towards identifying deficiencies and seeking means, within the spectrum of ITS improvements, that could ameliorate those deficiencies. The central charge of this investigation is truck traffic, and to the extent appropriate, its relationship with other modes of freight movement.

Information for this special investigation was gathered from a variety of sources and through a variety of means. During the initial project data gathering effort, representatives of the various trucking companies were contacted. Through individual, face-to-face interviews and in group sessions, their ideas and concerns were solicited. Subsequently, representatives of trucking firms were individually contacted and interviewed by telephone with the specific objective of addressing the interests of this investigation.

The principal need identified was for improved information. Whether the subject of the information is highway congestion, construction activity, or vehicle routes, truck operators preferred to have information with which to make decisions on how best to deal with their specific problems. Both real-time and advisory information would assist in moving freight through the area.

Also important was a need for information dissemination through current technologies: highway advisory radio, variable message signs, standard highway signing, and possibly, dial-in services. Information systems that might require private sector expense were not cited at all.

Similarly, concerns over administrative needs could be reduced to matters of cost to freight operators. Improvements that might entail private sector investment, even with eventual offsetting savings, were not generated through this investigation.

The summary of findings and FRH recommendations are addressed in detail in the *Special Investigation: Freight Mobility* Issues document (1).

3.2.2 Personalized Public Transit

Personalized Public Transit is a user service which, in general, entails using a fleet of vehicles to carry passengers, on demand, between individualized origins and destinations. These vehicles could be publicly, privately, or jointly operated.

Early in this study, the project team noted a concern over the quality of personalized public transit in the study area, specifically that there appeared to be a lack of taxi service. Individuals contacted during the course of the initial project interviews also described existing paratransit service and indicated that generally, such service was confined to individual jurisdictions and often for a select clientele. Social service providers, through public or private operators, frequently using volunteer drivers, transport their clients from homes to their agency's facilities and occasionally to selected, outside destinations (e.g., shopping trips, doctors). These transportation services are independent of one another and are not available to the general public.

Also early in the study, the project team in cooperation with the project Steering Committee established project goals. The evaluation of user services identified Personalized Public Transit as a high priority issue. On the basis of this information, the project team launched an investigation to identify deficiencies in the current personalized public transit system and a means of expanding and improving the system. The question became, "What is the reason for the apparent lack of taxi service in the Richmond area?"

The investigation focused on the Richmond area, specifically, downtown Richmond and the airport. Secondarily, the entire City and adjacent suburban counties were investigated. Representatives, owners, operators, and dispatchers from taxi companies, regulatory agencies, and social service agencies were contacted and interviewed to assist in answering the questions posed for this investigation. The passengers' perspective was gathered through contact with these and other individuals responding as potential riders and through the project team members' personal observations.

Increased taxi service should be promoted within the Richmond area. Initial emphasis should be centered on travel downtown and to the airport. In this way, as traffic volumes grow and parking becomes more difficult to find, the alternative of taxi travel will be better established. Service outside of the CBD does not appear warranted at this time given the prevalence and ready accessibility to the automobile.

Initial promotion of taxi service should include a broad-based educational program to advise potential riders of:

- telephone numbers to call for a taxi;
- the fares for taxis; and
- the location of cab stands within the CBD.

Future efforts could entail efforts to make taxis more attractive through alternative payment plans and fare structures, customized service, and contract arrangements with businesses and other organizations.

The details and findings of this special investigation can be found in the *Personalized Public Transit* document (5).

3.3 SUMMARY OF PROBLEMS AND OPPORTUNITIES

FRH has determined that the Richmond/Tri-Cities area problems and opportunities generally fall into two classes:

- *General.* These problems and opportunities address issues that are not tied to a specific geographic location. For example, inter-agency cooperation issues, inter-jurisdictional issues, and public transit network issues.

- *Location-Specific.* These problems and opportunities are best represented by a specific geographic location (i.e., a point on a map). For example, recurring congestion at a specific interchange, failure of,. or construction on, a bridge, or concerns about a toll facility.

Based on the system data collected, compiled and obtained from the above information gathering processes, a comprehensive list of Richmond/Tri-Cities regional problems and issues that could be addressed (soived) by the deployment of ITS technologies was established. This list is shown in Table *3-4.*

TABLE 3-4

SUMMARY OF PROBLEMS AND OPPORTUNITIES

ITS Area	Problems and Opportunities
Travel and Transportation Management	• There is inadequate information for tourists, local residents and businesses about tourist attractions, alternate routes or planned construction activities. • There is a lack of regular traffic reports in some areas outside of the City of Richmond. • Need to improve intersections and signal system coordination and timing. • Red light running, speed enforcement, railroad crossings, maintenance and snow removal efforts are regional concerns. • Diversion routes with older bridges may be inadequate for some links on major interstates. • There is interest in providing real-time information via telephone and.cable TV. • Need to collect information for traffic management, and increase surveillance at the I-95/I-64 interchange. • VMS units will be constructed on I-95 N and S of the I-95/I-295 interchanges. • The region has strong mutual aid agreements, but coordination and field communications among VDOT, VSP, fire departments and local administration should be improved. • The VDOT TEOC is a resource that might be better used. • The University of Richmond and Virginia Commonwealth University present FM radio traffic broadcasting opportunities with their stations. • Improvements to AM broadcasting facilities should be investigated.
Travel Demand Management	• Parking in the CBD is limited and expensive. • There should be more promotion of carpooling/ridesharing, targeting employers in addition to individual workers. • Ridefinders actively promotes ridesharing. • Additional park and ride lots should be constructed where needed. • Improvements to local road networks are needed to improve accessibility to new developments, but getting approvals from residents and jurisdictions can be difficult.
Public Transportation Operations	• Dispatchers should have the ability to call drivers in emergencies. • Bus service should be coordinated on a regional basis and should include businesses, malls, medical facilities and transportation centers. • Bus service for the disabled could be improved. • Taxi service needs to be improved. • Bus shelters should be provided at key locations. • There are locations along the Amtrak routes that present opportunities for use and upgrading service. The downtown multi-modal center will have a Greyhound bus terminal in 2003.
Electronic Payment	• Electronic toll systems will be installed at the airport and are being considered by the RMA and VDOT.

TABLE 3-4 (Continued)

SUMMARY OF PROBLEMS AND OPPORTUNITIES

ITS Area	Problems and Opportunities
Commercial Vehicle Operations	• The Port has a lack of clearance for double stack trains and poor rail service connections. • CSX operates a terminal in the Richmond area, which serves as a point of distributing freight from rail to other transport modes.
Emergency Management	• Some fire fighting equipment is incompatible from county to county. • A separate cellular non-emergency call number would be of benefit for reporting all minor incidents to the VSP. • VDOT needs to develop a heavy-duty wrecker list that includes only those providers that meet minimum standards.

For additional information on the identified problems and opportunities, consult the *Synthesis of Problems and Opportunities* document, (17).

3.4 RELATIONSHIP TO PROJECTS

In Section 8 of this document, FRH recommends and defines a collection of ITS projects covering, as applicable, the ITS areas listed above. These projects, if properly executed, should ameliorate the Richmond/Xi-Cities area of the transportation problems it is currently faced with, and should put the region in a position to sufficiently address the region's future transportation problems. These projects have been structured to accomplish these goals by taking advantage of the opportunities identified through the execution of the processes outlined in this section.

SECTION 4
PRIORITIZED USER SERVICES

Fundamental to the creation of a system architecture for the Richmond/Tri-Cities Intelligent Transportation System is a thorough understanding of the user services that should be implemented. The National Intelligent Transportation System Program Plan (NPP) is focused on the development and deployment of a collection of inter-related user services. Twenty-nine user services have been defined to date as part of the national program planning process. This list is neither exhaustive nor final, with services and the accompanying descriptions expected to evolve through program plan updates.

The users of these services include travelers using all modes of transportation, transportation management center operators, transit operators, Metropolitan Planning Organizations (MFO's), commercial vehicle owners and operators, state and local governments, and many others who will benefit from deployment of ITS.

4.1 USER SERVICE DESCRIPTIONS

Each of the user services share common characteristics and features. It is, therefore, useful to understand these characteristics and features as a precursor to describing the individual services.

Individual user services are building blocks that may be combined for deployment in a variety of fashions. The combination of services deployed will vary depending upon local priorities, needs, and market forces. Within the National ITS Program Plan, user services have been grouped into "bundles" based on likely deployment scenarios. The services and bundles are shown on Table 4-l.

User services are comprised of multiple technological elements or functions which may be common with other services. For example, a single user service will usually require several technologies, such as advanced communications, mapping, and surveillance which may be shared with other user services. This commonality of technological functions is one basis for the suggested bundling of services.

User services are in various stages of development and will be deployed as systems according to different schedules. Some of the technologies required by various user services are currently available in the market place, while others will require significant research and development before they can be deployed.' The development and deployment of an individual service will be guided by the policies and priorities established by both the public and private sector participants. These policies and priorities will evolve based on changing technologies, economic factors, and market conditions.

Costs and benefits of user services depend upon deployment scenarios. Once the basic technological functions, such as communications or surveillance, have been deployed for one user service, the additional functions needed by one or more related services may require only a small incremental cost to produce additional, often significant benefits.

Many user services can be deployed in rural, suburban and/or urban settings. User services are not specific to a particular location. Rather, the function of the service can be adapted to meet local needs and conditions.

TABLE 4-l

ITS USER SERVICES

TRAVEL AND TRANSPORTATION MANAGEMENT	COMMERCIAL VEHICLE OPERATIONS
• En-Route Driver Information • Route Guidance • Traveler Services Information. • Traffic Control • Incident Management • Emissions Testing and Mitigation [1]	• Commercial Vehicle Electronic Clearance • Automated Roadside Safety Inspection • On-Board Safety Monitoring • Commercial Vehicle Administrative Processes • Hazardous Materials Incident Response • Freight Mobility [3]
TRAVEL DEMAND MANAGEMENT	EMERGENCY MANAGEMENT
• Pre-trip Travel Information • Ride Matching and Reservation • Demand Management and Operations [2]	• Emergency Notification and Personal Security • Emergency Vehicle Management
PUBLIC TRANSPORTATION OPERATIONS	ADV. VEHICLE CONTROL AND SAFETY SYSTEMS
• Public Transportation Management • En-Route Transit Information • Personalized Public Transit • Public Travel Security	• Longitudinal Collision Avoidance • Lateral Collision Avoidance • Intersection Collision Avoidance • Vision Enhancement for Crash Avoidance • Safety Readiness • Pre-Crash Restraint Deployment Automated Highway Systems
ELECTRONIC PAYMENT	
• Electronic Payment Services	

The ITS User Services listed in the preceding table will be implemented through the leadership of many organizations. In some instances the organizations leading the implementation efforts are public agencies, in others they are private sector firms, and in a few there are public-private partnerships. In several cases leadership opportunities exist for both the public and the private sector.

A preliminary screening was performed to identify the user services that require the leadership of the public sector and those that are primarily dependant upon private sector leadership. This screening, shown in Table 4-2, was also based on materials contained in the "National Program Plan for Intelligent-Vehicle Highway Systems," as well as the discussions that have taken place with VDOT staff and the other members of the project Steering Committee, interviews with agency representatives, and group meetings with transportation system users.

4.3 BASIS FOR ESTABLISHING PRIORITES

Priorities for the ITS User Services were selected in conformance with the guidelines developed by FHWA. The three major factors used to determine the short-, medium-, and long-term user service objectives are: the ability of the user services to address the goals identified for this project; the need for these user services in the community; and the ability to implement these user services. These factors were. evaluated independently for each of the ITS User Services. The results of these independent analyses were then combined to produce the overall ranking for the user services shown in Table 4-3. The material within this section briefly describes the criteria for the ranking services. The User Service Plan (20) goes into greater detail on this ranking process.

4.3.1 Ability of the User Services to Satisfy the Region's Goals

The ability of the user services to satisfy the region's goals was determined using a three step process. The first step in this process identified a preliminary series of goals, and developed weights for these goals based on their relative importance. The second step assigned a series of compliance ratings to each user service based on how well that user service satisfied each of the regional goals. The third and final step ranked the user services based on the sum of the products of the goal weights and the compliance ratings.

4.3.2 Ability of the User Services to Satisfy the Region's Needs

The needs of the region are reflected in the statements of problems and opportunities that were gathered during the interviews with the Steering Committee, other agency personnel, and the representatives of the local communities. These statements are views of problems in the region, and opportunities for introducing transportation improvements as seen from a host of different individual perspectives. They also provide valuable insight into these issues from a regional -perspective, For example, numerous people from different parts of the region cited problems with traffic signal coordination. These comments were synthesized with other statements of intersection deficiencies into a single statement indicating that there' is a "need to improve intersections, signal system coordination, and timing".

TABLE 4-2

IMPLEMENTATION LEADERSHIP OF ITS USER SERVICES

	IMPLEMENTATION	LEADER
BUNDLE/USER SERVICE	PRIVATE SECTOR	PUBLIC SECTOR
Travel and Transportation Management		
En-Route Driver Information	*	*
Route Guidance	*	*
Traveler Services Information	*	*
Incident Management		✔
Emissions Testing and Mitigation		✔
		✔
Travel Demand Management		
Pre-Trip Travel Information	*	*
Ride Matching and Reservation	*	*
Demand Management and 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 Electronics Clearance		✔
Automated Roadside Safety Inspection		✔
On-Board Safety Monitoring	✔	
Commercial Vehicle Administrative Processes		✔
Hazardous Materials Incident Response	*	*
Freight Mobility	✔	
Emergency Management		
Emergency Notification and Personal Security	✔	
Emergency Vehicle Management		✔
Advanced Vehicle Control and Safety Systems		
Longitudinal Collision **Avoidance**	✔	
Lateral Collision Avoidance	✔	
Intersection Collision Avoidance	✔	
Vision Enhancement for Crash Avoidance	✔	
Safety Readiness	✔	
Pre-Crash Restraint Deployment	✔	
Automated Highway Systems	*	*

* Leadership opportunities in both the Public Sector and Private Sector

A systematic evaluation of the relationships between these statements and the ITS User Services was performed for user services in the following six bundles:

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

4.3.3 Ranking of the User Services Based on the Ability to Implement Them

The user services were also ranked on their ability to be implemented, also referred to as their "implementability".

This qualitative ranking reflected a variety of factors related to the implementability of the user service. These factors included: the relative cost of the program, the degree to which the service can be disaggregated into a series of projects, efforts that are already underway to implement various aspects of the user service, the degree of change required in the ways that the agencies currently perform activities related to the user service, and the dependance of some of these user services on others.

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

4.4 PRIORITIZED USER SERVICE OBJECTIVES

A matrix was produced based on the needs and implementability rankings of the user services. This matrix is shown in Table 4-3. The degree of goal satisfaction is also shown in this matrix within the parentheses that follow the user service name. (It will be noted that this degree of goal satisfaction is a relative ranking of between 0 and 4.)

TABLE 4-3

COMPOSITE RANKING FOR ITS USER SERVICES

RANKING BASED ON NEEDS	RANKINGS BASED ON IMPLEMENTABILITY		
	HIGH	**MEDIUM**	**LOW**
HIGH	Incident Management (3.2)*	En-Route Driver Info (2.6)* Pre-Trip Travel Info (3.0)	Demand Mgmt. & Operations (2.6)
MEDIUM	Ride Matching & Reservation (2.7)	Traveler Services Info (1.4) Public Transportation Mgmt (2.7)	Route Guidance (2.3) Public Travel Security (3.0) En-Route Transit Info (2.5)
LOW	**Traffic Control (3.6)** Electronic Payment Services (2.1)	Emergency Vehicle Mgmt (2.31 Automated Roadside Safety Inspection (0.001	Emissions Testing & Mitigation (1.4) **Personalized Public Transit (3.6)** Commercial Vehicle Electronic Clearance (0.0) Commercial Vehicle Administrative Processes (0.0) Hazmat Incident Response (0.0)

*These ITS User Services were ranked as having very high needs.
Bold indicates higher goal satisfaction rankings than other user services in this level of needs priority.
Private sector initiatives are not included in this ranking.

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

One additional adjustment was made to the user service priorities based on the degree to which the user services can satisfy the regional goals. The goal satisfaction rankings for Traffic Control and Personalized Public Transit are clearly higher than the goal satisfaction rankings of the user services in that cell or the surrounding cells. For this reason, we have raised the implementation priority for these two user services one level each.

The result of this composite ranking is presented in Table 4-4 which shows the overall short-term, medium-term and long-term implementation priorities for ITS User Services in the Richmond/Tri-Cities area.

It should be further noted that the "need" rankings for Incident Management and En-Route Driver Information user services were both very high. Improvement plans should be developed for both of these user services, as soon as possible.

TABLE 4-4

OVERALL ITS USER SERVICE IMPLEMENTATION PRIORITIES

SHORT-TERM (1-3 Year Implementation)	**MEDIUM-TERM (4-7 Year Implementation)**
Incident Management* En-Route Driver Information* Pre-Trip Travel Information Ride Matching and Reservation Traffic Control	Traveler Services Information Public Transportation Management Demand Management and Operations Personalized Public Transit Electronic Payment Services
LONG-TERM, PUBLIC AND PUBLIC/PRIVATE SECTOR (7-20 Year Implementation)	**LONG-TERM, PRIVATE SECTOR ONLY (7-20 Year Implementation)**
Route Guidance Emergency Vehicle Management En-Route Transit Information Emissions Testing and Mitigation Public Travel Security Automated Roadside Safety Inspection Commercial Vehicle Electronic Clearance	Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance Vision Enhancement for Collision Avoidance Safety Readiness Pre-Crash Restraint Deployment Automated Highway Systems On-Board Safety Monitoring Freight Mobility Emergency Notification and Personal Security

* Immediate action implementation plans should be developed for these User Services.

The user services, whose implementation, rests primarily with the private sector, are also included in Table 4-4. For purposes of this table they have been identified as having long-term implementation priorities. However it must be recognized that their actual deployment may be advanced if the private sector's evaluation of their rewards and risks indicates that it is advantageous to implement them sooner.

SECTION 5
FUNCTIONAL REQUIREMENTS

The functional requirements on which the system architecture is based are defined through specific market packages that are best suited to implement the user services that were previously identified. These market packages, which were developed as part of the ITS National Architecture effort, reflect a refinement and more focused concept of how ITS improvements will be implemented.

This section describes the process by which market packages were selected to meet the requirements of the user services identified by the Richmond/TriCities ITS Early Deployment study. These market packages establish the functional requirements for the definition of the system architecture described in Section 6, and the identification of specific projects that could be undertaken to facilitate the delivery of the ITS User Services in the Richmond/T&Cities area.

5.1 MARKET PACKAGES

The market packages shown in Table 5-l respond to transportation problems and needs identified as part of the ITS National Architecture program. They address specific services that might be required by traffic managers, transit operators, travelers and users of the transportation system. Descriptions of these market packages are in the National Architecture documents. (24 through 32)

These market packages are closely coordinated with the general architecture and have been defined in ways that make them ITS building blocks. The incremental approach incorporated in their design and definition allows the basic packages to support the efficient implementation of the more advanced packages.

This selection of market packages for this study was based on the user services in the short-term and the medium-term implementation priority groups. The procedure used in this selection is described in the remainder of Section 5.

5.2 RELATIONSHIP BETWEEN THE USER SERVICES AND MARKET PACKAGES

The relationship between the user services and market packages, shown in Table 5-2, is taken from the Implementation Strategy (26) prepared by the ITS National Architecture, This table indicates how each of the 29 user services is mapped into the market packages. The synergies among the user services and market packages are illustrated by the fact that many of the user services are associated with multiple market packages, and conversely, in that a particular market package may be associated with multiple user services. It should be noted that the user services in this table have been marked to identify those that were identified as short-term and medium-term implementation priorities.

TABLE 5-l

MARKET PACKAGES

ATMS	**ATIS**	**APTS**
• Network Surveillance • Probe Surveillance • Surface Street Control • Freeway Control • HOV and Reversible Lane Management • Traffic Information Dissemination • Regional Traffic Control • Incident Management System . Traffic Network Performance Evaluation . Dynamic Toll/Parking Fee Management • Emissions and Environmental Hazards Sensing • Virtual TMC and Smart Probe Data	• Broadcast Traveler Information • Interactive Traveler Information • Autonomous Route Guidance • Dynamic Route Guidance • ISP Based Route Guidance • Integrated Transportation Management/Route Guidance • Yellow Pages and Reservation • Dynamic Ridesharing • In-Vehicle Signing	• Transit Vehicle Tracking • Transit Fixed-Route Operations • Demand Response Transit Operations • Transit Passenger and Fare Management • Transit Security • Transit Maintenance • Multi-modal Coordination
EM	**cvo**	**AVSS**
• Emergency Response • Emergency Routing . Mayday Support	• Fleet Administration • Freight Administration • Electronic Clearance • Electronic Clearance Enrollment • International Border Electronic Clearance • Weigh-In-Motion • Roadside CVO Safety • On-board CVO Safety • CVO Fleet Maintenance • HAZMAT Management	• Vehicle Safety Monitoring • Driver Safety Monitoring • Longitudinal Safety Warning • lateral Safety Warning • Intersection Safety Warning • Pre-Crash Restraint Deployment • Driver Visibility Improvement • Advanced Vehicle Longitudinal Control • Advanced Vehicle Lateral Control • Intersection Collision Avoidance • Automated Highway System
ITS Planning		
. ITS Planning		

EM - Emergency Management
ATIS - Automated Traffic Information Systems
APTS - Automated Public Transit Systems
AVSS - Advanced Vehicle Safety Systems

TABLE 5-2 MARKET PACKAGE TO USER SERVICE RELATIONSHIPS

Legend
- ■ Core Packages
- ▩ Additional Key Packages
- S Short-Term Implementation Priorities
- M Medium-Term Implementation Priorities

USER SERVICES

	MARKET PACKAGES	1.1 - Pre-Trip Travel Information	1.2 - En-Route Driver Information	1.3 - Route Guidance	1.4 - Ride Matching and Reservation	1.5 - Traveler Services Information	1.6 - Traffic Control	1.7 - Incident Management	1.8 - Travel Demand Management	1.9 - Emissions Testing and Mitigation	2.1 - Public Transportation Mgmt.	2.2 - En-Route Transit Information	2.3 - Personalized Public Transit	2.4 - Public Travel Security	3.1 - Electronic Payment Services	4.1 - Commercial Vehicle Electronic	4.2 - Automated Roadside Safety	4.3 - On-Board Safety Monitoring	4.4 - Commercial Vehicle Administrative	4.5 - Hazardous Fleet Management	4.6 - Commercial Fleet Management	5.1 - Emergency Notification and	5.2 - Emergency Vehicle Management	6.1 - Longitudinal Collision Avoidance	6.2 - Lateral Collision Avoidance	6.3 - Intersection Collision Avoidance	6.4 - Vision Enhancement for Crash	6.5 - Safety Readiness	6.6 - Pre-Crash Restraint Deployment	6.7 - Automated Vehicle Operation
		S	S		S	M	S	S	M		M		M		M															
ATMS	Network Surveillance						✓																							
	Probe Surveillance						✓																							
	Surface Street Control						✓	✓																						
	Freeway Control						✓	✓	✓																					
	HOV and Reversible Lane Management						✓		✓																					
	Traffic Information Dissemination						✓																							
	Regional Traffic Control						✓																							
	Incident Management System							✓																						
	Traffic Network Performance Evaluation						✓		✓																					
	Dynamic Toll/Parking Fee Management								✓						✓															
	Emissions and Environmental Hazards									✓																				
	Virtual TMC and Smart Probe Data		✓				✓	✓																						
APTS	Transit Vehicle Tracking										✓	✓	✓	✓																
	Transit Fixed-Route Operations										✓	✓																		
	Demand Response Transit Operations										✓	✓	✓																	
	Transit Passenger and Fare Management											✓			✓															
	Transit Security										✓			✓																
	Transit Maintenance										✓																			
	Multi-modal Coordination						✓		✓		✓																			
ATIS	Broadcast Traveler Information	✓	✓									✓																		
	Interactive Traveler Information	✓	✓									✓	✓		✓															
	Autonomous Route Guidance		✓	✓																										
	Dynamic Route Guidance		✓	✓																										
	ISP Based Route Guidance	✓	✓	✓											✓															
	Integrated Transportation Mgmt/Route		✓	✓											✓															
	Yellow Pages and Reservation	✓	✓			✓									✓															
	Dynamic Ridesharing	✓	✓		✓							✓	✓		✓															
	In Vehicle Signing		✓				✓																							
AVSS	Vehicle Safety Monitoring																											✓	✓	
	Driver Safety Monitoring																											✓		
	Longitudinal Safety Warning																							✓				✓		
	Lateral Safety Warning																								✓			✓		
	Intersection Safety Warning																									✓		✓		
	Pre-Crash Restraint Deployment																											✓	✓	
	Driver Visibility Improvement																										✓			
	Advanced Vehicle Longitudinal Control																							✓						
	Advanced Vehicle Lateral Control																								✓					
	Intersection Collision Avoidance																									✓				
	Automated Highway System																													✓
CVO	Fleet Administration																				✓									
	Freight Administration																			✓										
	Electronic Clearance															✓			✓											
	Electronic Clearance Enrollment															✓			✓											
	International Border Electronic Clearance															✓			✓											
	Weigh-In-Motion															✓														
	Roadside CVO Safety																✓													
	On-board CVO Safety																	✓												
	CVO Fleet Maintenance																	✓			✓									
	HAZMAT Management							✓												✓	✓									
EM	Emergency Response																						✓							
	Emergency Routing																						✓							
	Mayday Support																					✓	✓							
	ITS Planning										✓																			

Since many of short-term and medium-term priority user services for this study have been mapped into multiple market packages, it is clear that the most important of these market packages must be identified for initial deployment. This sorting of the potential market packages associated with the user services has been performed using another aspect of the information provided by the ITS National Architecture that identifies “core functions.” These core functions provide ". . .critical early capabilities that will enable future deployments of more advanced services.”

Core market packages are available for all but two of the short-term and medium-term priority user services: Ride Matching and Reservations (a short-term priority user service), and Traveler Services Information (a medium-term priority user service). In order to implement these user services two other market packages must be added to the initial group of core packages.

In addition to these core market packages, the ITS National Architecture has also identified several “key” market packages in which ". ..a compelling benefit or significant market activity for a market package caused it to be identified as a key even though there may be remaining standards or institutional issues associated with that package."

The core market packages, additional key market packages, and other market packages (i.e, not “core” 'or “additional key”) associated with the short and medium market package priority user services are shown in Table 5-3. This table also shows preliminary recommendations for the implementation time frames for each market package that is based on the implementation priorities of the user service(s) that it is most closely associated with. Some market packages are not recommended for short or medium term implementation. These market packages may be considered over a longer time frame than within the scope of an early deployment plan.

5.3 SYNERGY DIAGRAMS

As shown in Table 5-3, most of these market packages are part of three basic groups: Advanced Traffic Management Systems (ATMS), Advanced Public Transit Systems (APTS), and Advanced Traveler Information Systems (ATIS). The relationships among the market packages in these three groups are shown in Figure 5-1, Figure 5-2, and Figure 5-3 respectively. In these figures the lines between the market packages reflect three different types of relationships that exits among the market packages: common functions, shared information, and complementary packages. (In cases where the linkage is to a market package that is external to the group, the other group is indicated by the initials within an oval.)

TABLE 5-3

MARKET PACKAGES ASSOCIATED WITH THE SHORT AND MEDIUM-TERM MARKET PACKAGE PRIORITY USER SERVICES

Market Package	Package Type*	Preliminary Recommendation for Implementation Time Frame
Advanced Traffic Management Systems		
Network Surveillance	Core	Short
Probe Surveillance	Core	Short
Surface Street Control	Core	Short
Freeway Control	Core	Short
Traffic Information Dissemination	Additional Key	Short
Regional Traffic Control	Core	Short
Incident Management System	Additional Key	Short
Dynamic Toll/Parking Fee Management	Core	Medium
Advanced Public Transit Systems		
Transit Vehicle Tracking	Core	Medium
Transit Fixed-route Operations	Core	Medium
Demand Response Transit Operations	Core	Medium
Transit Passenger & Fare Management	Core	Medium
Transit Security	Additional Key	Medium
Transit Maintenance	Additional Key	Medium
Advanced Traveler Information Systems		
Broadcast Traveler Information	Core	Short
Interactive Traveler Information	Core	Short
Autonomous Route Guidance	Core	Short
Yellow Pages & Reservation	Other	Short
Dynamic Ridesharing	Other	Short
Other Systems		
HAZMAT Management	Additional Key	Short
ITS Planning	Core	Medium

See text for explanation of package type

Common Functions: A solid line between packages indicates that the market packages share common functions. This type of synergy reflects the potential sharing of hardware or software to perform a function that is required by both packages.

Shared Information In some instances a market package relies on information that is provided by another market package. This shared information synergy usually reflects information that is shared between an information collection package and the market packages that provide this information to users. This condition is shown by a dotted line.

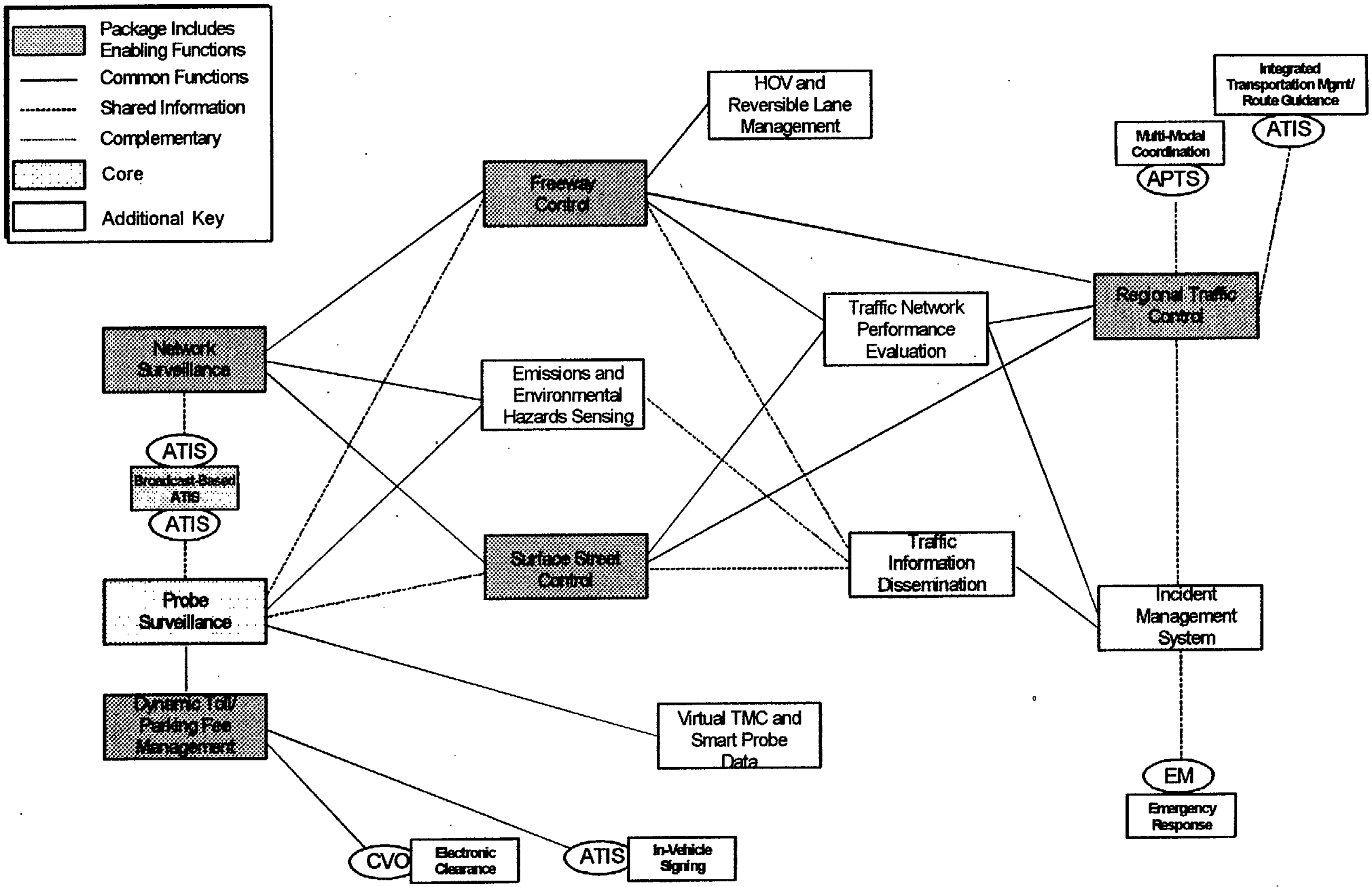


Figure 5-1
Advanced Traffic Management Systems Market Package Synergies

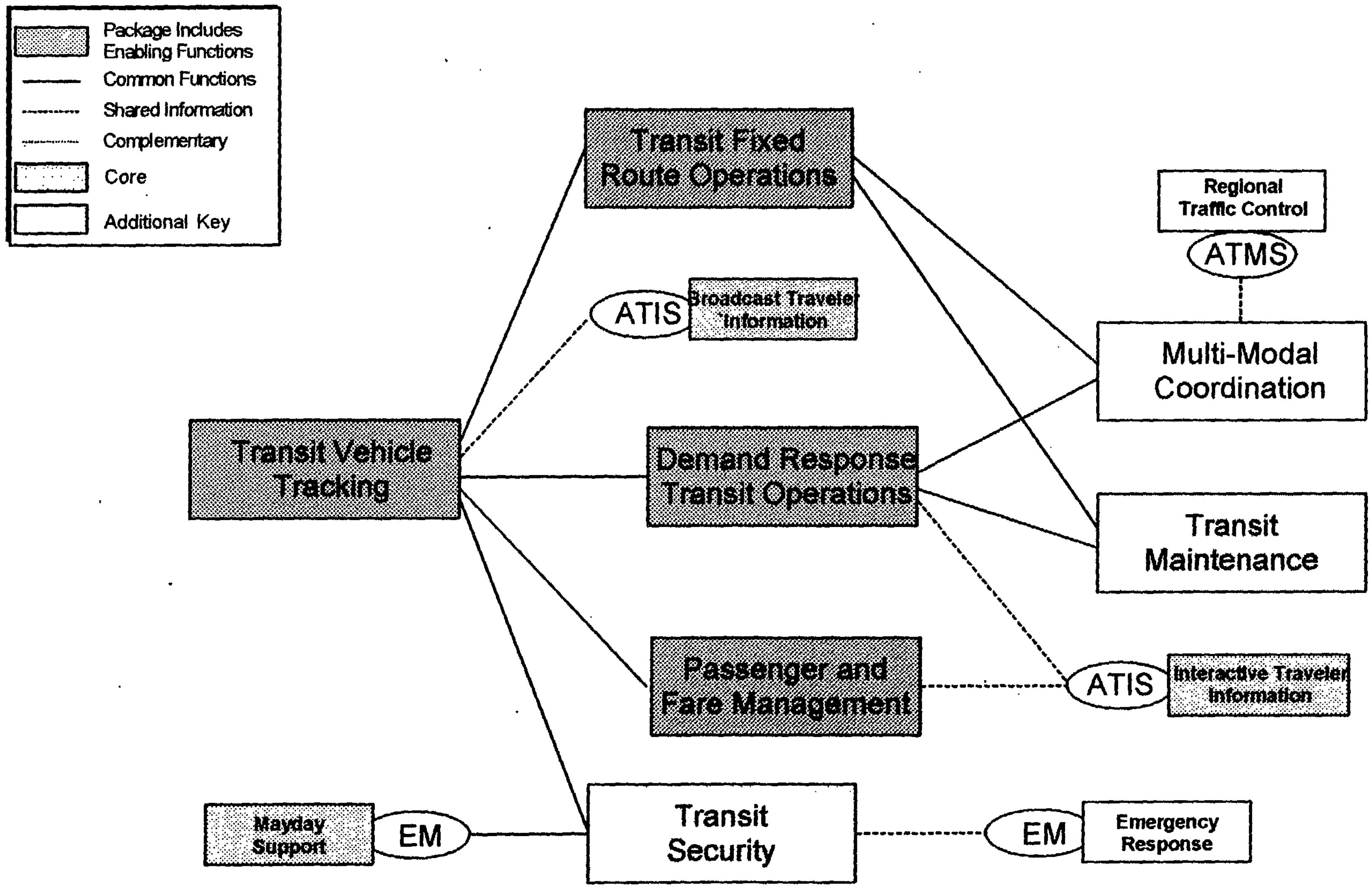


Figure 5-2
Advanced Public Transit Systems Market Package Synergies

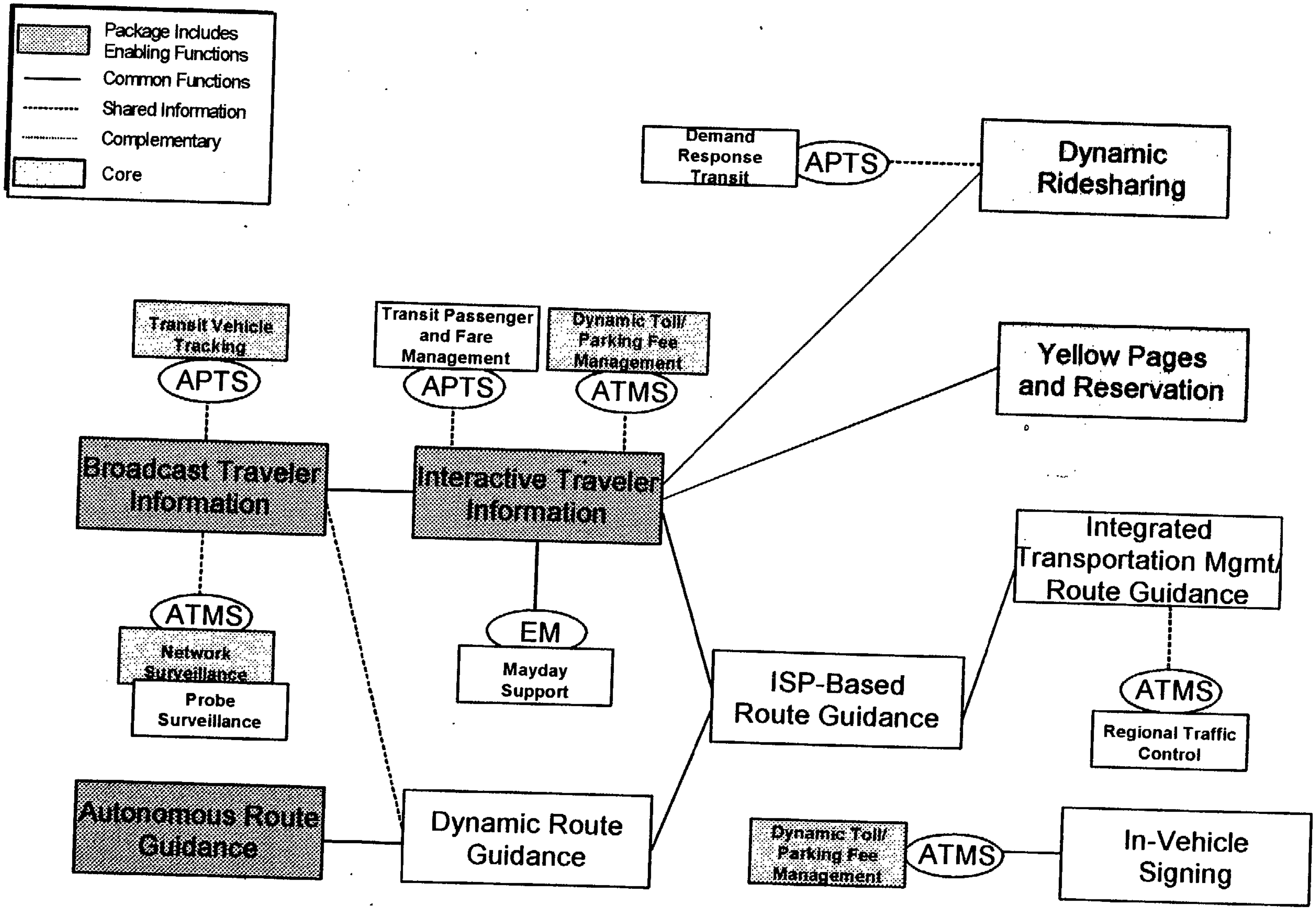


Figure 5-3
Advanced Traveler Information Services Market Package Synergies

Complementary Packages: Complementary packages do not share equipment and are not required to share information. Although independent, the information provided by one package can enhance the information provided by the other package. This is shown as a dotted line with very small dots.

Figures 5-l through 5-3 also indicate the market packages that the ITS National Architecture has identified as packages that include "Enabling Functions." These are the basic building blocks that include the functionality needed by other important packages within that group.

In the discussion that follows it should be noted that Figures 5-l through 5-3 contain additional market packages that were not associated with the short-term and medium-term priority user services. Although these market packages are not described in the following discussions, these market packages are, by default, associated with a long-term implementation time frame. It is anticipated that they will be implemented as needs arise. No matter when they are implemented, the synergy diagrams illustrate how these remaining market packages can make use of functions and information that are implemented as part of the short and medium-term market package implementation plan.

5.3.1 Advanced Traffic Management Systems

Most of the ATMS (Advanced Traffic Management Systems) market packages in Figure 5-l are associated with the short-term implementation priorities identified in this study. The synergies for these packages that are shown in the figure indicate that the Network Surveillance market package provides common functions needed by the Freeway Control and Surface Street Control market packages, and these in turn provide functions required by the Regional Traffic Control market package.

The Dynamic Toll/Parking Fee Management market package provides functionality required by the Probe Surveillance market package, which generates information that is shared with the Freeway Control and Surface Street Control market packages. Both of these market packages produce information that is shared with the Traffic Information Dissemination market package.

The Incident Management market packages focuses on the functionality involved with the automated collection of traffic data that is used to identify incidents and the dissemination of information to the public through HAR, VMS, etc. This functionality is achieved through Regional Traffic Control market package and the Traffic Information Dissemination package. The Incident Management market package was identified as a medium priority because these other elements, which have higher priorities, must be implemented first. However, there are many aspects of incident management (such as the initiation of incident management teams, and other planning and coordination activities) that do not depend upon the deployment of technology. These aspects should still be pursued as short-term priority activities.

Given the nature of these interdependencies and synergies, a revised list of implementation priorities for these market packages is shown in Table 5-4.

TABLE 5-4

REVISED IMPLEMENTATION PRIORITIES FOR ATMS MARKET PACKAGES

Market Package	Recommended Implementation Time Frame
Advanced Traffic Management Systems	
Network Surveillance	Short
Probe Surveillance	Short-Medium*
Surface Street Control	Short
Freeway Control	Short
Traffic Information Dissemination	Short&Medium**
Regional Traffic Control	Medium
Incident Management System	Medium
Dynamic Toll/Parking Fee Management	Short

* Follows Dynamic Toll market package implementation
**Follows Freeway/Surface Street Control market package implementation

5.3.2 Advanced Public Transit Systems

Figure 5-2 is the synergy diagram for the market packages in the APTS (Advanced Public Transit Systems) group. As seen in this figure, the Transit Vehicle Tracking market package is the fundamental package in this group. It provides functions that are in common with the market packages associated with Transit Fixed-Route Operations, Demand Response Transit Operations, Transit Passenger and Fare Management, and Transit Security. Two of these market packages, Transit Fixed-Route Operations and Demand Response Transit Operations provide functionality that can be utilized by the Transit Maintenance market package.

Although all of the market packages in the APTS group were associated with user services in the medium-term implementation priority group, it is clear that some of these market packages must precede the implementation of others. Consequently, the recommended implementation time frames for these market packages have been adjusted to provide the necessary phasing, and these revised recommendations are shown in Table 5-5.

TABLE 5-5

REVISED IMPLEMENTATION PRIORITIES FOR APTS MARKET PACKAGES

Market Package	Recommended Implementation Time Frame
Advanced Public Transit Systems	
Transit Vehicle Tracking	Short-Medium
Transit Fixed-route Operations	Medium
Demand Response Transit Operations	Medium
Transit Passenger & Fare Management	Medium
Transit Security	Medium
Transit Maintenance	Medium-Long

5.3.3 Advanced Traveler Information Systems

The synergies among the market packages in the ATIS (Advanced Traveler Information Systems) group are indicated in Figure 5-3.

As seen in this figure the basic functionality is provided by the Broadcast Traveler Information market package. This package provides some of the functionality used by the Interactive Traveler Information market package. The Interactive Traveler Information market package then adds additional capabilities to provide some of the functionality that is utilized by the Dynamic Ridesharing, and the Yellow Pages and Reservation market packages.

It should also be noted that this group contains the Autonomous Route Guidance market package. Autonomous Route Guidance relies on in-vehicle equipment, and there is no external communication between this equipment and outside entities. Hence, it is completely dependent upon the private sector for its implementation.

With the exception of the Yellow Pages and Reservation market package (which was associated with a medium-term implementation priority), all of the remaining market packages in this group were identified as having a short-term' implementation priority. However, based on the synergy diagram, some adjustments to the implementation priorities seem reasonable. These adjusted implementation priorities are shown in Table 5-6.

TABLE 5-6

REVISED IMPLEMENTATION PRIORITIES FOR ATIS MARKET PACKAGES

Market Package	Recommended Implementation Time Frame
Advanced Traveler Information Systems	
Broadcast Traveler Information	Short
interactive Traveler Information	Short
Autonomous Route Guidance	•
Yellow Pages & Reservation	Medium
Dynamic Ridesharing	Short-Medium

***Implementation is private sector dependant**

5.3.4 Other Market Packages

Two other market packages were identified by the ITS National Architecture. as having associations with the user services that were selected as short-term and medium-term implementation priorities for the Richmond/Tri-Cities Early Deployment study. These are: HAZMAT Management and ITS Planning.

The HAZMAT market package is associated with Incident Management, a short-term implementation priority. As defined in the National Architecture, the HAZMAT market package provides HAZMAT spill notification to the Emergency Response market package. The Emergency Response market package, in turn, provides the basic dispatcher support capabilities which provide information for the multi-agency coordination associated with the Incident Management System market package in the ATMS group, and the Transit Security market package in the APTS group.

Since the Incident Management market package was recommended for implementation in a medium-term market package time frame, it is reasonable to assign a medium-term market package implementation time frame to the Emergency Response market package. The implementation time frame for the HAZMAT market package is dependant upon the priority assigned to this activity by the private sector's CVO community.

The ITS Planning market package supports ITS planning functions. It gathers data from every subsystem and uses this data to plan new deployments and new market packages. Although this market package was associated with the Public Transportation Management user service it would appear to have strong associations with all of the major market packages that are implemented. The implementation time frames for the market packages are summarized in Table 5-7.

TABLE 5-7

REVISED IMPLEMENTATION PRIORITIES FOR OTHER MARKET PACKAGES

Market Package	Recommended Implementation Time Frame
HAZMAT Management	*
Emergency Response	Medium
ITS Planning	Medium

***Implementation is private sector dependant**

5.4 SUMMARY OF IMPLEMENTATION PRIORITIES

Table 5-8 summarizes the results of the functional requirements efforts by identifying the market packages that are most important to the implementation of the short and medium-term user services selected for the Richmond/Tri-Cities Early Deployment Study, and by identifying the recommended time frames for the implementation of these market packages.

TABLE 5-8

REVISED IMPLEMENTATION PRIORITIES FOR THE MARKET PACKAGES

Market Package	Recommended Implementation Time Frame
Advanced Traffic Management Systems	
Network Surveillance	Short
Probe Surveillance	Short-Medium*
Surface Street Control	Short
Freeway Control	Short
Traffic Information Dissemination	Short-Medium**
Regional Traffic Control	Medium
Incident Management System	Medium
Dynamic Toll/Parking Fee Management	Short
Advanced Public Transit Systems	
Transit Vehicle Tracking	Short-Medium
Transit Fixed-route Operations	Medium
Demand Response.Transit Operations	Medium
Transit Passenger & Fare Management	Medium
Transit Security	Medium
Transit Maintenance	Medium-Long
Advanced Traveler Information Systems	
Broadcast Traveler Information	Short
Interactive Traveler Information	Short
Yellow Pages & Reservation	Medium
Dynamic Ridesharing	Short-Medium
Emergency Response	Medium
ITS Planning	Medium

*Follows Dynamic Toll market package implementation
“*Follows Freeway/SurfaceStreet Control market package implementation

5.5 DEVELOPMENT OF THE PROJECT LIST

5.5.1 Candidate Projects

An initial list of candidate projects was developed to address the market packages that were previously identified. The primary source for the development of this list was the ITS National Architecture documents which identified a long series of "Equipment Packages" for each market package.

It should be noted that because of the effort to follow the guidelines of the ITS National Architecture, similar projects appear in several places on this list of candidates. Very often the "Traffic Management" subsystem and the "Roadway" subsystem of a market package will contain two parts of what appears to be the same project, with the hardware and software deployed at the control center, and the devices that will be installed in the field under the Roadway heading.

This list of equipment packages was then supplemented with additional candidate projects that were suggested by the Steering Committee. The final list of candidates contained 92 separate projects.

5.5.2 Strategic Deployment Plan Workshop

Prior to the meeting, the Steering Committee members were asked to review the full list of 92 projects and identify the projects that they believed to be very important. The FRH project staff also sifted through the projects to identify the ones that appeared to best serve the region. This resulted in a short list of 15 projects that were identified for discussion at the workshop.

The purpose of the workshop was to discuss these projects, and as part of this discussion, identify important factors that were associated with them, such as: related projects; potential funding sources; institutional issues; priorities; and concerns. Other projects that were identified by the Steering Committee members were also discussed. In addition, the Steering Commmittee indicated that it would be adviseable to combine several projects that had very similiar objectives.

The resulting Early Deployment Progarm of 10 projects is shown below in Table 5-9.

TABLE 5 9

PROJECT EVOLUTION

Initial Project List	Final Project Designation
Establish an On-Going Group to Coordinate ITS Planning	Establish an On-Going Group to Coordinate ITS Planning
Identify a Host Agency and Location for Centralized Information Management	Establish the TEOC as the Centralized Information Manager
Develop System for Exchanging Data Among Local Agencies	Develop System for Exchanging Data Among Local Agencies
Install Incident Detection System	Install Incident Detection System
Install Systems with Centralized Monitoring Capability and Timing Plan Selection Develop Timing Plans for Diversion Route Conditions *Coordinate Closely Spaced Signals'*	Improve Signal Coordination and Timing Plan Implementation on Major Diversion Routes
Install HAR System Install VMS System to Serve Freeway to Freeway Interchanges *Elements of Install Central* Software *and Hardware for HAR and VMS Systems,lnstall HAR System (I-95 Corridor Coalition),lnsta// HAR Alert Signage, Install VMS* System to *Serve Freeway to Freeway Interchanges, Develop Plans for Deployment and use of Portable VMS Units**	Develop and Implement Coordinated HAR and VMS Systems
Develop Region-Wide or Statewide Standard for ETC Tags	Develop Region-Wide or Statewide Standard for Electronic Toll Collection
Provide Real-Time Transit Schedule Information	Provide Real-Time Transit Schedule /Location Information
Provide Coordinated Traffic Information to ISPs Develop Incentive Program for ISPs Develop Interactive Travel Information Number with Phone Company	Establish One Phone Number Accessing Travel lnfdrmation for All Modes
Adopt, Train, and Utilize Incident Command System Develop Plans for Coordinated Response to Major Incidents *Elements of Improve incident response capabilities (service patrols, incident response teams, etc.) and Develop procedures for improved inter/intra agency communications'*	Improve Interagency Coordination at Incidents

Italics denote those additional projects** that **resulted from Steering Committee Meeting No. 8.

SECTION 6
SYSTEM ARCHITECTURE

This section explains the approach that was used to develop the system architecture for the Richmond/TriCities ITS Early Deployment Study, and provides a summary of the *Draft System Architecture* document (18), and its supplement (19), which were previously provided to the study participants.

With the help of the study's Steering Committee, FRI-I identified the prioritized User Services, the functional requirements, and the architecture components that are necessary to provide the User Services in the region. This section reviews the definitions of these architectural building blocks and references the resource documents that were used for their selection. By better understanding these building blocks, we can better understand the composite project architectures in Section 8. By using the building block approach, we have identified a set of open architectures that are expandable and flexible, will be able to incorporate future User Services, and will be able to interface with other National ITS Architecture-based systems.

6.1 APPROACH

The approach that was used in developing the Richmond/Tri-Cities area system architecture was based on the general steps defined in the Federal Highway Administration (FHWA) ITS Deployment Study process, while also using the more detailed steps and terminology from the National ITS Architecture. The individual steps that were used are shown in Figure 6-l.

Here is a summary of the steps shown in the figure, and where further information is available about each step:

- **Prioritize User Services.** The prioritized User Services, and the process that was used in their selection, are summarized in Section 4. Out of the 29 total ITS User Services, we selected ten for a one to seven year implementation priority.

- **Select Market Packages.** This step is a process based on the National ITS Architecture, and is described in Section 5 and subsection 6.2 of this document. Out of the total 29 User Services and 53 Market Packages, this step mapped the ten priority User Services to 20 Market Packages. The Market Packages were ranked for short to medium-term implementation. For further detail, refer to the *System Architecture,* DRAFT (18); (Section 8 and Appendix A).

- **Consider ITS in Other Studies.** This step provided a comparative analysis of architectures from sii other regional studies, and also summarized ITS activities in Virginia. The Virginia activities included the *VDOT Vision and Goals* (36), and integration with the other systems in the Commonwealth, including coordination with the traffic management centers and the I-95 Corridor Coalition. This step is summarized in subsection 6.3 of this document.

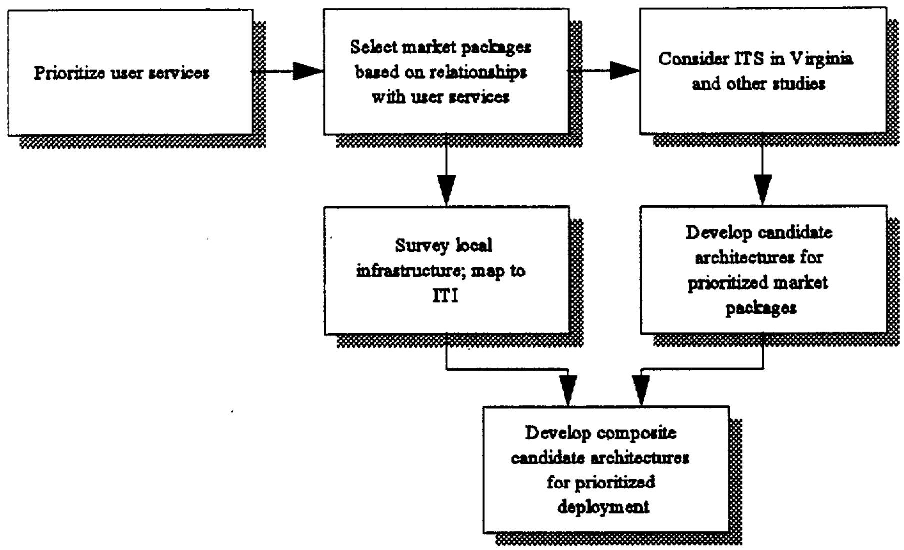
- **Survey Local Infrastructure.** This step surveyed and summarized the existing local information and communications system infrastructure in the study area. This survey provided a baseline of the infrastructure on which to build the new ITS projects. Highlights of the summary information are part of the project descriptions in Section 8.2 of this document. For further detail, refer to the System Architecture, DRAFT (18); (Section 8 and Appendix A).

- **Develop Candidate Architectures.** This step developed candidate architectures for the 20 short to medium-term implementation Market Packages. The architecture development included information from the National ITS Architecture and the Intelligent Transportation Infrastructure. A sample from this step is illustrated in subsection 6.4 of this document. The candidate architectures were presented as 20 figures. Each figure showed the physical architecture subsystems, the Equipment Packages included in the subsystems or Market Packages, and the data flows that will support the Market Package operation. For further detail, refer to the *System Architecture,* DRAFT (18); (Section 9).

- **Develop Composite Deployment Architectures.** This step developed four composite deployment architectures for the ten recommended projects. The composite architectures combined the candidate Market Package architectures that most closely supported deployment of the projects. The composite architectures are described and shown as four figures in Section 8.3 of this document.

FIGURE 6-1

APPROACH TO DEVELOPING THE COMPOSITE DEPLOYMENT ARCHITECTURES



6.2 MARKET PACKAGE SELECTION

After determining the prioritized User Services, we turned to the National ITS Architecture for guidance in developing the regional system architecture. By doing this, we were able to use the architectural building blocks that the National Architecture has produced. The National Architecture introduced many new terms and definitions. The most important of these terms are described below:

Subsystems. The National Architecture has divided ITS into 19 separate physical subsystems. These are logically independent entities -- for instance, personal vehicles, traffic, transit, and emergency management centers, various roadside devices, etc. The advantage of making these divisions is that the functions of ITS can be distributed systematically, and information can be shared between subsystems to take advantage of synergies (e.g., buses can gather information about roadways that's useful to traffic management centers and others).

Equipment Packages. The National Architecture developers identified a number of devices that someone could actually buy to make ITS happen; these are called equipment packages. Examples would be a transit on-board fare collection system, an in-vehicle two-way communications system, an information kiosk, and an at-home interactive information system through your TV set.

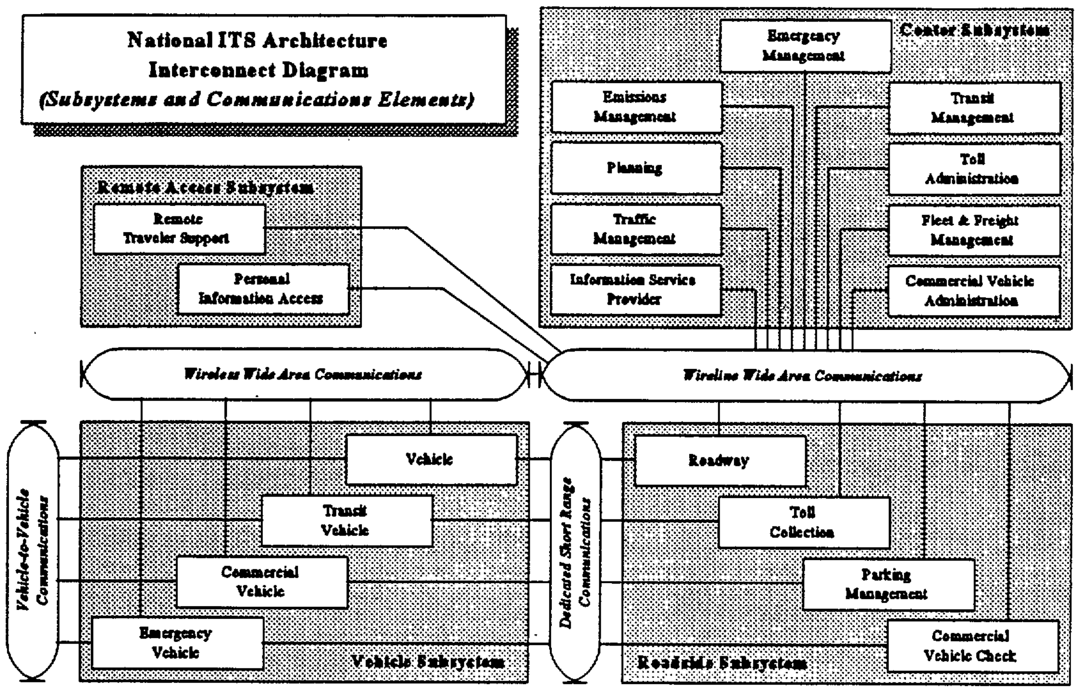
Market Packages. The National Architecture groups equipment into sample market packages, each of which described a group of equipment packages that needed to work together to deliver a particular ITS User Service. A whole suite of equipment must work together to make up the market package and deliver the service. The architecture recognizes that a diverse marketplace will result in a whole range of market packages that can deliver a particular User Service.

Communications. Just as small, fast, and cheap computing technology has changed information processing, the new communication technology will provide new communications linkages that will be used by the new ITS services. For example, wide area broadcast communications could be received by your car' s FM radio, but there will be digital traffic data on a "subcarrier" above the station's stereo program material. Dedicated short range communications is the term used for wireless vehicle electronic tags for toll collection. And wireline communications includes both telephone line connections for computer on-line services and the Internet, and broadband services like cable television.

The interconnectivity of the physical architecture's nineteen subsystems is shown in Figure 6-2. The subsystems are grouped together in the four "classes" of subsystems. The major communications interconnects are shown between the subsystems. Due to the shape of the communications linkages, this is called the "sausage diagram." This diagram served as a template for surveying the local infrastructure in the Richmond/Tri-Cities area. Other deployment studies have used this diagram as a template for their regional system architecture. This is one of the most frequently used figures from the National ITS Architecture.

FIGURE 6-2

SUBSYSTEMS AND COMMUNICATIONS INTERCONNECT DIAGRAM



The National Architecture identified a total of 53 Market Packages. The discussion of the functional requirements of the User Services, and the mapping of the User Services to the Market Packages, was described in Section 5. The mapping and functional analysis identified the 20 Market Packages that are in Table 6-1.

TABLE 6-1

PRIORITY MARKET PACKAGES

Market Group	Market Package	Recommended Implementation Time Frame
Advanced Traffic Management Systems [ATMS)	• Network Surveillance • Probe Surveillance • Surface Street Control • Freeway Control • Traffic Information Dissemination • Regional Traffic Control • Incident Management System • Dynamic Toll/Parking Fee Management	• Short • Short-Medium • Short · Short • Short-Medium • Medium • Medium • Short
Advanced Public Transit Systems (APTS)	• Transit Vehicle Tracking • Transit Fixed-Route Operations • Demand Response Transit Operations • Transit Passenger & Fare Management • Transit Security • Transit Maintenance	• Short-Medium • Medium • Medium • Medium • Medium • Medium-Long
Advanced Traveler Information Systems (ATIS)	• Broadcast Traveler Information • interactive Traveler Information • Yellow Pages & Reservation • Dynamic Ridesharing	• Short • Short • Medium • Short-Medium
Emergency Management	• Emergency Response	· Medium
ITS Planning	• ITS Planning	• Medium

6.3 ITS IN OTHER RELATED STUDIES

This step provided a summary of other ITS activities in Virginia, and a comparative analysis of system architectures from six other regional studies. This step is summarized in the following subsections.

6.3.1 VDOT Vision and Goals

The fundamental goal of the system architecture is to provide the framework which will assist the State of Virginia in realizing the vision and goals established by VDOT for the deployment of ITS in the Commonwealth. The overall vision for ITS in the year 2005 is comprised of the following complementary views:

- Statewide ITS vision
- Urban ITS vision
- Transportation system management vision
- Public safety vision
- Transportation operations ITS vision

The established set of goals is comprised of the following major objectives:

- Make the Virginia transportation system user friendly
- Operate the Virginia transportation system efficiently and effectively
- Enhance public safety
- Enhance agency operations, and maximize effectiveness and efficiency of personnel, equipment, and resources.

It is essential that this deployment plan support these visions and goals. We have provided a plan that is consistent with these visions and goals.

6.3.2 Integration with Other Svstems in Virginia

Although the ITS system architecture for the Richmond/Tri-Cities area is mainly concerned with transportation activities that take place in this region, it is strongly recommended that the functions described in this architecture be coordinated with the functions of the TMS centers located in Northern Virginia and Hampton Roads.

6.3.3 Other Deployment Studv Architectures

The FHWA has funded seventy-five ITS early deployment planning studies across the country. Of these, fewer than thirty have been completed and are available for review. Some of the completed studies have characteristics similar to the Richmond/Tri-Cities area and were used as a basis of comparison and for their lessons learned.

Table 6-2 shows a comparison of the Richmond / Tri-Cities area with the six deployment studies that were selected for review in this study. The table columns compare the population in the study areas, the study participants, the identified objectives or prioritized user services, the date of the study, and a thumbnail highlight of the recommended architectures.

Table 6-2. Comparison of Deployment Studies in Other Regions

Deploymnet Study	Study Area Pop. in thous.	Study Area Major Geo-Political Participants	Study Objectives or User Services	Date of Study	Highlight(s) of Architecture Recommendations
Richmond/Tri-Cities, VA	**919**	***VDOT, Cities of Richmond, Petersburg, Hopewell,*** and Colonial ***Heights, nine counties, planning district commissions***	***Ten User Se/vices for 1to 7year implementation***	***October 95 - October 96***	***Twenty Market Package-based architectures***
Hartford, CT	1,085	City of Hartford, ConnDOT, COG	Eleven User Services: en-route driver info, route guidance, traffic control, incident mgmt, pre-trip travel info, etc.	June 94 - June 96	Peer-to-peer ATMS and a centralized ATIS
Boston, MA	4,171	Mass Hwy Dept, Mass Turnpike Authority, MBTA, State Police, MassPort	NA	December 92 - January 94	Transportation Information and Coordination Center (TICC) to serve as central clearing house of realtime information
Detroit, MI	4,665	M-DOT, City of Detroit	Reduce congestion, increase traveler safety, and enhance incident management	September 92 - September 94	High level definition of: (1) distributed modular design, (2) defined interface protocol, and (3) standardized electrical interface; add to existing Metropolitan Transportation Center
Cleveland / Lorain, OH	2,759	NA	Develop traffic surveillance and control system	January 95 - June 96	Distributed system for short-term implementation, to evolve into hybrid or centralized in future
St. Louis Bi-State Area	2,444	Missouri Hwy and Trans Dept, City of St. Louis, City of St. Charles, Jefferson Co., Franklin Co., St. Louis Co., IDOT Monroe Co.. St. Claire Co.. Madison Co.	Evaluate ATMS and ATIS technologies and architectures	September 92 - May 94	Processing and control distributed to four different levels; each jurisdiction has primary device control; state agencies have supervisory capability
Kansas city Metro Bi-State Area	1,566	Kansas DOT, Missouri Hwy and Transportation Dept, Mid-America Regional Council	Mitigation of recurring congestion and incidents on the freeway system	December 94 - December 95	Each state to have its own central computer server, leading to a single traffic operations center

The review of these other regions did reveal an important difference between most of the earlier deployment studies and a few of the more recent studies in their approach in handling the architectural descriptions of the transportation information and communications systems. The earlier studies appear to bundle together the architectures for the transportation information processing and the communications infrastructure. The earlier architectures provided descriptions of, and used terminology like, "peer-to-peer,!' "distributed systems," "central computer server," 'wide area network," and "fiber optic backbone." In fact, many of the architecture figures in these studies are essentially diagrams showing communications connectivity among organizational bubbles. We feel that this communications-oriented approach misses some important points of an overall systems architecture – that is, where to assign the functions, and what information and data flows are needed to support the functions. Today, providing communications connectivity is relatively easy; the harder part is defining the information-handling aspect. Two of the defining issues for information handling are identifying the information flows that will be economically successful for an organization that wants to function as an information service provider, and defining the baseline information flows in and out of a Traffic Management subsystem that can be handled automatically.

In contrast to these previous deployment studies, the approach taken by the National ITS Architecture is to "decouple" the Transportation and Communications Layers. This decoupled approach is also used in the Richmond/Tri-Cities regional system architecture. Transportation and Communications are the two "technical" layers of the National Architecture; the third layer is the Institutional Layer. The Transportation Layer includes the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and other equipment used by the traveler to access ITS services. The Communications Layer provides for the transfer of information between the distributed elements within the Transportation Layer. The architectures in most of the previous deployment studies did not have the benefit of the completed National Architecture. The Richmond/Tri-Cities ITS Early Deployment Study builds on what has been accomplished by the Phase II architecture team, and provides a regional system architecture that will be more useful in determining the more difficult deployment decisions.

6.4 CANDIDATE ARCHITECTURES FOR PRIORITIZED MARKET PACKAGES

This step developed candidate system architectures for the 20 Market Packages recommended for the short-to-medium term implementation time frame. The candidate system architectures were based on the Market Package architectures defined in the National ITS Architecture's *Implementation Strategy* (26), with appropriate enhancements from USDOT's *Building the ITI: Putting the National Architecture into Action* (37). The Intelligent Transportation Infrastructure (ITI) is the infrastructure portion of ITS in metropolitan areas. The IT1 refers to those portions of ITS-related hardware, software, and services that will manage and support the transportation-related services and activities.

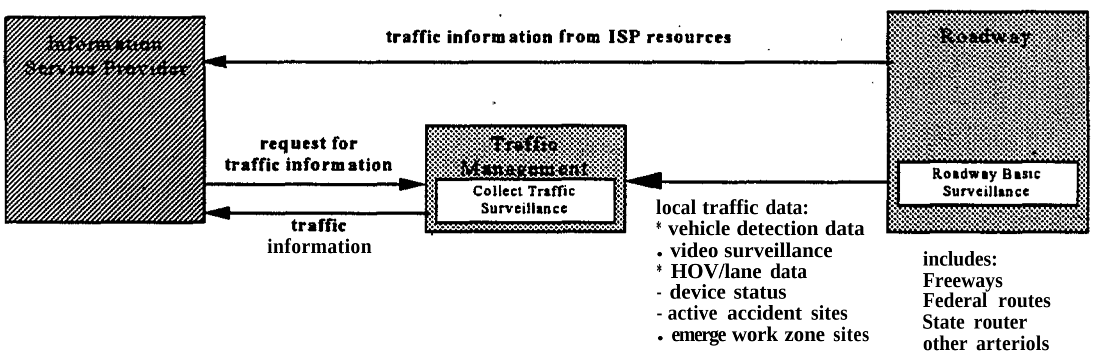
Figure 6-3 is an example of a market package description and architecture diagram. The architecture diagram shows the physical subsystems (Traffic Management, Roadway, etc.; some of the 19 subsystems from the sausage diagram), the equipment- packages (Collect Traffic Surveillance, Roadway Basic Surveillance), and the data flows that support the market package operation. The elements in these architecture diagrams were used as the building blocks for the composite project architectures that are described in subsection 8.3 of this document.

FIGURE 6-3

EXAMPLE OF A MARKET PACKAGE DESCRIPTION AND ARCHITECTURE DIAGRAM

MARKET PACKAGE: Network Surveillance. This basic market package provides the fixed roadside surveillance elements using wireline communication to transmit the surveillance data. It can be a very localized implementation, such as loop detection connected with signal control at a particular intersection, or it can be surveillance cameras sending video back to traffic management centers over many miles. All of the elements in this architecture enable traffic managers to monitor road conditions, identify and verify incidents, analyze and reduce the collected data, and make it available to users and private information providers. The market package requires roadside sensors, communication links between the devices and the traffic management system, a processing or control capability, and may include links between the Traffic Management Center and the traveler information providers.

Network Surveillance



SECTION 7
TECHNOLOGY SURVEY

This section reviews the approach that was used in performing a survey of ITS technologies that can be used in the Richmond/Tri-Cities ITS Early Deployment. The section also summarizes the technology areas that were surveyed and provides some highlights of several of the areas. The complete survey is reported in a series of tables in Appendix A.

In a narrow sense, ITS represents the development of several new and unique technologies. But in a more broad view of where information and communications technology is headed, ITS represents the integration of many existing technologies, and their application to the transportation management.

Everyone should be reminded of the fact that technology is always changing. There will always be something new, improved, less expensive, or more reliable. This survey has only captured the state-of-technology at one point in time, and should only be used as a starting point when designing an ITS project. Consider this ITS technology survey to be an introduction to the depth and breadth of the products and services that are available.

7.1 TECHNOLOGY SURVEY APPROACH

There were two different ways to organize the ITS technology survey. One way was to use the technology areas in the VDOT Scope of Work for this Early Deployment Study. The other way was to use the FHWA technology areas from the National ITS Architecture. We chose to use the FHWA technology areas. These are summarized in Table 7-1, and also used in the tables in Appendix A (there's a description of the technology area in each table). The tables in the Appendix A also list the related Work Scope technology areas from the VDOT project documents.

The actual survey involved researching vendor and product information in the ITS trade magazines and in the extensive FRH literature file. Each product was classified by technology area, and described in the table entry. The vendor contact information was also listed, and summarized alphabetically in Appendix A Table A-5. We did not intend that this survey would be comprehensive, or would explore all technology areas. We concentrated on those technologies that could be used in support of the ten prioritized User Services and the 20 candidate Market Packages. We did not attempt to contact vendors or find products in those technology areas that were not relevant to this study. The product list is not considered to be all-inclusive and is not an endorsement of any product.

TABLE 7-l

TECHNOLOGY AREAS AND SURVEY RESULTS

FHWA Technology Area	Number of Products Surveyed	Number of Priority Market Packages (out of 20) That Need Technology
Traffic sensors	13	8
Vehicle status sensors	5	1
Environmental sensors	1	0
Vehicle/Driver monitoring sensors	2	4
Cargo monitoring sensors	0	0
Obstacle ranging sensors	0	0
Lane tracking sensors	0	0
Security sensors	1	2
Location determination	6	3
Cell-based communications	3	7
Vehicle-Roadside communications	6	1
Vehicle-Vehicle communications	4	1
Fixed communications	1	13
Algorithms	2	7
Information management	5	13
Payment	13	2
Driver/Traveler/Operator interface	3	8 / 6 / 20
Signals	3	3
Signs	6	1
Vehicle control	4	0

7.2 TECHNOLOGY AREA HIGHLIGHTS

The "Operator Interface" technology area is the one that is "most required" by the Market Packages needed for deployment. The Operator Interface includes those audio, visual, and tactile interface technologies that would be appropriate for interaction with system operators during operation. System operators would include: the traffic engineers and managers operating the Traffic Management subsystem, the dispatchers at the Emergency Management subsystem, the traffic analysts and information specialists at the Information Service Providers, and all the other who would be sitting in front of a computer terminal or operator workstation.

The next most required technologies include "Fixed Communications," "Information Management," and "Traffic Sensors." There are new developments in each of these areas on an almost daily basis,

There are multiple communications options available to the system designer. The flexibility in choosing between various options allows each implementor the ability to select the specific technology that meets the regional needs. The Fixed Communications technologies are used to carry information between fixed locations. The technology options are largely dependent on local service providers. The Fixed Communications are the same as the "Wireline Wide Area Communications" in Figure 6-2. There are numerous wireline technologies to choose from for fixed-to-fixed communications requirements. For example, the Traffic Management subsystem can use leased or owned twisted wire pairs, coaxial cable, or fiber optics to gather information and monitor and control Roadway subsystem equipment packages. All of the "Center" group of subsystems are linked together over a wireline network. This allows each Center subsystem to collect, integrate, and disseminate collected information to all other Center subsystems, resulting in improved intejurisdictional communications, and coordination that in turn will directly affect the efficiency and effectiveness of all Center subsystems operations. Wireline network options include network technologies such as Ethernet, Synchronous Optical Network (SONET), and Asynchronous Transfer Mode (ATM). Public shared network technologies include leased analog lines, leased digital lines, frame relay, Integrated Services Digital Network (ISDN), and the Internet.

7.3 RESOURCES

The following resources were used in the ITS technology review.

National ITS Architecture Implementation Strategy Deliverable Document
Published by:
The Federal Highway Administration

To obtain a copy of this document and other volumes in the National ITS Architecture series, Contact:
ITS America
Department #0667
Washington, D.C. 20073-0669
(202) 484-4548

Brief Description of Publication:
One in a series of deliverables documenting the ITS Architecture developed under contract to the US DOT. Describes the architecture to potential implementers, clarifies the relationship between architecture and implementation, and recommends policies and actions that will encourage cost-effective nationwide implementation of ITS. Provides a general vision of how an efficient deployment of systems compatible with the. National Architecture can take place over time. Provides an overall strategy that spans, and supports, diverse deployments throughout the nation.

ITE Journal
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The Institute of Transportation Engineers

Subscription Information:
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Washington, D.C. 20024-2797
(202) 554-8050
1 year subscription: $25 / twelve issues

Brief Description o f Publication:
This is a monthly published trade journal made available to members of the Institute of Transportation Engineers (ITE) The ITE Journal is a peer-review publication containing technical articles and news of members and the transportation engineering profession.

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Brief Description of Publication:
This is a bimonthly published trade journal made available to transportation and traffic professionals. ITS World offers news, up-close looks at technologies and their applications, new product information, and reviews of current ITS-related issues.

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Andrew Barriball

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Surrey SM 11DJ
United Kingdom
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Brief Description of Publication:
This is one of the newest trade journals in circulation. ITS is made available to the American Traffic/Transportation professional, but has its roots and its focus primarily in the U.K. New technologies and projects emerging in America, Europe and Japan are featured,

The International ITS Index, 1996

This annual publication offers profiles of agencies involved in every realm of ITS, including associations, vendors, and research and development organizations. Involvement with ITS projects and/or marketed products are also included within each profile.

For copies:
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cost: $195

USDOT's Intelligent Transportation Systems Projects
This report describes ITS projects, tests, and studies initiated through September 30, 1995 that have been partially or totally financed from Federal ITS funds.

Product Brochures
This includes all cut sheets, pamphlets, flyers, videos, and all other marketing materials for ITS products and services made available for this review.

SECTION 8
IMPLEMENTATION PLAN

8.1 INTRODUCTION

As indicated in Section 5, the Strategic Deployment Workshop, and the efforts that preceded this workshop, narrowed the list of 92 candidate projects to an Early Deployment Program of 10 projects. These projects are shown below in Table 8-l.

Table 8-1
RECOMMENDED ITS EARLY DEPLOYMENT PROGRAM

PROJECT NAME
Establish an On-Going Group to Coordinate ITS Planning
Develop System for Exchanging Data Among Local Agencies
Install Incident Detection System
Improve Signal Coordination and Timing Plan implementation on Major Diversion Routes
Develop and Implement Coordinated HAR and VMS Systems
Develop Region-Wide or Statewide Standard for Electronic Toll Collection
Provide Real-Time Transit Schedule /Location Information
Establish One Phone Number Accessing Travel Information for All Modes
Improve Interagency Coordination at Incidents
Establish the VDOT TEOC as the Centralized Information Manager

These projects are described and discussed in subsections 2 and 3 of this section. The materials include various aspects of the project that were brought out in the discussions that took place at the Strategic Deployment Workshop such as: related projects; potential funding sources;

institutional issues; priorities; and concerns. In addition, the features of the system architecture that are related to these projects, and other associated materials are also presented.

Each of these projects will produce benefits for the Richmond/Tri-Cities area. The technical memorandum *Performance Criteria* (6), describes the benefits that are expected to accrue as a result of the implementation of projects that support selected user services.

The final two subsections that are presented here conclude this report by identifying the next steps in the implementation process and order of magnitude project cost estimates.

8.2 RELATIONSHIP TO THE SYSTEM ARCHITECTURE

As summarized in Section 6,.0, the approach to developing a system architecture for this Early Deployment Study was based on the market package architectures that were developed for the ITS National Architecture. The prioritized User Services were mapped to related market packages, and candidate system architectures were described- for recommended implementation in a "short-" to "medium-" term time frame. At the time, this approach seemed fragmented, and did not result in one large, overall system view of the Prioritized User Services in the study area.

However, the utility of this approach can now be fully realized. The Steering Committee process has selected candidate projects that can be used to implement the prioritized User Services. For each candidate project, there are associated elements in the market package architectures. Table 8-2 shows the relationships among the candidate projects, the candidate market package architectures, and the subsystems, equipment packages, and information flows within the market package architectures.

We can take the selected elements from the market package architecture and use them to build several composite system architectures for the groups of projects. These building blocks were grouped together to form four composite system architectures:

- Regional Roadway Traffic Management
- Regional Electronic Payment
- Regional Multimodal Management
- Regional ITS Planning

The different market package architectures in the System Architecture document have a lot of redundancy -- the same physical architecture subsystems appeared in many of the market packages. (These physical architecture subsystems are the Traffic Management, Roadway, Vehicle, Information Service Provider, etc. that were shown as blocks in the System Architecture diagrams.) These subsystems contained the equipment packages, and were also the nodes for the information flows. The composite architectures in this section of this document removed most of these redundancies. The composite architectures were constructed from the elements that are needed to help plan the project implementations.

TABLE 8-2

ARCHITECTURE ELEMENTS FOR THE CANDIDATE PROJECTS

Candidate EDS Project	Related Candidate Market Package Architecture(s)	Required Subsystem(s)	Required Equipment Package(s)	Required Information Flows
Establish an On-Going Group to Coordinate ITS Planning	• ITS Planning	All of the "Center" class of subsystems, except Emergency Management, are required	• Data Collection and ITS Planning	• Road network use • Operational and planning data
Develop System for Exchanging Data Among Local Agencies	• Regional Traffic Control • Network Surveillance	• Traffic Management • Other TM • ISP	• TMC Incident Dispatch Coord/Communications	• Local accident data • Local traffic data • Freeway traffic flow • TMC coordination
Install Incident Detection System	• Incident Management System	• Traffic Management • Roadway • Emergency Vehicle • ISP • Other TM	• TMC Incident Dispatch Coord/Communications	• Local accident data • Freeway traffic flow • TMC coordination
Improve Signal Coordination and Timing Plan Implementation on Major Diversion Routes	• Surface Street Control	• Traffic Management • Roadway	• Roadway Signal Controls • TMC Basic Signal Control • Traffic Maintenance	• Signal control • Signal system data
Develop and Implement Coordinated HAR and VMS Systems	• Traffic Information Dissemination	• Traffic Management • Roadway	• TMC Traffic Information Dissemination • Roadway Traffic Information Dissemination	• VMS/HAR messages
Develop Region-Wide or Statewide Standard for Electronic Toll Collection	• Dynamic Toll/Parking Fee Management	• Traffic Management • Vehicle • Toll Collection • Parking Management	• TMC Toll/Parking Coordination • Vehicle Toll/Parking Interface • Toll Plaza Toll Collection • Toll Administration • Parking Management	A standard for electronic toll collection will principally be based on: • Request tag data • Tag data • Tag update
Provide Real-Time Transit Schedule/Location Information	• Transit Vehicle Tracking	• Transit Management • Transit Vehicle • ISP	• Transit Center Tracking and Dispatch • On-board Trip Monitoring	• Vehicle location • Transit information request • Transit and fare schedules
Establish One Phone Number Accessing Travel Information for All Modes	• Transit Fixed-Route Operations	• Transit Management • Transit Vehicle • ISP	• Transit Center Fixed-Route Operations • Vehicle Dispatch Support	• Transit information request • Transit and fare schedules

TABLE 8-2 (Continued)

ARCHITECTURE ELEMENTS FOR THE CANDIDATE PROJECTS

Candidate EDS Project	Related Candidate Market Package Architecture(s)	Required Subsystem(s)	Required Equipment Package(s)	Required Information Flows
Improve Interagency Coordination at Incidents	Incident Management System	• Traffic Management • Emergency Vehicle • Roadway • ISP	• TMC Incident Dispatch Coord/Communication • Emergency Response Management	• Incident data • Incident notification • Emergency vehicle driver status update • Incident information
Establish the VDOT TEOC as the Centralized Information Manager	• Network Surveillance • Traffic Information Dissemination	• Traffic Management • Roadway • ISP	• Collect Traffic Surveillance • TMC Traffic Information Dissemination	• Local accident data • Local traffic data • Freeway traffic flow • Request for traffic information • Status information

Not all of the candidate projects are closely tied to a physical system architectures. Several of the projects are more concerned with information flow, rather than infrastructure. These projects can be implemented by developing concepts of operation, memorandums of understanding, or joint agreements. These types of projects may benefit from information flow analysis and business process re-engineering. The physical architecture and subsystems are important to understanding the information flows and how they can be designed, but the physical architecture is not critical to the process.

The physical architecture diagrams are presented at a high-level view. Their purpose is to provide a graphical basis for understanding the relationship of the subsystems that will be required to make the projects work. One of the first steps in project planning would be dissected to show the type of information (voice, fax, e-mail, video, client/server database data, etc.), the information content, the source and destination of the information, and the communications media that would be used to support the information transfer.

The four Composite System Architectures are described in the following subsections.

8.2.1 Composite Architecture for Regional Roadway Traffic Management

The architecture is shown in Figure 8-1. This composite architecture combines six of the market package architectures. The architecture is centered on the TEOC Traffic Management subsystem and its associated equipment packages. The current TEOC already provides functions in support of the equipment packages “Collect Traffic Surveillance” and TMC Traffic Info Dissemination” on a very limited basis.

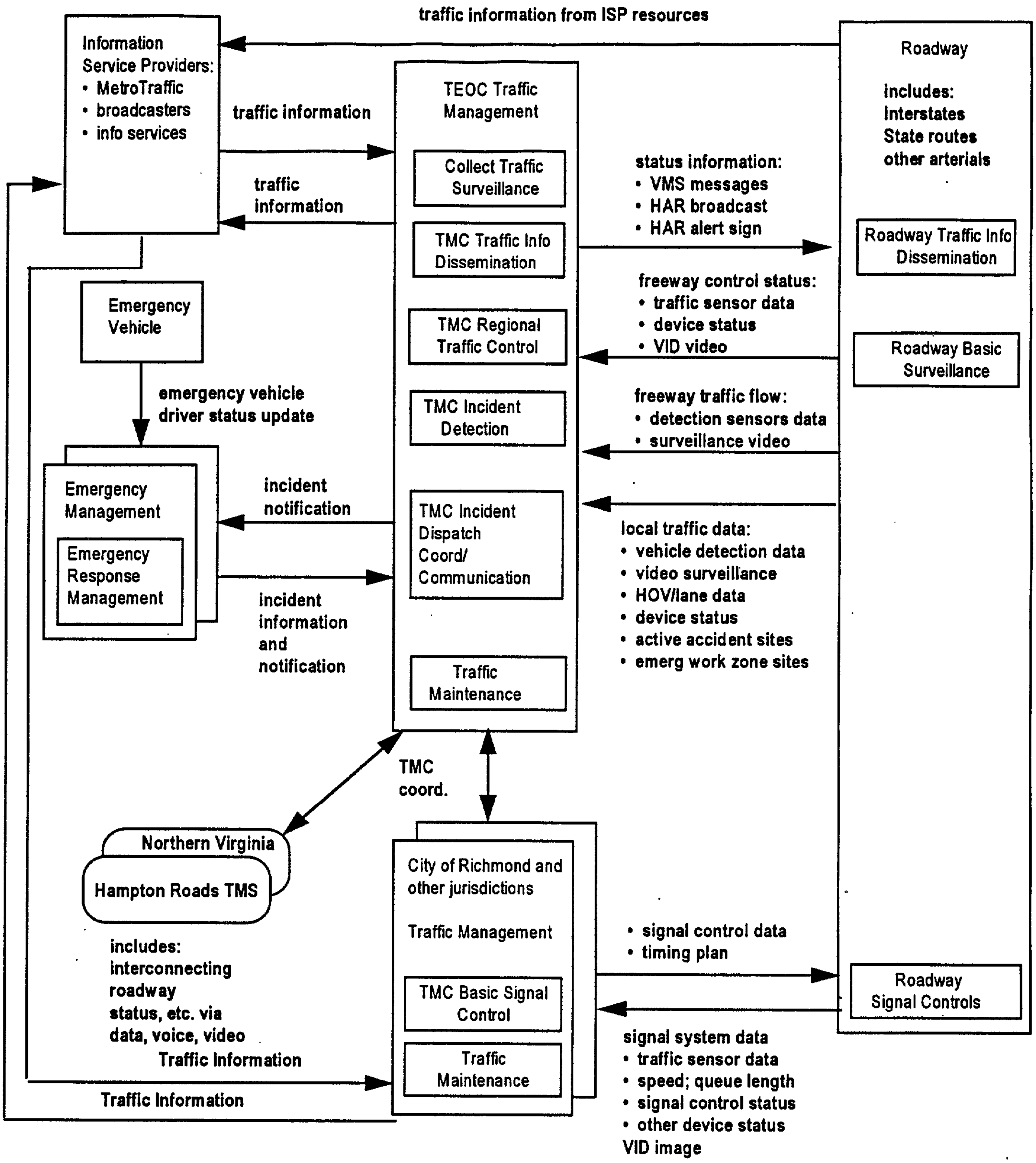

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Figure 8-1
Composite System Architecture for Regional Roadway Traffic Management

8.2.2 Composite Architecture for Regional Electronic Payment

The architecture is shown in Figure 8-2. This composite architecture consists of only one of the market package architectures. The architecture is divided among five subsystems and their associated equipment packages. A standard for electronic payment is most concerned with the "Toll Plaza Toll Collection" and "Vehicle Toll/Parking Interface" equipment packages. It is within these equipment packages, and the information flows between them, that a standard would direct the type of technology that would be used for implementation. The technology options are varied: there are many current and proposed vehicle tags, operating radio frequencies, types of data messages, and different toll plaza or parking facility tag readers.

8.2.3 Composite Architecture for Regional Multimodal Management

The architecture is shown in Figure 8-3. This composite architecture combines two of the Market Package architectures. The architecture is centered on the Transit Management subsystem and its associated equipment packages.

8.2.4 Composite Architecture Regional ITS Planning

The architecture is shown in Figure 8-4. This composite architecture consists of only one of the Market Package architectures. The architecture is centered on the Planning subsystem and its associated equipment package. This is a mostly procedural architecture, and is not dependent on a hardware implementation.

8.2.5 Technology and Architecture

A system architecture can be used to identify the major system elements: the subsystems, the information flows, and the interfaces. The diagrams and analytic techniques of architecture analysis are an important part of project planning in a setting where there are multiple jurisdictions and many differing levels of expectations. Rather than just textual descriptions or line items in a budget proposal, the architecture diagrams can ensure that everyone's understanding of a project is much more similar. The diagrams provide a visualization of the facilities that need to be organized, and the supporting information that needs to be defined. The architecture diagram can be both the catalyst for new ideas to make a project better, and the recording system to keep track of what agreements have been reached.

An architecture diagram can be used as a simple, one page depiction of where you want a project to go. You can use the diagram as a blueprint, and build the new system piece-by-piece, making incremental advancements. The architecture diagram can help identify which are the critical components, so you can target those elements for the initial system capability. The architecture diagram is a key place to start when planning for deployment of the projects. The system architecture can be used to develop the system block diagram. A system block diagram shows the hardware components and their interconnection. The hardware components will be located within the subsystems (the TEOC Traffic Management subsystem, the Roadway subsystem, etc.) as part of the equipment packages. The communications network in the block diagram will connect together

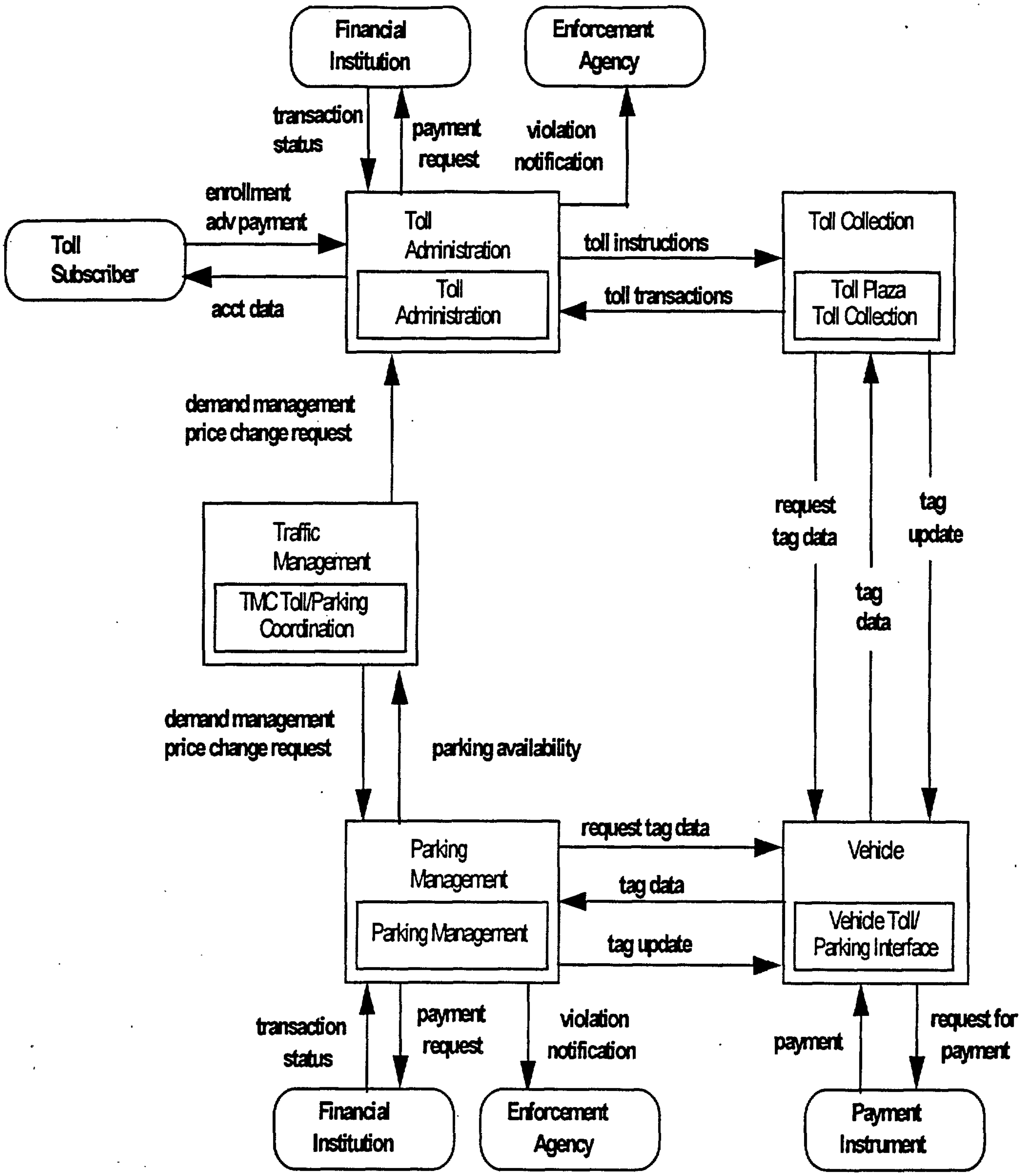

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Figure 8-2
Composite System Architecture for Regional Electronic Payment

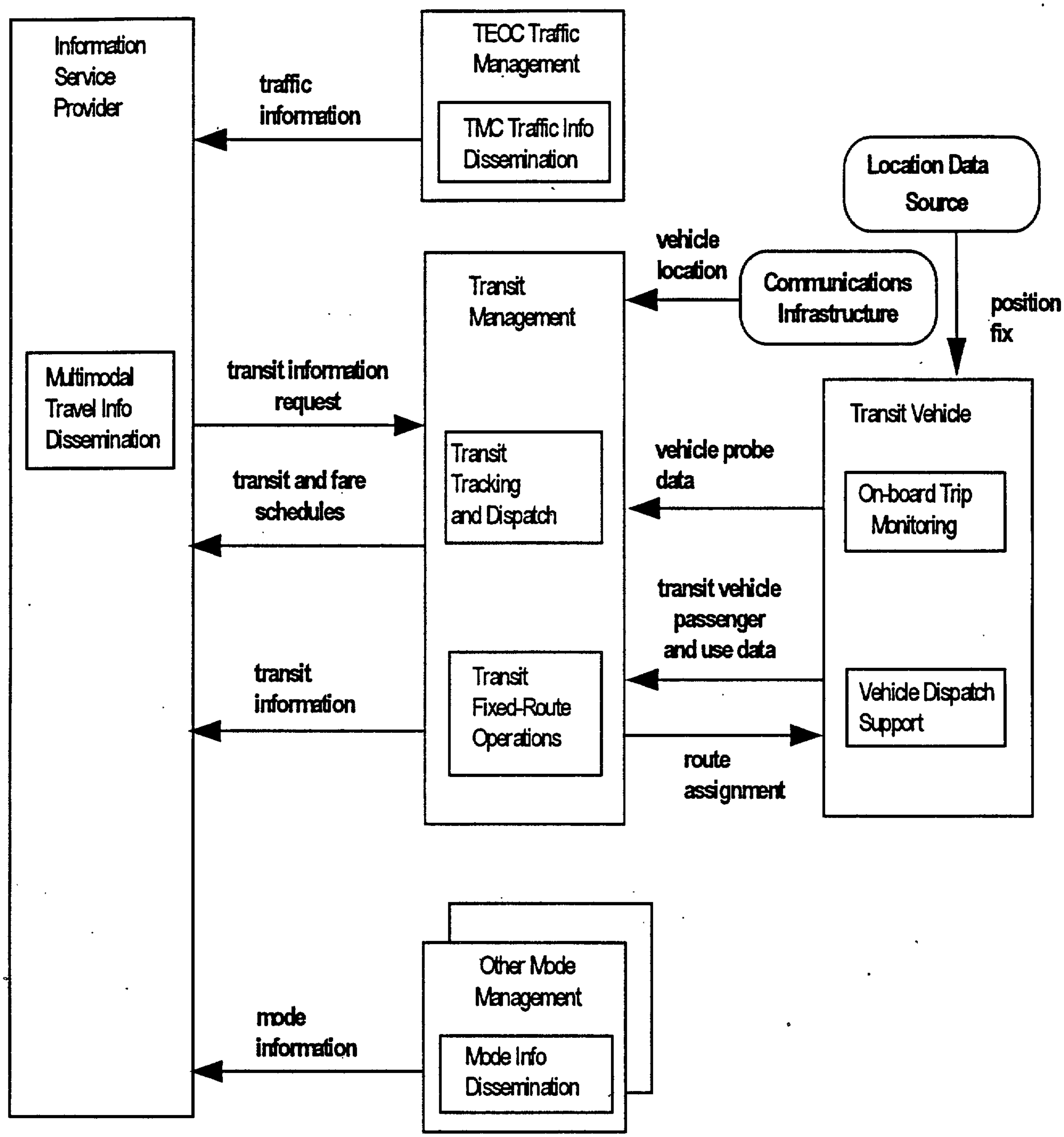

Figure 8-3
Composite System Architecture for Regional Multimodal Management

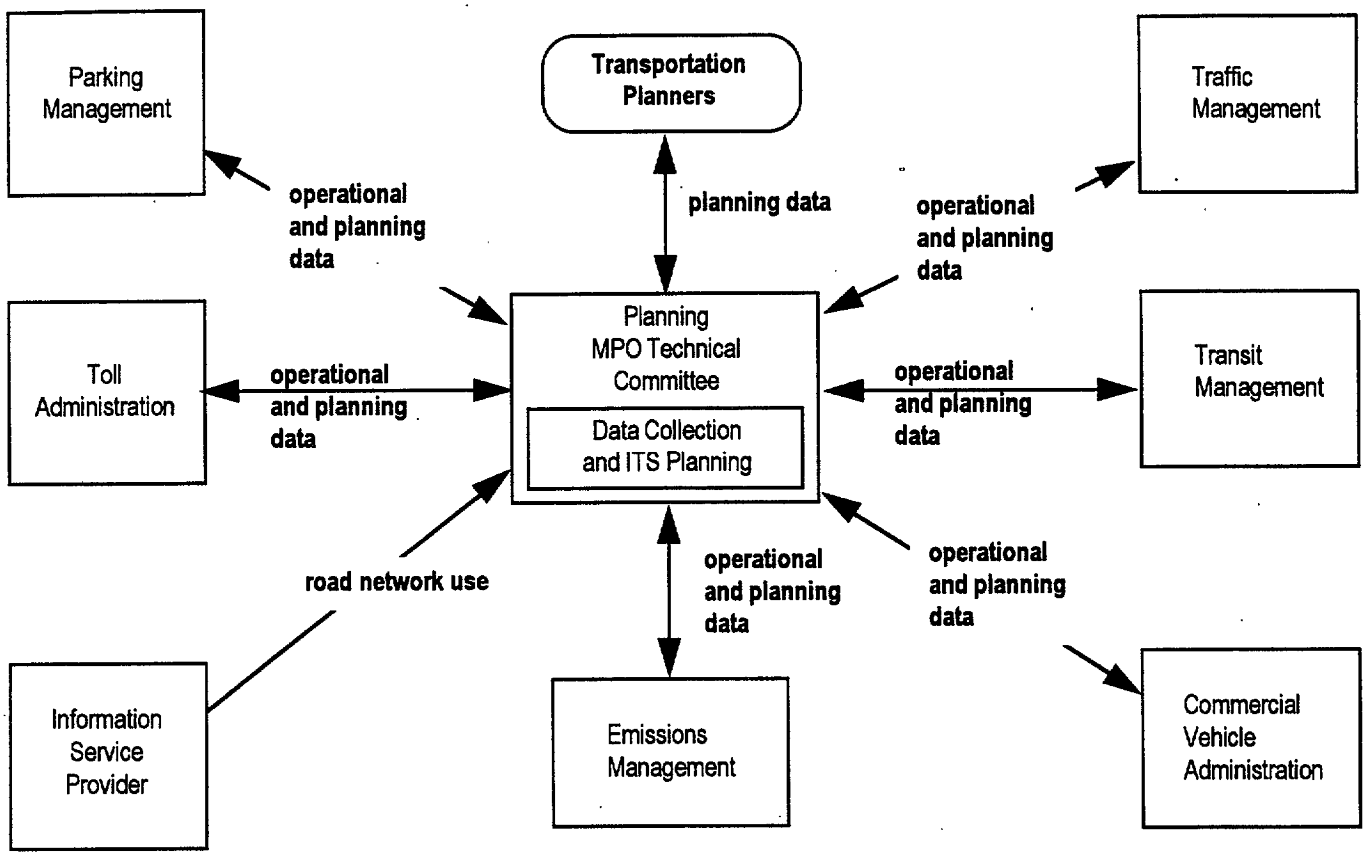

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Figure 8-4
Composite System Architecture for Regional ITS Planning

the hardware components. The data and information originating in the system hardware, flowing over the communications network, and terminating in other system hardware, are the information flows of the system architecture.

The system architecture is independent of specific technologies, but has to show some respect for technology in general. For example, a system architecture does not specify a particular computer system manufacturer or software application, but the architecture can show a level of technical evolution, such as a client/server system configuration over a wide area packet data network.

8.3 ITS EARLY DEPLOYMENT PROGRAM

8.3.1 Establish an On-Going Group to Coordinate ITS Planning

Description: It is recommended that the RRPDC establish a subcommittee of its Transportation Committee that will meet 2 to 4 times a year to coordinate and foster the implementation of ITS services. This group would be responsible for continuing the ITS planning process and project implementation in the Richmond/Tri-Cities area.

It is further recommended that the by-laws of this subcommittee be structured to accommodate membership by representatives of the local agencies, and by other public and private sector organizations, including but not limited to: VDOT, the State Police, GRTC, the Chambers of Commerce, ISP (such as Metro Traffic), academic institutions such as VCU, and tourist oriented organizations such as the Metropolitan Richmond Convention and Visitors Bureau. Because of the regional nature of ITS, it may also be desirable to include representatives of some of the organizations that lie within the boundaries of the Crater Planning District.

There should be some overlap in membership or attendance by RRPDC staff so that the discussions that take place in these meetings are reported to the Transportation Committee and the MPO.

This direct association with the MPO has many advantages including:

- A built in relationship to the ISTEA planning process and TIP prioritization process.
- A mechanism for coordination with congestion management projects underway by the MPO.
- The fact that it is an existing forum that represents the region, and not just one jurisdiction.
- It has existing ties to the political process in many jurisdictions, and because of this can generate support from many political leaders of the community.
- Projects desired by the subcommittee and by the MPO can be funded from sources that might not be available to an individual jurisdiction or agency.
- The data gathered by the centralized information manager for use by the ITS coordinating group will be directly available to the RRPDC for in-house research, analysis and local distribution.

Related Projects and Activities: In accordance with ISTEA, the Tri-Cities MPO is establishing procedures within their metropolitan planning process for a congestion management system '(CMS) to encompass: the cities of Colonial Heights, Hopewell, and Petersburg; and urbanized portions of

Chesterfield, Dinwiddie, and Prince George Counties. The network of roads included in the CMS consists of all transportation facilities identified for inclusion in the National Highway System (NHS), and other arterials that either provide a connection between the Tri-Cities area and adjacent localities or are identified as major routes within the region. The Preliminary Draft CMS will be updated based on the latest planning assumptions and federal guidance prior to its full operational due date of October 1, 1997. It is unclear what part ITS will play in the CMS.

In its *"Report to the Business Community and* Government" (34), the Transportation Study Task Force of the Greater Richmond Chamber of Commerce recommended that a permanent transportation advocacy entity be created through the Chamber. The proposed entity would work in a cooperative manner with the RRPDC, the MPO and all regional agencies that receive state and/or federal funding for transportation projects. However, ITS does not appear to be a major focus of this group.

Project Classification: This project is a planning project.

Implementation Issues: It is assumed that the RRPDC would be responsible for the duties associated with scheduling meetings, sending out announcements to the subcommittee members, and preparing summaries of the meetings. Federal funding sources for planning activities are FHWA PL and HPR, and FTA (Federal Transit Administration) Section 5303. The State (through VDOT and VDRPT) provides one half of the required local match for these Federal funds. The remaining funds are raised through local agencies. The activities of the MPO are normally paid for through Federal, State, and local funds. It may also be possible to use these sources to support the efforts of the ITS Planning Subcommittee.

In addition, it is anticipated that staff support for the ITS Planning Subcommittee will be provided by experts from the VDOT central office staff, consultant staff assigned through VDOT's On-Call ITS Services contract, or *by* pro-bono publico support by Frederic R. Harris staff.

System Architecture Implications: This project is the Composite System Architecture for Regional ITS Planning, shown in Figure 8-4. The project architecture is based on the ITS Planning architecture. This is a procedural architecture centered on the Data Collection and ITS Planning that defines the functioning of the MPO technical committee.

System Architecture Technology: Although the formation and periodic meetings of the ITS Planning Subcommittee does not require the direct use of any technology, this group could greatly benefit from the existence of the data exchange network previously recommended. This data exchange network could be used to support the activities of the subcommittee in the distribution of meeting announcements, minutes, technical papers, and other reports and information of interest to the subcommittee.

8.3.2 Develop System For Exchanging Data Among Local Agencies

Description: This project will facilitate and expedite the exchange of information among the agencies, MPOs and Information Service Providers (ISPs) in the region using existing computer systems and communications capabilities, or easily obtainable upgrades to these systems. This system will provide the centralized information management unit with timely and accurate reports of incidents and other traffic related events. The project will also develop guidelines and procedures for the exchange of traffic related information using this system. In the future, an enhanced data exchange network could be used for a variety of purposes. These include: informing other agencies in the area of major incidents; exchanging files that contain traffic data for local analysis and regional planning; and transmitting images from a CCTV system.

Background: VDOT maintains two separate communications systems that are physically linked in close proximity, yet offer totally different services and communication capabilities. VDOT headquarters, districts, and residency offices are all linked by dedicated 512 kb circuits. This forms the backbone of the VDOT WAN (wide area network). Over these lines, data is exchanged, and e-mail may be sent using VDOT's VAX minicomputer system and a software package referred to as "All in One".

To date, the local FHWA office, Chesterfield County Transportation Planning, and Henrico County Traffic Engineering have been given access to this WAN. Plans are already being developed for the City of Richmond to have full-time connectivity to the VDOT network when a new fiber backbone is installed, with connectivity to Richmond City Hall. If requests are received from other local agencies in the study area, VDOT will open access to the system over dial-up connections. Although dial-up connections are limited in speed, they will be adequate for e-mail and access to selected VDOT files.

The Virginia Operational Information System (VOIS) is a separate network allowing for the exchange of information among various agencies including VDOT, VSP, DEQ (Department of Environmental Quality), TEOC, Virginia National Guard, Department of Parks and Recreation, and others. Physically, this system "piggy backs" on the existing VDOT infrastructure, but is a separate system which has no ties to the VDOT VAX system. A major use of the VOIS. is for the Emergency Information System (EIS) managed by the TEOC. Currently, e-mail is not an option over the VOIS, due in part to the differences in networking equipment utilized by local government agencies presently on the system.

Most local agencies in the study area use either the telephone or fax system for exchanging information. VDOT and the agencies using the VOIS routinely exchange data via networks, and if the system were to expand, they would likely take a lead role in the development of a formal data information exchange system among all agencies. However, the questionof whether to use the "All in Gne" system or the VOIS for the routine exchange of traffic information among VDOT and the local government agencies in the Richmond/T+Cities area remains to be answered.

Project Classification: Institutional: The identification and extension of the existing computer and communications systems necessary to implement the data exchange network should not require any major expenditure. However, future upgrades to this system may be included in future agency budgets. Similarly, the development of guidelines for use of the data exchange network will require some staff hours, but should not require any direct funding.

Implementation Issues: Most government agencies in the Richmond/Tri-Cities area should already have an established system for cataloging data created within their agency. One of the concepts that this project is trying to achieve is a system that would allow an agency to notify the other agencies in the area when new published materials become available. It might also be possible to directly download this data through the system. The establishment of an e-mail system among the agencies would allow an agency to notify the others when new materials are published. Other agencies that are interested in this data could then request that copies be sent to them through the mail.

Additional implementation issues are identified below:

- Henrico County may want access to the video images from the Richmond CCTV system. This may be difficult to accomplish over a WAN.
- Details of the best ways to interface the systems of the various agencies and implementation assistance should be developed in cooperation with the data processing directors of the agencies.
- The State Police and VDOT's Richmond District Office send "Road Closure" reports to the TEOC when a major incident closes the roadway.
- The local agencies may not be aware of the information that is currently available.

Funding: Each agency would be expected to pay its share of the costs of the data exchange network. For VDOT this would include the hardware and software costs associated with the file servers for this system. It might also be reasonable to expect VDOT to pay the initial costs of providing communications to the local agencies.

The local agencies would be expected to pay for their share of the hardware and software costs associated with the PC equipment in their offices, and the monthly charges for the dial-up telephone lines used to link these systems to VDOT.

Another anticipated cost for some agencies would be for the engineering support necessary to install and periodically maintain these systems. This cost could be minimized by establishing a pool of local agency personnel who are familiar with these systems, that could be accessed by another local agency that did not have personnel with these skills. Or alternatively, the MPO could establish a contract with one firm or vendor who would provide this support to all of the agencies in the region.

System Architecture Implications: This project is included in the Composite System Architecture for Regional Roadway Traffic Management, shown in Figure 8-1. An architecture for a system of exchanging data among local agencies will raise a number of issues. For example, there has to be two or more agencies concerned with 'the management of transportation traffic flow for an information exchange to occur. Each of the exchanging agencies must need information in a quantity, accuracy, or timeliness that exceeds their own capacity to obtain it, which will provide some of the incentive to enter into a symbiotic relationship with others. And as a final example, each of the agencies must have reached a level of technical sophistication consistent with the methods that would have to be used to implement the information exchange. From a system architecture perspective, the TEOC can serve as the information clearinghouse for this type of an inter-agency system. This project will be based on the installation of equipment to collect traffic data and to disseminate traffic information.

System Architecture Technology: The technology options that are available can readily support inter-agency information exchange. Only imagination, and budgetary dollars, would serve to limit the capabilities of such. a system. And there are a range of capabilities. VDOT is currently using a centralized data base system on computer network servers (the Emergency Information System) for the status of Commonwealth roadways. Some ISPs that serve radio broadcast outlets use a computer bulletin board system, that is dialed frequently by their clients, to receive their traffic information broadcast script. The ISP uses an abbreviated textual shorthand for their traffic reports, which is automatically expanded into a full-text announcer's script. Other standards developing through efforts resulting from the National ITS Architecture will address the message requirements between TMCs.

8.3.3 Install Incident Detection System

Description: This program for installing an incident detection system consists of multiple projects. The first three of these projects are planning efforts that can proceed concurrently, and should be completed before the remaining projects in this program which focus on the installation of field equipment.

The first project will identity the best way of linking the existing detection systems to the TEOC (or another location if the TEOC is not selected as the centralized information management center). These detection systems include the CCTV system that is currently being installed on I-64, the 911 calls and #77 calls recorded on the new State Police CAD (Computer Aided Dispatch) system, and the reports logged on the City of Richmond's CAD system.

The second project will review the accident data from the region to determine where accidents occur most frequently, and will produce a prioritized list of locations for installing field equipment for incident detection and verification.

The third project will select the mix of technologies that Will be used for incident detection and verification. This mix should include the existing systems identified. above as well as other technologies. The additional technologies that should be considered include radar, machine vision, acoustic detectors, and the monitoring of vehicles equipped with electronic toll tags.

The fourth project will deploy the field technologies and provide the communications infrastructure that is needed to bring the data from this field equipment back to the TEOC. This communications infrastructure should also enable State Police dispatchers to view the images from the CCTV system.

The fifth project will provide the software and hardware required 'to "fuse" the data from different sources together and provide meaningful tabular and graphical summaries that can be shared with other concerned local organizations.

Following this fifth project, additional deployment projects for field equipment can then be implemented to expand the coverage area monitored by the field devices in keeping with the established priorities.

Related Projects: I-64 has been designated by VDOT as a test site for new traffic monitoring and incident detection equipment. Early in 1996, VDOT established a demonstration project along the I-64 Corridor between New Kent County and the City of Richmond to test new incident detection systems. This system will be monitored at the TEOC. The demonstration project will be parallel to Rt. 60, thereby allowing VDOT to reroute traffic onto this road in the event of an incident. The TEOC will also use the information from the system to develop messages for the Highway Helpline and the new HAR and VMS systems.

High bandwidth digital communication, Integrated Services Digital Network (ISDN), lines are being investigated for use between the TEOC and the test site, but analog phone lines will initially be utilized to gather data from the monitoring equipment. This data will be in the form of black and white images.

Surveillance will be conducted on I-64 between the following interchanges:

- Between Rt. 249 and I-295 (New Kent)
- I-295 and Airport Drive (Rt. 156)
- Rt. 156 and Labumum Ave.
- Laburnum Ave. and 9 Mile Rd.
- 9 Mile Rd. and Mechanicsville Tnpk.
- Mechanicsville Tnpk. and I -95

Project Classification:

- Planning - The first three projects are pure planning projects and can be done without the expenditure of construction funds.
- Design/Construction - The latter projects are design/construction projects that will prepare plans and specifications for implementation by a construction contractor

Implementation Issues:

- The State Police and VDOT have made some provision for VDOT access to the CAD system being installed by State Police, but it is unclear what remaining steps are required to incorporate reports from the *911 and #77 systems.
- Perhaps a video based system can be developed that can use the same cameras/communications infrastructure for detection and CCTV surveillance.
- VDOT has indicated that, under current traffic conditions, the State Police 911 system is managing incident detection adequately for their needs; however, VSP is concerned about receiving too many non-emergency calls, a majority of which are passed on to other agencies. VSP has also expressed an interest in video detection.

Funding: It may be possible to complete the first three projects using the resources of the VDOT "On-Call ITS Services" contract. There are no surplus funds in VDOT's Richmond District budget that could be used for the design and construction of these systems.

System Architecture Implications: This project is included in the Composite System Architecture for Regional Roadway Traffic Management, shown in Figure 8-1. This project will be based on the TMC Incident Detection Equipment Package contained in the Traffic Management subsystem and the Roadway Basic Surveillance Equipment Package contained in the Roadway subsystem. This is a straightforward "two node, one link" architecture. A system of roadway sensors detect incidents or traffic flow, communicates the information to Traffic Management, and TM detects, classifies, and/or reports the incident.

System Architecture Technology: In spite of the range of vehicle detection technology, from simple inductive loops, to video image processing, calls from cellular phones might be the most effective method of detecting incidents in this financially constrained environment. The market penetration of cellular telephones has experienced a rapid increase. In many areas, the same roadside incident is reported by multiple callers on their cellular phones. This public involvement represents a powerful incident reporting capability. Exporting the information from the CAD systems into the TEOC computers will allow the reported transportation incident to be electronically reported. When funds are available, sensors and surveillance cameras can be used at the high-accident locations to confirm the incident, and to assist in the rapid dispatch of appropriate response equipment.

8.3.4 Improve Signal Coordination and Timing Plan Implementation on Major Diversion Routes

Description: The overall goal of this project is to improve the ability of the agencies responsible for traffic signals to adjust signal timing in response to incidents that divert traffic from major highways. The achievement of this goal has three major steps: first, to provide coordination between adjacent signals; second, to provide communications links so that the timing of the signals can be changed from each agency's centralized monitoring facility or remote terminals; and third, to prepare signal timing plans that can be implemented when a diversion plan is in effect. An associated objective is to provide "coordination" between signals that are controlled by different agencies to facilitate overall improvements in traffic flow in the region.

The first step will be implemented through a series of VDOT and local agency projects that will coordinate closely spaced signals on the diversion routes. The coordination mechanism between signals operated by a single agency may be wire or wireless communication media. This communications system should also provide the capability to relay messages that enable timing plan selection and the remote installation of data for new timing plans.

A second series of projects will provide each agency with communication links that will enable their signals to be controlled from their own centralized or remote terminals. These communication links may be through lines owned or leased by the agencies. With these communication links, the agencies will be able to select the appropriate timing plan from the library of plans stored in the traffic signal controllers, or download a completely new timing plan.

The third series of projects will develop a series of timing plans for use when diversion routes are in effect. The advanced preparation of these plans is recommended because it is faster, easier and safer to implement timing plans that are developed in advance than to prepare a new timing plan during a major incident. However, because of the variety of traffic flow conditions that may exist when an incident occurs, it should be recognized that it will be necessary to prepare several timing plans from which the most appropriate can be chosen.

The associated objective of providing coordination between signals that are controlled by different agencies can be achieved by developing the timing plans as if the signals were all part of the same system, and storing the timing plans for each signal with the agency responsible for that signal. When the timing plan is needed, 'both agencies will work cooperatively and implement their portion of the plan. (Although true synchronous coordination between adjacent systems is desirable, it is probably unnecessary since the systems will be operating in a "damage control" mode without the need for progression between signals.)

Related Projects: VDOT has approximately 325 signals in the region and' about l/3 are on closed loop systems. 22 signals are linked by spread spectrum radio. They are expanding these systems, and approximately 80-85% of the signals will eventually be included.

Henrico County has about 100 signals, but only a few are on a closed loop system. They would like to expand this system, preferably in the "West End".

The City of Richmond is currently the only signal system in the region with monitoring capabilities. Table 8-3 summarizes the Richmond signal system and the other traffic signal systems in the Richmond/Tri-Cities area. This table also includes any plans for signal system upgrades or coordination.

Project Classification: All of these projects can be classified as design/construction projects.

Implementation Issues:

- A road closure plan for major incidents that identifies these diversion routes has been developed by the State Police and VDOT.
- Several VDOT operators are available to change signal timings in real-time when there is an incident, but there are no "canned" diversion route timings already prepared. Funding might be accelerated by emphasizing the accident reduction potential and signal timing features.
- Consider having coordinated systems in place on all Federal routes followed in a priority basis by State routes, other principal arterial corridors, and other minor arterial corridors.

Funding: It may be possible to facilitate funding and expand the area with coordinated signals by stressing the incident management features of these projects and their inter-jurisdictional nature.

TABLE 8-3

TRAFFIC SIGNAL SYSTEMS IN THE RICHMOND/TRI-CITIES AREA

City/County	Present No. Of Signals	NO. Coordinated	Coordination Equipment	Plans to Upgrade/Expand/Co. ordinate?	Operating Agency
Charles City County	2	0		-	VDOT
Chesterfield County	158	134	TC-75, LTC-2, MCU-100, INTERN.; 25 are linked via spread spectrum radio (master @ Beach Rd./Lori Rd.)	-	VDOT
City of Colonial Heights	18	9	--	Hamilton/Temple to Hamilton and S. Park (5 signals)	The City
City of Richmond	431	256,18	256 signals are under central control of the Richmond Signal System, utilizing MONARC Traffic Control Software; the remaining 18 are on the Hull Street System, which is a 3-dial, timeofday master system inter-connected with twisted pair cable (the Hull Street System).	12 signals on Broad St., Monument Avenue and Patterson Avenue to be added in 1997 Expansion project does not include timing.	The Cii
Dinwiddie County	7	3	MOD-31 8, EPAC-300	-	VDOT
Goochland County	7	2'	LMD-8000, EPAC-300		VDOT
Hanover County	33	20	EPAC-300, MOD-318, LMD-8000, 1880-EL MOD-l 880	-	VDOT
Henrlco County	121	103	MOD-840 EPAC-300, MCU-I 00, 1880-EL, LC-8000, DP-9000 LMD-8000, TC-75, TC-81000, INTERN.	-	VDOT controls signals on primary route numbers. Henrico controls all others.
New Kent County	5	4	TC-75, TC-8100, INTERN.		VDOT
Powhatan County	2	0	-	-	VDOT
Prince George County	14	6	TC-75, TC-8100, CU-33, LTC-2	-	VDOT
Town of Ashland	5	0	TCT Controllers	3 intersections may see coordination this fiscal year with the construction of Hill Carter Pkwy: Carter Rd. & England; Cottage Green & England; Hill Carter Parkway & England	The Town

System Architecture Implications: This project is included in the Composite System Architecture for Regional Roadway Traffic Management, shown in Figure 8-l. This project will be based on the equipment packages (called the TMC Basic Signal Control) in the various municipal Traffic Management subsystems. Each municipal TMC will control their own signals (they will be linked with the Roadway Signal Controls equipment package in the Roadway subsystem). Each of the municipal TMCs will also respond to requests from the TEOC about their signal timing. This project requires a simple “two node, one link” architecture -- the intersection signals, the central control, and the connecting communications link. However, the implementation of the architecture into a functioning, area-wide system becomes difficult because of the political boundaries that must be crossed by the communications links.

System Architecture Technology: The primary technology feature that would facilitate this program is the adoption of the National Transportation Communications for ITS Protocol (NTCIP) communications protocol for traffic signal controllers. Although this would not make a significant difference in the short-term, in the long-term the open communications standards established through the NTCIP will facilitate equipment upgrades and the coordination of equipment provided by different manufacturers.

8.3.5 Develop and Implement Coordinated HAR and VMS Systems

Description: This program will develop and install a Highway Advisory Radio (HAR) system and a Variable Message Sign (VMS) system that will serve the entire Richmond/Tri-Cities area. The program includes multiple projects that will implement, upgrade and-expand the capability of these systems to provide information to travelers on the major roadways in the region.

The VMS units installed as part of the bridge reconstruction projects on I-95 should be supplemented through a series of additional VMS projects that will install signs on the approaches to all major freeway-to-freeway interchanges.

In order to facilitate the TEOC's operation of the HAR and VMS systems, (and the Highway Helpline) a project should be undertaken to provide a coordinated control system to facilitate the preparation and removal of messages for these systems. The objective of this project is to minimize the efforts that are required to select HAR and VMS messages from a library of prepared messages, indicate the units that will be used to provide these messages, and periodically ask the operator if the message(s) should continue to be provided. Ideally, this control system would also incorporate data gathered from the incident detection project and data exchange project to automatically inform the operator of potential incidents.

As an immediate action project, VDOT should develop a strategy for the location and use of portable VMS and HAR units throughout the region. When not needed in other areas for construction or special events, these portable VMS and HAR units should be installed on the sides of major roads so that they can be incorporated into the VMS and HAR systems. In order to facilitate a quick response to incidents, it is recommended that these units be solar powered, and have a cellular telephone link that can receive the messages. At locations where these portable units will be used on a semi-permanent basis, a small concrete pad can be installed to facilitate the setting and removal of these units.

Background: The TEOC has been selected to serve as operating unit for any new HAR system implemented by VDOT in the Richmond area. The HAR alert signage would also be controlled by the TEOC. The TEOC will also be responsible for the management of permanent VMS that VDOT has planned to install on the I-95 Corridor at the 1-95/I-295 interchanges.

Related Projects: VDOT will continue it efforts to install HAR transmitters with regional coverage.

A current VDOT construction contract is installing 3 permanent variable message signs along the I-95 Corridor prior to the I-95/I-295 interchanges. These installations are currently under construction and the signs have not yet been installed. Table 8-4 indicates their locations.

TABLE 8-4

LOCATIONS OF NEW VMS ON I-95

Milepost	County	Direction
89	Hanover	Southbound
43	Prince George	Northbound
46	Prince George	Northbound

VDOT has indicated that funds are available for the installation of more signs. Their objective is to install 2 more by the end of the next fiscal year. Potential locations for those signs have been determined and are shown in Table 8-5.

TABLE 8-5

FUTURE LOCATIONS OF VMS ON I-95

Milepost	County	Direction
86	Hanover	Southbound
80	Hanover	Southbound

Project Classification: The installation of the permanent HAR alert signs and the VMS units are design/ construction projects. The use of portable HAR and VMS units is an institutional project requiring minimal funds.

Implementation and Funding Issues:

- The MPO's TIP was recently amended to allocate $1,520,000 in NHS funds for the installation of VMS and a highway advising network of interstate roads in the Richmond Construction District.

- Discussions should be undertaken to determine if the HAR system, when it is not being used to broadcast a traffic alert, can be used as part of a tourist information system. If it can, the State Division of Tourism, the Metropolitan Richmond Convention and Visitors Bureau, and the National Park Service can contribute to the cost of installing the HAR signs and/or operating the HAR system.

- Any messages that appear on VMS regarding traffic news and information should be coordinated with information provided through the HAR broadcast.

System Architecture Implications: This project is included in the Composite System Architecture for Regional Roadway Traffic Management, shown in Figure 8-1. This project will be based on a portion of the TMC Traffic Information Dissemination equipment package, which will be linked with the Roadway Traffic Information Dissemination equipment package in the Roadway subsystem. This is also a "two node, one link" architecture: the roadside devices (VMS or HAR), the central TMC control, and the connecting communications link. The issues are in the implementation. To identify a few issues, there is usually a need to support both wired and wireless communications links, there are currently different protocols for different vendor's signs, and message selection is usually required from several locations.

System Architecture Technology: Standardization on a single communications protocol will help mitigate the implementation problems. HAR control technology is becoming increasing sophisticated, which allows the creation, storage, and selection of audio messages in a digital format, and multiple operators accessing the system over a wide area computer network. However, as previously indicated, it is important to coordinate the information being disseminated by both the VMS and HAR, and to have one central point to monitor the messages. Additional "back channel" communications may be required for these monitoring functions. For example and AM broadcast receiver is frequently used to monitor the HAR broadcast, and a surveillance camera can be used to visually monitor a message on a sign.

8.3.6 Develop Region-Wide or Statewide Standard for Electronic Toll Collection

Description: Electronic toll collection (ETC) facilitates the payment of parking fees and tolls, and can substantially increase the capacity of toll lanes. Electronic payment is one of the personal travel user services identified in VDOT's ITS Interim Tactical Plan (38). The vision for ITS in Virginia is that by the year 2005, automatic fee collection systems will be in operation on all toll roads in the State.

This project would convene a series of meetings of agency administrators and commissioners to agree on the use of a common electronic toll collection system. Through a series of follow-on projects, the agencies would implement electronic toll collection of their facilities.

The adoption of a standardize tag would facilitate the use and acceptance of electronic toll collection by residents of the Richmond/Tri-Cities area. If the penetration rate is adequate, these toll vehicles could also be used as probe vehicles that could be used to identify travel times and incidents throughout the region.

Facilities in the Richmond/Tri-Cities area that could potentially use electronic payment include: the Richmond Airport, Powhite Parkway, Downtown Expressway, Powhite Extension, parking facilities operated by the RMA and others, and the GRTC. Other new roads in the region, such as I-285, could also utilize this electronic payment system if the roads are financed through toll revenues.

Background: VDOT has discussed the issue of creating a Statewide standard for the automatic collection of tolls. The FASTOLL system is currently used both on the Dulles Toll Road (and the Greenway extension) in Northern Virginia and on the Coleman Bridge in Gloucester County. If a Statewide standard for toll collection were to be implemented, VDOT would more than likely choose to adopt the FASTOLL system. The long-term goal of the National ITS Architecture for ETC systems is to incorporate a common payment method for not only roadways, but parking garages and lots, public transit, and other "pay per use" transportation facilities. Some agencies, such as the RMA, have gone forward with plans to implement an electronic payment system within their operations independent of the FASTOLL system. These agencies, as well as others who in the future plan to implement electronic payment systems, need to form a consensus on a compatible system so that separate toll collection systems may still be incorporated, but a common transponder or smart card will work at all facilities. Compatible systems will eliminate the need for the motorist to carry multiple cards or be forced to make a decision about which transponders or smart cards to purchase, or to choose on which systems to continue using cash to make transactions.

Related Projects: In 1996, the Richmond Airport selected a provider for an ETC system both for access to airport facilities (i.e. monitoring use of the airport by taxis, andother commercial vehicles) and for airport parking. When the Airport Commission learned that the RMA was considering the FASTOLL system on the Powhite Parkway, they delayed the installation of their system so that they could test the FASTOLL system to determine if it is compatible with their present, on-line, revenue control system.

Project Classification: The development of a consensus on the type of electronic toll collection system to be used is an institutional project. The implementation of these systems are design and procurement projects.

Implementation Issues:

- Toll evasion-and enforcement elements must be incorporated into these systems.
- Although several of the Commissioners of the RMA and the Powhite parkway are from the same jurisdiction they are not the same people.
- Coordination of payment to multiple agencies/organizations may be complex to administer. This is likely to involve the need for a bank or other financial organization for collecting, processing and disbursing the toll receipts.
- In addition to the technology issues, which are identified in the following paragraphs, the very nature of the financial system (cash card, credit card, debit card on a prepaid account, etc.) must be decided.

System Architecture Implications: This project is included in the Composite System Architectui-e for Regional Electronic Payment, shown in Figure 8-2. This project architecture is based on the Dynamic Toll/Parking Fee Management equipment package architecture. Although there are many subsystems associated with electronic payment, the key interface is between the Vehicle subsystem's Vehicle Toll/Parking Interface equipment package and the Toll Collection subsystem's Toll Collection equipment package. This is the wireless interface that must be standardized to make the system work at all of the required facilities. In addition to the interface, there are other subsystems, such as Toll Administration and Parking Management, that need to be developed to make the project work. If these subsystems can be combined, it will simplify the architecture and thereby reduce the implementation costs.

System Architecture Technology: Many parameters associated with the wireless interface between the tag and transponder must be standardized to provide an open architecture that can be used by a wide variety of systems. These parameters include: type of tag and transaction system, data communications wireless interface (RF or IR, frequency, data packet message parameters, protocol, etc.), and tag reader configuration (single device, multiple frequencies, etc.). Until these standards are in place, a decision to use one type of system is tantamount to excluding all others. Because of this, many vendors are competing for the electronic payment market, and there is no clear leader with the major market share. Federal policy is still being developed for the radio frequency band that will be used for the wireless communications link, which is now called Dedicated Short Range Communication (DSRC).

8.3.7 Provide Real-Time Transit Schedule/Location Information

Description: This project will provide schedule information to transit riders using real-time forecasts of the arrival time of buses. These forecasts will be based on the actual position of the vehicles which will be determined through some form of AVL (automatic vehicle location) system. The arrival information will be displayed on monitors provided by the Greater Richmond Transit Company (GRTC) at selected public locations, and through other individually accessed electronic information systems. Until the system is fully implemented, the public monitors would display arrival and departure information that is based on the scheduled arrival times.

Because of the large cost of equipping the entire fleet with radios and GPS (global positioning systems), it is recommended that the GRTC equip a portion of its fleet as a test of this system. The arrival information will be displayed on monitors provided by the Greater Richmond Transit Company (GRTC) at selected public locations, and through other individually accessed electronic information systems. Until the system is fully implemented, the public monitors would display arrival and departure information that is based on the scheduled arrival times.

Because of the large cost of equipping the entire fleet with radios and GPS (global positioning systems), it is recommended that the GRTC equip a portion of its fleet as a test of this system. These GPS-equipped buses would be assigned to selected routes. The selection of the routes could be based on one or more of the following criteria: routes where many people transfer from one route to another, and where it may be necessary to have a bus wait at the transfer point until these transfers are made; routes where individuals are likely to have access to electronic public information systems; and routes where improved information and schedule adherence may attract additional ridership.

Related Projects: The GRTC is presently making two contributions to ITS in the Richmond/Tri-Cities region. First, they are purchasing scheduling software for their transit operations. This software will be used to generate operator shifts in an effort to minimize labor costs and reduce labor time required by drivers. One feature of this system will allow customers to obtain automated transit information over the phone. GRTC also plans to install radio systems in transit vehicles with AVL functionality. This will enable dispatchers to monitor buses for schedule adherence.

Project Classification: This project is a design/procurement project.

Implementation Issues: Equipping only part of the fleet with the GPS equipment and new radios will require extra work on GRTC's part so that only properly equipped buses are assigned to the selected routes.

Institutional Issues and Funding Sources:
The primary responsibility for funding and deploying a real-time transit schedule information system falls upon the GRTC. GRTC has allocated funds to install new radios in their bus fleet in an effort to improve operations. With this system, operators must rely on position information that is radioed in by the bus drivers, not necessarily in real time.

As previously indicated, it is recommended that GRTC use part of the funding originally allocated to the radio system as a test of the AVL system:

It may be possible to partially defray the cost of the monitors in public locations by incorporating brief advertisements into the material that is displayed, or by placing "static" advertisements close to the schedule displays. Any advertisements that use the monitor will have to be carefully incorporated so that they do not interfere with the functionality of the system. Organizations presently advertising on GRTC buses would be the logical first points of contact to determine the feasibility of this funding source.

System Architecture Implications: This project is part of the Composite System Architecture for Regional Multimodal Management, shown in Figure 8-3. This project architecture is based on the equipment needed for transit vehicle tracking. This architecture describes a system with three or four nodes, and three links. The four nodes are: the location data source, the transit vehicle, the transit management center, and the information service provider (ISP). The ISP may be eliminated if the transit management center provides the information directly to the users. The three links are: position fix, vehicle probe/location data, and transit and fare schedule information. There are several alternatives to determining the transit vehicle locations, so both the Location Data Source and Communications Infrastructure nodes are shown in the composite architecture.

System Architecture Technology: There are several technologies and experienced system integrators available that can implement this type of project. Generally, there are three types of AVL systems: systems that make use of a GPS receiver in the vehicle; systems that place a tag on the bus and install fixed transponders along the route to read the passing tags; and systems that use radio base stations to determine position by triangulating on the broadcasts from a transponder on the vehicle.

8.3.8 <u>Establish One Phone Number Accessing Travel Information for All Modes</u>

Description: This project would establish a telephone number (such as "TRAVELER") that people could dial for access to travel information for all modes. The system would ask callers to "Push 1 for Traffic Information," "Push 2 for Transit Information," etc. The options available could include: local traffic, highways in other areas, public transit, transit for the disabled, taxis, cat-pooling, train travel, auto clubs, and directions to area attractions. (If the number of choices is large, it may be necessary to have the caller perform the selection in two steps.) Depending upon the response, the call would then be electronically routed to the appropriate organization such as the ones indicated below:

- Local traffic – Metro Traffic (or another ISP)
- Highways in other areas – VDOT's TEOC
- Public Transit – GRTC or PAT (based on the are in which the call originates)
- Transit for the disabled – STAR
- Taxis – (Routed to the cab company in the area in which the call originates)
- Carpooling – Ridefinders
- Train Travel – Amtrak
- Auto Clubs – (AAA or other clubs depending upon a second entry)
- Directions to area attractions – Metropolitan Richmond Convention and Visitors Bureau

In essence, the TRAVLER phone answering system would function as a switch, directing the call to the appropriate organization based upon the caller's travel needs. All of the participating organizations would then start using this number (or both this number and their direct number) in their advertisements.

Metro Traffic (or another ISP) could provide the local traffic information through a recorded audio tape or an interactive system. The ISP would get continuous updates of traffic conditions and transit delays through the system used to exchange information among the agencies. This message provide by the ISP could be preceded by a brief commercial to help provide income to operate the system. Drivers could also be reminded that there are other ways to commute by adding "GRTC is operating normally" or "Find out about carpooling through TRAVELER" to the recorded message.

Related Projects: The VDOT TEOC currently operates the "Highway Helpline", a toll-free number (1-800-367-ROAD) available within the continental US. By using this number, motorists can report road conditions affected by inclement weather by inclement weather, highway to receive customized information. Using this menu system, the number also informs motorists of special travel conditions and of requirements and procedures for the transport of hazardous materials through the region. Another menu option is incident or hazard reporting. If more information is needed, such as local public transportation services or tourist information, the caller may speak directly with TEOC staff and obtain numbers for paratransit, public transit, ridematching services, the visitor's bureau, AAA, and other services.

Ridefinders, the Richmond/Tri-Cities area commuter travel service, currently operates a toll-free number that citizens may also use to obtain information regarding ridesharing. All others agencies can also be reached directly at their local telephone numbers.

Project Classification: This project is primarily a design/construction project because of the efforts associated with the design and installation of the telephone switching system. However, the preliminary efforts that are needed to forge the alliance of public and private sector organizations, that will participate in the system and fund its operation, will require extensive planning.

Funding: The basic cost of this project would be paid by the participating organizations from the budget items that are normally used for advertising or customer service. In addition, the cost of this service may be partially offset by a recorded "commercial" that is played after the caller has made a selection. (Note: this message should not be played if the caller has selected an information source that has its own commercial message.)

System Architecture Implications: This project is part of the Composite System Architecture for Regional Multimodal Management, shown in Figure 8-3. This project architecture is based on the Transit Fixed-route Operations equipment package architecture and a part of the TMC Traffic Information Dissemination equipment package in the Traffic Management subsystem (Figure 8-1). This architecture describes a system with multiple nodes, the number of which will depend on the number of participating agencies. Any node could serve as the host for the main access number of participating agencies. Any node could serve as the host for the main access number audiotext computer system. Subordinate audiotext systems would be located at each participating agency.

System Architecture Technology: The interactive audiotext computer system that will be used to implement this system already exists and is available through a variety of vendors. The traveler information system described in this project is already functioning in Boston, Massachusetts.

8.2.9 <u>Improve Interagency Coordination at Incidents</u>

Description: This project will take steps to help the region's organizations improve interagency coordination at major incidents. This coordination will provide improved responsiveness, a better working relationship among the field forces of different organizations, and a broader understanding of the need to balance the priorities of different agencies while safeguarding life and property.

The most reasonable first step is to convene regular meetings of an region wide incident management team. These meetings are a forum for discussions of coordination and response activities, and critiques of past incidents. The meetings would include representatives from the police, fire and rescue, EMS, and traffic organizations serving the communities in the region. The meeting could also include representatives from VDEQ (Virginia Department of Environmental Quality), heavy duty tow-truck operators, and traffic reporting services, if desired by the other members of the committee.

Because of the size of the Richmond/Tri-Cities area, and the need to focus the discussions among people who work these incidents together, it may be desirable to divide the area into two incident management teams. The initial suggestion is to have one team for the area north of the James River and a second team for the area south of the James River. There are likely to be representatives of several organizations (i.e. the State Police, VDOT and the City of Richmond) who should attend both meetings. It is recommend that the initial series of meetings be held every other month, and would decrease to a quarterly or bi-annual basis as the number of issues that need to be discussed declined.

Recommendations coming out of the incident management team meetings, that involve adjustments to the guidelines, procedures and coordinated response plans that are followed at an incident would be handled within the organizational structure of each agency. Recommendations that require the purchase of the new equipment would be forwarded to the ITS subcommittee to obtain regional support for these acquisitions.

It is strongly recommended that the incident management teams promote and train their personnel in the use of the Incident Command System (ICS). The ICS was developed by the fire services to organize and coordinate the response of multiple fire companies at the scene of a fire. It has been adopted for use by law enforcement agencies at police actions that require the coordination of many people, and has been used successfully at major traffic incidents in other states where the coordination of activities by several agencies is required.

Background: The Commonwealth of Virginia and local agencies have a long history of cooperating and coordinating their activities through mutual aid agreements and interagency meetings. VDOT, the VSP and many local agencies are participants in the Statewide Incident Management (SIM) Committee. This group meets three times a year, and is an excellent forum for the discussion of issues that affect incident management throughout the State.

Local activities in the Richmond/Tri-Cities area generally have more of a county or facility focus. All Jurisdictions in the region have indicated that they have either formal or informal mutual aid agreements with their counterparts in other communities. The major incident management activities in the area are indicated as follows:

- Henrico County is the home of the regional HAZMAT response team for the Richmond/Tri-Cities area. The team, one of seven State-recognized and funded organizations, functions as a fire fighting unit for Henrico County's Station 11 when HAZMAT services are not required. The HAZMAT team has a separate, written mutual aid agreement between each county that falls into its service area, and routinely participates in coordinated incident response training exercised with other jurisdictions.
- New Kent County incident response operations are coordinated between the Sheriff's Department, the Volunteer Fire Department, and the Volunteer Rescue Squad.
- The Goochland County emergency response system utilized a computer network for coordinated response. The emergency operations plan allows contact between various agencies, and coordinates the HAZMAT incident response program in cooperation with Henrico County.
- Dinwiddie County is a member of an "Incident Management Group". The County provides all emergency services within its boundaries.
- The RMA incident management group consists of the City of Richmond, the Counties surrounding Richmond, and the City of Petersburg. This group coordinates the response to incidents, and provides a single message given to the media. Regular meetings are held among participating agencies.
- Richmond International Airport police and fire personnel maintain cooperative agreements with their county counterparts in order to share information on incidents.
- VDOT's Richmond District maintains a "detour trailer" in which cones and signs are kept for use when there is incident. Upon notice of an incident, the detour trailer is brought to the incident scene and portable VMS units are placed in appropriate locations.

Project Classification: This is primarily an institutional project because the formation of the incident management teams does not require any direct funding. However, in some jurisdictions, funds have been used to provide consultant support. This support can cover a variety of activities including: distributing announcements and minutes of meetings, presentations by individuals involved in incident management activities in other areas, the development of training materials, etc.

The purchase of new equipment or supplies would require additional expenditures that would be classified as design or procurement. These expenditures could be relatively small, (i.e. the ordering of additional supplies, tools or small numbers of special radios that would be used at major incidents), but could also be significant if the purchases or replacement of large pieces of equipment or new systems are desired.

System Architecture Implications: This project is included in the Composite System Architecture for Regional Roadway Traffic Management, shown in Figure 8-1. The project architecture is based on the Incident Management System Market Package architecture. The key relationship is between the Emergency Response Management equipment package in the Emergency Management subsystem, and the TMC Incident Dispatch Coordination/Communications equipment package in the TM subsystem. The architecture will become more complex as multiple Emergency Management subsystems are introduced for each of the public safety and emergency medical services in the region.

System Architecture Technology: This project has a minimum technology involvement. However, interagency coordination among public safety organizations at the scene can be hindered by lack of common land mobile radio channels.

8.3.10 Establish the TEOC as the Centralized Information Manager

Description: The Virginia Department of Transportation should identify their Transportation Emergency Operations Center (TEOC) as the organization that will serve as the host for the centralized transportation information management center for the Richmond/Tri-Cities area. Under this expanded role, the TEOC will be responsible for coordinating the collection of traffic information among the various organizations within the region, and then disseminating this information to other agencies, public information providers, and the general public. This information should include information on all major streets and arterials in the community in addition to VDOT's principal roadways.

The actual dissemination of information to the public by the TEOC should be limited to the VMS and HAR systems, and the 1-800-367-ROAD telephone information system. The TEOC should provide summary packages of traffic information to MetroTraffic and other ISPs (information service providers), who will in turn provide this information to the public using a variety of communication media.

Background: This project evolved from a candidate project that focused on identifying "a Host Agency and Location for Centralized Information Management." This agency should be centrally located and should have vested regional interests. Five such candidate organizations with no institutional barriers have been identified. These organizations include the Virginia State Police, VDOT Central, VDOT Richmond District, the Richmond Regional Planning District Commission (RRPDC), and the Crater Planning District Commission(CPDC).

A majority of calls coming into the Virginia State Police (VSP) are transportation-related issues, and many of these get forwarded to VDOT. Although the VSP office has been identified as a potential site, they do not intend to take the lead in hosting a centralized transportation information management center. The cost of expanding their current operations to handle transportation-related issues, as well as any additional manpower that would be required make the task unfeasible.

The RRPDC and the CPDC were also targeted as candidates for housing a regional information management center. Both the Crater Planning District Commission and the Richmond Regional Planning District Commission have historically not been involved with operational issues. However, because of the ISTEA requirements that Congestion Management Systems be developed by MPOs as elements of their transportation plans, both of these organizations see themselves as having more operational capabilities in the near future. They have the advantage of having multiple funding sources for such a system, and have the legal capability to deliver operational services.

Both VDOT Central and the Richmond District Office have also been cited as agencies having the potential to expand their operations to create and manage a regional Traffic Management Center (TMC). They feel that the TEOC is better suited for the task and have agreed that TEOC will soon be responsible for monitoring future and currently deployed VMS and HAR systems throughout the study area. The responsibilities of the TEOC are being expanded to focus on regional operations, while still maintaining its roots in statewide coordination activities. With the TEOC's current and expanding roles in traffic management for the region, it would appear to be independent agency with similar responsibilities of the TEOC are being expanded to focus on regional operations, while still maintaining its roots in statewide coordination activities. With the TEOC's current and expanding roles in traffic management for the region, it would appear to be redundant to empower an independent agency with similar responsibilities.

The alternatives and factors cited in the preceding paragraphs were raised at the Deployment Workshop. Overall, the TEOC was the unit that was identified by the Steering Committee as having the most potential for serving the centralized information management role in the Richmond/Tri-Cities area. Several arguments support the Committee's reasoning for selecting the TEOC to carry out this role:

- The TEOC is strategically located in the City of Richmond, housed within the VDOT Central Office on West Broad Street.
- The TEOC is currently staffed by VDOT personnel on a 24-hour, 7 day per week basis.
- The State Police already notify VDOT of major incidents and would prefer that VDOT continue to handle the information management activities.
- The TEOC has a terminal on the Information Exchange Network (IEN) being developed by the I-95 Corridor Coalition.
- Many of the signals in the region are already controlled by VDOT. In the long run this will facilitate changing the timing plans for these signals in response to accidents and congestion on interstate highways in the area.

- As required by the Emergency Operations Plan, the facility currently provides a state level and regional central coordinating unit that is responsible for keeping the public informed during normal and extraordinary conditions, managing the flow of information among field units, executive management and other state and federal organizations. With its current responsibilities, the TEOC presently has connectivity with all necessary transportation entities as well as the media.
- VDOT is presently expanding the TEOC's current role from a state-wide emergency coordinating entity to one which also provides routine traffic monitoring and information exchange capabilities to transportation officials and information service providers on a regional level.

Related Projects: The Richmond District and the VDOT central office have agreed that the TEOC will monitor the CCTV system, and the HAR and VMS units that are currently being installed in the area. This is consistent with recent recommendations from VTRC which suggest that the TEOC operate the VMS and HAR systems in areas of the state that do not have a dedicated Traffic Management (TMC). In effect, the TEOC will act as the TMC for the Richmond/Tri-Cities area. The dissemination of information to other agencies, information service providers, and the general public is entirely consistent with the other TMC functions that have already become the responsibility of the TEOC.

Table 8-6 highlights current projects that are underway to expand the current responsibilities of the TEOC.

TABLE 8-6
TRAFFIC MANAGEMENT PROJECTS IN THE REGION THAT INVOLVE TEOC PARTICIPATION

Managing Agency	Project Description	Location	TEOC Responsibility
VDOT	Installation of 15 new VMSs	Throughout the Richmond/Tri-Cities Areas	TEOC will update all messages and manage equipment.
VDOT	Installation of HAR System	2 Locations designated for the Richmond District	TEOC will operate and manage the HAR system and will have responsibility for updating messages.
VDOT	Video Traffic Surveillance	I-64 Corridor between New Kent County and the City of Richmond	TEOC will monitor video output from the system and will report any incidents.
VDOT/VSP	Electronic Information Exchange; TEOC and VSP to be connected on shared network	VSP Headquarters and VDOT TEOC	TEOC will work with VSP to monitor the I-64 Corridor
I-95 Corridor Coalition	Information Exchange Network (IEN)	The IEN terminal is located in the TEOC	TEOC will transmit and receive messages of major incidents on the interstate system to other members of the Coalition.

With the full implementation of these projects, the TEOC will begin to make its transition from a statewide coordinating agency to one with more responsibilities in regional traffic management. **Project Classification:** Institutional-This project does not require a direct expenditure of funds. It does require that concerned administrative units within VDOT and local agencies agreethat the TEOC should act as the central information source.

Concerns: Local agencies sometimes fear that a new TMC will assume "control" of the traffic signals in the region during an emergency. It should be made clear that none of VDOT's existing TMCs control the traffic signals of any nearby city. However, other concerns about control also exist. For example, the RMA has indicated that it would have some institutional problems with another agency's having control over VMSs placed upon their roads.

Implementation Issues:

There may be some reluctance on the part of some local agencies to have VDOT be the centralized information manager.

- The RRPDC was suggested as one possible operator of the information management center because they represent multiple agencies and have access to several funding sources, but they are not currently an operating agency and only operate during standard business hours.
- It is important to recognize that the staffing requirements of the information management center can be quite extensive if it is run on a 24-hour, 7-day basis. (It takes 4 to 5 people to keep one operator position filled 24 hours a day, 7 days a week.)
- Local agencies should participate in the TEOC/TMC to give it a true regional thrust. This could be accomplished by having the local agencies provide on a rotating or part time basis during peak periods, and when there is a major incident. This is similar to the operations center serving the originally used at TRANSCOM, a traffic information and operations center serving the Metropolitan New York area, and to the staffing plan that is used when a disaster activates the State's Emergency Operations Center. Although the local agencies have no extra funds available, funding assistance may be a possibility if the RRPDC can access a funding source for the consortium of agencies that it could not access for an individual agency.
- The jurisdictions must be in agreement as to what information will be shared between agencies and the media. For example, it has been agreed that some level of coordination between the VSP and VDOT would benefit both parties. VSP has a need for getting road condition, weather, and other transportation-related information from VDOT. VDOT would probably like to receive incident and other related information. The nature of some information housed within both agencies is confidential, and both parties must be careful about what information gets relayed to the media.

Funding: Funding for this project must be regional in keeping with the broad geographic area that will benefit. Funding may come from traditional jurisdiction and agency funds, and may be used for this project as a means of furthering individual missions in a collective manner. CMAQ funds may also be used for advancing this project.

Responsibility for managing the system may be placed upon an agency independent of VDOT, with multi-jurisdictional representation. This system will operate regionally, and it is expected that the region will share in the cost. The private sector may also play a large role in providing funds and services. Because the system will be established for the benefit of the public, the private sector may have some, but not all, financial involvement in the development of the system. Private sector involvement could come through paying for access to information gathered at this central location.

System Architecture Implications: This project is included in the Composite System Architecture for Regional Roadway Traffic Management, shown in Figure 8-1. From a system architecture perspective, establishing the TEOC as the centralized information manager for the region means identifying the TEOC as the primarily needs more information about the regional roadways, and must establish coordination with other traffic management subsystems in the region. The most important existing, local TMC is the City of Richmond Traffic Signal Control System across the street in City Hall. Other coordination links are needed with the VDOT TMSs in Northern Virginia and Hampton Roads. In its current role, the TEOC is equipped with the information management systems for State-wide roadway condition information collection and dissemination. This is the functionality associated with the Equipment Package "TMC Traffic Information Dissemination." When this project is implemented, the TEOC will expand its regional role, and add the Equipment Package "TMC Regional Traffic Control."

System Architecture Technology: There are several technologies already associated with the TEOC that can be used as a foundation for expanded capabilities. Using the existing communications and transportation infrastructure provides "leverage" in the design of new systems with expanded capabilities. This leverage also minimized the risk and cost of deployment, and maximizes user acceptance and minimizes deployment time. The existing TEOC technologies include: (1) Highway Helpline 1-800-367-ROAD public telephone call direction, (2) LAN/WAN with client/server emergency management software from Emergency Information Systems (EIS), (3) Video Traffic Surveillance of I-64 and other video information channels with multiple monitors, (4) I-95 Corridor Coalition Information Exchange Network (IEN) connectivity, and (5) plan for an Internet Website. Of note is the traffic surveillance and detection technology demonstration project being planned for a portion of the I-64 corridor, between New Kent County and the City of Richmond. Six video cameras will be placed along the corridor. Black and white images of traffic conditions will be sent over standard phone lines, with efforts to incorporate into incident management. The new Website could ultimately provide Internet subscribers with video images of traffic conditions fed from video monitoring stations potentially located throughout the region. Also, the City of Richmond will be incorporating two CCTV locations into the expansion of their traffic signal system.

8.4 NEXT STEPS – CONCLUSIONS

The projects described in this section respond to the more pressing needs of the Richmond/Tri-Cities area. They can be implemented without overcoming major obstacles and will not impose costs upon the agencies that might be involved in excess of available funds. In many cases, these projects build upon existing operations and facilities and, therefore, capitalize on local and individual efforts to produce regional benefits. Implementation of these projects can also be expected to produce tangible results upon the movement of goods and people in the study area. This, in turn, will inspire agencies to continue with the larger list of medium and long-term projects in response to the growing need for transportation improvements in the area.

The following paragraphs describe the next step or steps that should be taken to initiate or advance the short-term projects. For many of the projects, the next step is a plenary meeting between representatives of the various agencies that would participate in the project. In some cases, steps beyond that session are proposed.

The steps proposed below are recommended as a means of advancing these ITS projects. Clearly, there are other means of continuing with this effort. Additional and alternative support is encouraged.

8.4.1 Establish an On-Going Group to Coordinate ITS Activities

Staff from the Richmond RRPDC and Crater PDC, respectively, should organize a formal Richmond/Tri-Cities ITS Activity Group meeting. This group would be responsible for the direction that ITS planning and related activities take in the Richmond/Tri-Cities area. Representatives that participate in the present Richmond/Tri-Cities ITS Early Deployment Study could participate in the formalized group, as well as representatives from the private sector. Committee organization and responsibility of participants, as well as meeting frequency, times, dates, and locations would be determined at the first formal meeting. The PDC staffs would recommend, to their respective PDC's, the formation of this group consistent with those agencies' guidelines.

8.4.2 Develop System for Exchanging Data Among Local Agencies

The VDOT VAX, which is currently the VDOT Wide Area Network (WAN), should serve as the pilot system for electronic information exchange between participating agencies until such time a separate, independently operated network is deemed appropriate for development.

The director of the TEOC should prepare instructions to agencies and information service providers interested in accessing the VDOT VAX. A "regional mail box" for all incoming data from participating agencies should be established. The system would initially be used for posting traffic-related news and information, construction delay information, news of reports and studies as they become available, and other general e-mail information exchange among agencies and information service providers. A member of the VDOT staff would manage and secure the operation and maintenance of the information exchange system, as well as design parameters that will limit rights and access to the system. VDOT would continue to utilize the VOIS for information exchange among state agencies.

Participants without WAN capability should upgrade their communications capabilities to gain access to the VAX. Each agency should provide staff to manage and maintain information collection and exchange activities between VDOT and other participating agencies.

The TEOC manager should achieve consensus among local transportation agencies that the Virginia Operation Information System (VOIS) would serve as an interactive traffic management software package. The package would utilize digital maps of the Richmond Metropolitan region, through which regional traffic news and related information could be monitored by participating agencies. The working group would be responsible for developing the software for the securing information of the system. The TMC would be responsible for managing the system.

8.4.3 Install Incident Detection System

The VDOT Central staff should investigate and select appropriate vehicle detection technology. Staff should establish at least two pilot segments to install detectors, based upon high incident potential. The director of the TEOC should meet with representatives of the State and local Police, and Fire and Rescue Services to discuss the operation of the pilot incident detection system and to establish emergency communications procedures between the TEOC and these agencies for verification of incidents detected by the system.

8.4.4 Improve Signal Coordination and Timing Plan Implementation on Major Diversion Routes

The Richmond District VDOT traffic engineers should organize and meet with agencies that operate and maintain traffic signals in their jurisdictions. Efforts should be directed at coordinating and improving timing of traffic signals on all major diversion routes throughout the study area. The Richmond District should be responsible for selecting, in cooperation with the local agencies, appropriate technology for this effort.

8.4.5 Develop and Implement Coordinated HAR and VMS Systems

The Director of the TEOC and VDOT Richmond District should work collectively to plan and deploy a pilot information dissemination system that will synchronize the time and content of announcements that appear on local HAR broadcasts and select VMS in the study area.

8.4.6 Develop Region-Wide or Statewide Standard for Electronic Toll Collection

VDOT currently utilizes a Mark IV Electronic Toll Collection system both in Northern Virginia on the Dulles Toll Road and Greenway and in Gloucester County on the Coleman Bridge. FASTOLL is a private, independent organization responsible for all administrative services on the toll road and the bridge, as well as opening and maintaining transponder toll accounts. Satellite FASTOLL account offices are located in Gloucester County for transponder sales, but all administrative activities are handled locally in the Reston office. VDOT Central Office staff should meet with representatives from the Powhite Extension, the RMA, and the Airport to establish FASTOLL as the standard electronic toll collection system in the Richmond area. They should plan for the location of FASTOLL account sales offices in the Richmond area.

8.4.7 Provide Real-Time Transit Schedule/Location Information

The GRTC should delay fleet wide installation of new radios in its bus fleet so that funds can be redirected to the purchase and installation of a pilot automated vehicle location system on several test vehicles. The GRTC should designate bus routes to utilize the technology as part of a pilot program, as well as the appropriate vehicle location technology. Planning for the deployment of the pilot program will take place between GRTC staff and a representative of the VDOT Central Office.

8.4.8 Establish One Phone Number Accessing Travel Information for All Modes

The Director of VDOT TEOC should establish, through the local phone service provider, an expansion of the existing Highway Helpline that will connect callers directly to one of the participating services. These services would include public transit schedules and related information, which will be the responsibility of those participating taxi services, directions and tourist information, which will be the responsibility of GRTC; local taxi services, which will be the responsibility of those participating taxi service; directions and tourist information, which will be the responsibility of Ridefinders; local traffic news and information, which will be the responsibility of Ridefinders; local traffic news and information, which will be the responsibility of Metro Traffic Control; statewide highway traffic news and construction delay information, which will be the responsibility of the TEOC and the auto clubs. The Director would organize and head a planning committee that would have representation from each of the participating organizations, and would work with the committee to develop the format for and deploy the information service routing system.

8.4.9 Improve Interagency Coordination at Incidents

Representatives of VDOT and the Virginia State Police should organize regularly scheduled incident management meetings that will include representatives of local police, fire and rescue services, EMS, HAZMAT, and local traffic organizations. Other representatives would include information service providers(local media) and low truck operators. The focus of the initial meeting should be to organize meeting times and locations. The group should advance the recommendations indicated in the Strategic Deployment Plan. After the initial session, meetings could be sub-divided into tow groups, each consisting of representatives from the North and South side of the James River. State Police, VDOT, the City of Richmond, and Chesterfield County would attend meetings in both locations.

8.4.10 Establish the TEOC as the Centralized Information Manager

The director of VDOT TEOC should organize and convene a meeting among local transportation agencies (e.g., county departments of public works) that would participate in the expansion of the TEOC into th regional traffic management center (TMC). The participating agencies, in cooperation with VDOT TEOC, would develop a strategy for the deployment of the TMC and determine the extent of operational involvement among those agencies.

The group would work with agencies outside of VDOT, including the media and State Police, to establish guidelines as well as the format by which transportation information will be disseminated to the public.

8.5 ORDER OF MAGNITUDE PROJECT COSTS

The short-term projects recommended in this Strategic Deployment Plan will need to be developed to a greater level of specificity before an engineering cost estimate can be prepared It is important, however, to understand the magnitude of the costs so as to begin identifying potential sources of funds.

TABLE 8-7

ORDER OF MAGNITUDE PROJECT COSTS

Project	Unit	Cost Estimate
Improve Interagency Coordination at Incidents	No Capital Expenditures Required.	N/A
Develop System for Exchanging Data Among Local Agencies	PC with Modem and Software (Monthly Internet Access Fee not included).	$3,500
Install Incident Detection System	Video Image Incident Detection System Per Mile of Roadway.	$32,000
Improve Signal Coordination and Timing Plan Implementation on Major Diversion Routes	Timing Plan Development and Coordination System per intersection.	$2,400.
Develop and Implement Coordinated HAR and VMS Systems	HAR Field Equipment for One Broadcasting Facility/VMS and Supporting Equipment and Software for Sii VMS (includes installation).	$50,000/$600,000
Develop Region-Wide or Statewide Standard for Electronic Toll Collection	No Capital Expenditure Required	NIA
Provide Real Time Transit Schedule/Location Information	Base Cost (Equipment and monitoring software) + Equipment Cost per Bus	$25,000 base * $2,000 per bus
Establish One Phone Number Accessing Travel Information for All Modes	Annual Contract Cost to Route Incoming Calls Directly to Participating Local Organizations.	Information to be provided by Bell Atlantic
Establish an On-Going Group to Coordinate ITS Planning	No Capital Expendiiures Required.	N/A

Costs for similar projects that have been implemented isther locales areles are useful as a starting point for developing those costs While the details of the project and local variations ma affect they ultimate cost estimate, these peer groups are helpful at the planning stage Table 8-7. indicates the magnitude of the costs for these projects based upon experience in other locales Details of these costs can be found in Appendix D.

APPENDIX A
TECHNOLOGY SURVEY

In the assessment of ITS technologies, a comprehensive listing of products and services that either are now commercially available or will soon be emerging on the market is presented in Tables A-l through A-4. Investigated technologies are summarized and linked with each of the ninety-two candidate projects, as well as the following categories:

FHWA Technology Area: This column presents the general technology that is being evaluated. For ease of reference, each technology is presented in the same format as those presented in the National ITS Architecture Implementation Strategy deliverable document.

Description: This column defines the technology area in general terms and describes what function the technology has been established to perform.

Maturity: This column defines the condition of the particular technology as either mature, mature with rapid innovation, mixed, or immature It should be noted that few absolute conclusions can be drawn from the technology maturity assessment alone. By stating that a technology is immature, we are not dismissing an opportunity to implement a technology that requires further research. Immature technologies have been applied successfully in products, and the success or failure of those products is based strictly upon the customer's needs, expectations, and the performance of the technology If the need to create a product exists, chances are that such a system is currently under development.

The following definitions, as included in the FHWA National ITS Architecture, provide definitions of each state of maturity for technologies:

- ***Mature:*** Current commercially available technology supporting the ITS requirements in this area .Deployment of the ITS Market Packages is not predicated on further research and development of these technologies.

- ***Mature with Rapid Innovation:*** Current commercially available technology supports the identified ITS requirements The area is one of a rapid technology growth which suggests that the basic support provided by current technologies will likely be superseded within the deployment period. While further research and development are not required to support ITS, future deployments may benefit from technology enhancements that should not be precluded by excessive rigidity in the architecture or deployment definitions.

- ***Mixed:*** This technology area satisfies a range of ITS requirements including some that current technology does not support. Useful services may be deployed using currently available technologies; however, satisfying all user service requirements will require additional research and development to bolster the identified deficiencies.

Immature: Additional research and development are required before technologies in this area can be cost-effectively and reliably applied to support ITS services. In some cases, potentially suitable technologies have been applied in defense or aerospace applications. Additional research and development are still required in these areas to address the unique producibility, safety, and cost issues associated with larger commercial markets.

Vendor/Manufacturer: This column defines the vendors or suppliers who have products available in the realm of the technology, as well as a contact person if one has been made available, An alphabetical listing of providers is provided in Table A-5.

Product/Service: This column identifies the specific products, services, and trade names associated with the technological area that are available through the vendor.

Description: This column describes what tasks the technology has been developed to perform.

Work Scope Technology Area: This column presents the scope of work technology area (presented in Section 2) supported by the highlighted technology.

Projects: This column presents each of the ninety-two candidate projects that correspond to the technology area.

TABLE A-1-A

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description	Maturity	Work Scope Technology Area	Project(s)
Traffic Sensors	Sensor technology which monitors overall traffic conditions. Enables collection of basic aggregate measures such as occupancy, volume, and speed.	Mature	Surveillance	· ATMS1.4 · ATMS1.8 • ATMS1.11 · ATMS7.4 · ATMS8.4

Vendor / Manufacturer	Product / Service	Description	Address	Telephone	Point-of-Contact
3M Traffic Control Systems	Opticom Priority Control System Series 500	Optical communications used to offer temporary control over traffic signals to public safety vehicles to improve emergency response times. System also offers public transit vehicles the ability to extend green lights for improved adherence to schedules.	3M Safety and Security Systems Division 3M Center Building 225-4N-14 St. Paul, MN 55144-1000	612-736-2588	Peter Smith
AT&T	Smart sonic Sensor	Smart Sonic Sensor for traffic surveillance applications.	Suite 150 2343 Alexandria Drive Holmdel, NJ 07733-3030	908-949-2117	Sunil K. Tewarson, ITS Global Marketing Manager
Burle Philips Communications & security Systems (CSS), Inc.	CCTV	Video Traffic Detection Systems and products for vehicle monitoring and incident detection on highways, toll booths, and bridges.	1004 New Holland Ave. Lancaster, PA 17601-5606	800-326-3270	C.L. (Herk) Rintz, Manager
Cohu, Inc.	CCTV	Video Traffic Detection Systems and products for vehicle monitoring and incident detection on highways, toll booths, and bridges.	5755 Keamy Villa Road San Diego, CA 92123	619-277-6700	
Econolite Control Products, Inc.	Autoscope	Wide Area Video Detection System.	3360 LaPalma Ave. Anaheim, CA 92806-2856	714-630-3700	
Image Sensing Systems, Inc.	Autoscope TM2004	A wide area video vehicle detection system.	500 Spruce Tree Centre 1600 University Avenue West St. Paul, MN 55104	612-603-7700	Lisa Dumke, Director, Sales and Marketing

TABLE A-1-A (Continued)

INVESTIGATED ITS SENSOR TECHNOLOGIES

Vendor / Manufacturer	Product / Service	Description	Address	Telephone	Point-of-Contact
Microwave Sensors, Inc.	Overhead Vehicle Detectors	Overhead vehicle detectors for a range of applications. Primary use includes signalized intersections that have been integrated into traffic management systems (speed/movement monitor) and volume count applications.	7885 Jackson Road Ann Arbor, MI 48103	800-521-0418	Bob Hunter, Sales Manager
NuMetrics	Countcard	Vehicle magnetic imaging traffic analyzers for count and classification; Permanent wireless traffic recorders.	Box 518 University Drive Uniontown, PA 15401	412-438-8750	Barbara Kovell, Vice President/ Marketing
Odetics, Inc.	VTDS; Fastrans; UTS10	Video traffic detection systems; Video tmnsmission systems; Universal time standard.	1585 South Manchester Ave. Anaheim, CA 92802-2907	714-758-0100	Mike Juha, Manager Marketing
PEEK Traffic	VideoTrak-900; PEEK Automatic Data Recorders (ADR-1000, 2000,3000, TrafficCOMP III)	Video' traffic detection system; Traffic counters.	1500 N. Washington Blvd. Sarasota, FL 34236	800-245-7660	TESCO Mark R. Robinson 703-548-5858
Rafael	Dirigible based video traffic monitoring systems	Live video transmission of roadway conditions from a gym-stabilized camera housed in a small balloon.	Rafael Dept. 4P Haifa POB 2250 Israel 31201	011-972-4-879-2342	Eli Tamir
Rockwell International Corp.	Trafficam	Video Image Detection System.	3370 Miraloma Avenue Anaheim, CA 92803	610-3284040	General Highway Products, Inc. 500C Abbott Drive P.O. Box 596 Broomall, PA 19008 (610) 3284040

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-1-B

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology	Description Area		Maturity	Work Scope Technology Area	Project(s)
Vehicle Status sensors	sensors which determine individual characteristics of passing vehicles. Technologies which assess individual vehicle length, weight, number of axles, lane position, and speed are available. Enforcement application technologies that monitor emissions and passenger counts for specific vehicles are less mature.		Mixed		ATMS3.9
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
AMP, Inc.	Piezoelectric Film Sensors	Piezo polymer axle detectors for vehicle classification and counting. Options include over the road and in the road configurations, as well as soon to be introduced weigh-in-motion sensors.	P.O. Box 799 Valley Forge, PA 19482	610-666-3500	Donald L. Halvorsen, Program Manager
Electronic Integrated Systems, Inc. (EIS)	Microwave Detectors	Overhead Microwave Traffic Detectors.	1401 Rockville Pike, Suite 500 Rockville, MD 20852	301-738-6900	
PAT Traffic Control Corporation	WIM, AVC, BCS	Weigh-in-motion, advanced automatic vehicle classification, bridge control systems, portable static scales, and traffic control, and monitoring netowrks.	1665 Orchard Drive Chambersburg, PA 17201	717-263-7655	Joseph R. Cal, Director of Sales and Marketing
PEEK Traffic	PEEK Automatic Data Recorders (ADR P-WIM)	Weigh-in-motion sensors used in conjunction with ADR counters/classifiers.	1500 N. Washington Blvd. Sarasota, FL 34236	800-245-7660	TESCO Mark R. Robinson 703-548-5858
Perceptics Corporation	License Plate Readers	Automated license plate reading equipment and software for applications in law enforcement, market surveys, and engineering studies	725 Pellissippi Parkway Knoxville, TN 37932-3350	615-966-9200	Terry Gibson

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TABLE A-1-C

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Environmental sensors	Sensor technology which monitors local climate (temperature, humidity, precipitation, wind, pollution) and mad surface status (dry, wet, ice, snow).		Mature		
Vendor	**Product**	**Descriptions**	**Address**	**Telephone**	**Point-of-Contact**
Scan systems, Inc. (SSI)	SCAN FP 2000 Roadwat Sensor; Roadway I Runway Weather Information Systems (RWIS)	In-pavement, passive sensor used to measure the freeze point of chemical/water solutions, and the amount of ice in the solution. Also measures and reports percent of chemicals in the solution, depth of solution, and pavement temperature and condition.	116612 Lilbum Park Road St. Louis, MO 63146-3535	800-325-SCAN (7226)	

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TABLE A-l-D

INVESTTGATED ITS SENSOR TECHOLOGIES

FHWA-Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Vehicle Monitoring Sensors	The range of on-board sensor technologies which monitor vehicle condition (e.g. engine, brake, tire, and suspension status) and performance (current speed, acceleration, yaw, traction, current steering, throttle, braking, and transmission status).		Mature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
Echelon Industries, Inc,	Monitoring sensors	Vehicle mechanicals monitoring equipment.	556 N. Diamond Bar Blvd., Suite 202 Diamond Bar, CA 91765	909-861-3881	Ray Rebeii

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-1-E

INVESTIGATED ITS SENSOR TECHNOLOGIES

.FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Driver Monitoring sensors	Technologies which monitor driver condition by monitoring driving characteristics and/or other psychophysiological symptoms associated with impaired performance.		Immature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
Northrop Grumman Corporation	Drowsy Driver warning System	This is part of an ITS IDEA study that Northrop Grumman has performed. This product is still in its development phase and is not yet a marketable product.	Advanced Technology and Development Center 8900 E. Washington Blvd., MS: N560/XA Pico Rivera, CA 90660-3783	310-942-5230	Richard Raiford, Manager, New Product Development

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TABLE A-1-F

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Cargo Monitoring sensors	Technologies which monitor various indicators of cargo status. Load distribution, temperature, acceleration, and pressure are among potential indicators that may be monitored depending on the nature of the cargo.		Mature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**

This list should not be considered all-inclusive and is nor an endorsement or any product.

TABLE A-1-G

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Obstacle Ranging sensors	Technologies which detect and characterize potential obstacles (other vehicles, people, road debris) in a vehicle's vicinity. Supports family of applications with variable performance requirements. Advanced headway maintenance requires high frequency and precision. Driver warning systems may have reduced requirements due to human time scale. Vision enhancement sensors must support overall environment imaging.		Immature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**

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TABLE A-1-H

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Lane Tracking Sensors	Technologies on-board the vehicle which monitor the position of the vehicle with respect to the travel lane and optionally Support interpretation of travel lane geometry ahead of the vehicle.		Immature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**

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TABLE A-1-I

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Security Sensors	Technologies which provide surveillance of, and restrict access to, secure public areas. Card readers which restrict access and closed circuit television cameras are examples.		Mature		• APTS1.1 • Ams1.3 • AFTs1.4 • APTS1.6 • APTS2.1 • APTS2.2 • APTS2.3 • APTS6.2
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
Echelon Industries Inc.	FARETRANS VMS (Fare Transaction and Vehicle Management System)	Transit vehicle security monitoring providing automated vehicle location, automated passenger counting, speech and display systems, printing system, and local or wide area radio.	556 N. Diamond Bar Blvd., Suite 202 Diamond Bar, CA 91765	909-861-3881	Ray Rebeiro

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TABLE A-l-J

INVESTIGATED ITS SENSOR TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Projects(s)
Location Determination	Technologies which determine absolute position. Examples include Global Positioning Systems (GPS) and other systems which apply trilateration to known locations, either terrestrial or space based. Augmenting these technologies are those which measure travel path and distance (e.g., odometer, compass, gyroscope) from a known location. Very high-precision systems associated with vehicle control applications are one remaining research area.		Mature with rapid innovation		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
Andrew Corporation	AUTOGYRO Navigator	Incorporates GPS technology with a fiber optic gyro system.	10500 W. 153rd St. Orland Park, IL 60462	800-255-1479	
Delco Electronics Corporation	Telepath 100	A low-cost in-vehicle GPS navigation system.	Mail Station CT 16A One Corporation Center Kokomo, IN 46904-9005	317-451-0657	Rob Leggat, Manager of Public Affairs
Morrow, Inc.	AVL Map Stations; AVL Mobile units; 220 MHz Mobile Data Radio Systems	Interface to radio systems and CAD systems; 6-channel Differential Global Positioning System (DGPS) radio control.	2345 Turner Rd SE P.O. Box 13549 Salem, Oregon 97309	503-581-8101	
Israel Aircraft Industries, Ltd.	SYSAL Fleet Management System	Differential Odometer; map matching; DGPS.	TAMAM Division Electronics Group/OFEK Technologies, Ltd.	703-875-3777	
Orbital Sciences Corporation (OSC)	Intelligent Fleet . Management Systems (for public transit)	GPS-based automatic vehicle location (AVL) system with on-board computer, schedule adherence, position-based signage and annunciation; Computer-aided dispatch; Real-time traveler information systems; AVL-based priority movement.	20301 Century Boulevard, MS B-14 Germantown, MD 20874	301-428-6023	
Siemens ITS North America	Tetra Star GPS System	A turn-by-turn autonomous navigation and driver information system.	2400 Executive Hills Drive Auburn Hills, MI 48326-2980	810-253-1000	Ronald P. Knockeart, Vice President, ITS North America

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TABLE A-2-A

INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area--	Description	Maturity	Work scope Technology Area	Project(s)
Cell-Based Communications	Wide-area wireless communications, both one-way and two-way. Primary examples include circuit-switched cellular, Cellular Digital Packet Data (CDPD), and FM subcarrier. Future, emerging technologies include Personal Communications Services (PCS) and various mobile Satellite Networks.	Mature with rapid innovation		

Vendor	Product	Description	Address	Telephone	Point-of-Contact
Modulation Sciences, inc.,	High Speed FM Subcarrier Provider	High clarity, short-range audio and data broadcasting system.	12A World's Fair Drive Somerset, NJ 08873	800-826-2603	Judy Englert, Sales & Marketing
Scientific-Atlanta, Inc.	High Speed FM Subcarrier Provider	High clarity, short-range audio and data broadcasting system.	3845 Pleasantdale Rd. Atlanta, GA 30243	404-903-2603	E. Scott Wood, Director of Communications
Seiko Communications Systems, Inc.	High Speed FM Subcarrier Provider	High clarity, short-range audio and data broadcasting system.	1625 Amber Glen Ct., Suite 140 Beaverton, OR 97006	503-531-1530	Gary Gaskill

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TABLE A-2-B

INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Vehicle-Roadside Communications (VRC)	Short range wireless communications between infrastructure and vehicle using active radio frequency, passive (backscatter) radio frequency, and/or infrared. ***[Note: also referred to as Dedicated Short Range Communications, DSRC]***		Mature with rapid innovation		• ATMS1.10 • ATMS4.2 • ATMS4.5 • ATMS8.4 • APTSl.2 • APTSl.5 • ATIS 1.1
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
AT/Comm, Incorporated	RF Tags and Readers for VRC and C V O Applications	Type III” smart transponders with unique read-write capabilities, a microprocessor, large memory storage, an LCD viewscredn, audio speaker, and touchpad.	30 Doaks Lane Marblehead, MA 01945	617-631-1721	Tod Hannaway
BMW AG *Information*	Companion	Roadside beacons that flash in the event of an incident or backup in order to warn approaching motorists; beacons are linked both together and to traffic operations center to provide incident detection and notification.	P.O. Box 50-20-44 D-80972 Munich Germany		
Cobra Electronics Corporation	Intelligent Radar Detectors	Compact receiver which alerts drivers to the presence of oncoming emergency vehicles or a stationary roadside hazard or construction zone.	6500 W. Cortland St. Chicago, II. 60635	312-889-8870	John Pohl, VP, Marketing
Hughes Transportation Management Systems	RF Tags and Readers	RF tag and reader systems for CVO applications, deployed for HELP, Inc. in California.	P.O. Box 3310 Fullerton, CA 92634-3310	714-446-2255	Philip Davy, Vice President, Marketing
Mark iv Industries, Ltd.	RF Tags and Readers	RF tags and readers suitable for a variety of automotive vehicle identification (AVl), and VRC applications such as ETTM and CVO.	6020 Ambler Drive Mississauga, Ontario L4W 2Pl	905-624-3025	Paul Manuel, Marketing Manager, IVHS Division
Siemens ITS North America	Ali-Scout	‘Beacon-based infrared driver navigation system.	2400 Executive Hills Drive Auburn Hills, MI 48326-2980	810-253-1000	Ronald P. Knockeart, Vice President, ITS North America

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TABLE A-2-C

INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area	Description	Maturity	Work Scope Technology Area	Project(s)
Vehicle-Vehicle Communications	High data rate, short range, reliable two-way digital communications between vehicles using RF, microwave or infrared spectrum. Favored technical approach has not been selected.	Immature		• APTS1.2 • APTS1.5 • ATIS1.1

Vendor	Product	Description	Address	Telephone	Point-of-contact
Cobra Electronics Corporation	Intelligent Radar Detectors	Compact receiver which alerts drivers to the presence of oncoming emergency vehicles or a stationary roadside hazard or construction zone.	6500 W. Cortland St. Chicago, Il. 60635	312-889-8870	John Pohl, VP, Marketing
Delco Electronics Coporation	Forewarn	A family of radar collision warning devices.	Mail Station CT16A One Corporation Center Kokomo, IN 46904-9005	317-451-0657	Rob Leggat, Manager of Public Affairs
Northrop Grumman Corporation	Collision warning System	Millimeter wave components for collision warning and communications systems, currently under development.	Advanced Technology and Development Center 8900 E. Washington Blvd., MS: N560/XA Pico Rivera, CA 90660-3783	310-942-5230	Richard Raiford, Manager, New Product Development
VORAD Safety Systems, Inc.	VORAD	On-board radar system to alert driver of potential collision.	10802 Willow Court San Diego, CA 92127	619-674-1450	Jerry Woll, Senior Vice President, Engineering

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TABLE A-2-D
INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Fixed communications	Technologies used to carry information between fixed locations; technology choices are largely dependent on local service provider or local preference for private networks. Various networks (PSTN, ISDN, IP, PDN, private local network) support ITS requirements.		Mature with rapid innovation		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-contact**
AT&T	SONET/SDH Based Networks optic	Various products and services related to fiber SONET/SDH based communications networks.	Suite 150 2343 Alexandria Drive Holmdel, NJ 07733-3030	**908-949-2I17**	Sunil K. Tewarson, ITS Global Marketing Manager

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TABLE A-2-E
INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Algorithms	Processing technology and advanced algorithms which enable advanced vehicle and traffic control applications. Overlap exists between this computational element and the other technology areas it supports.		Mixed		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
PEEK Traffic	Split, Cycle, and Offset Optimization Technique (SCOOT) Urban Traffic Control System: Speed Queue Warning systems	Traffic-Adaptive Signal Timing Optimizing Software Speed-Responsive Traffic Signal Control Devices.	1500 N. Washington Blvd. Sarasota, FL 34236	800-245-7660	TESCO Mark R. Robinson 703-548-5858
Zexel USA Corporation	Algorithms and Software	Algorithms and software for vehicle positioning, route guidance, and turn-by-turn guidance; electronic and computer architectures including position sensors, LCD, and GPS.	37735 Enterprise Court Farmington Hills, MI 48331	810-553-9930	Robert Borcherts, Vice President

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TABLE A-2-F
INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Information Management	Information storage, fusion, and retrieval systems supporting access to distributed heterogenous data.		Mature with rapid innovation		• ATMS1.7 • APTS2.1 • APTS2.2 • APTS3.1 • APTS4.3 • ATIS2.1 • ATIS7.1 • ATIS7.3 • ATIS8.3
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
Control Technologies Inc. (CTI)	Automated Traffic Management Systems Integrator and Software Developer	Provide the design, development, implementation, and enhancement of transportation management facilities including traffic control systems, freeway surveillance systems, telecommunications/ network mgmt., database mgmt., local area networks, hardware/software acquisitions, etc.	9015 Rhode Island Ave. College Park, MD 20740	301-513-5353	Warren Wayland
Ecotek Technology olutions	GeoMatch	GIS ride-matching software package connecting commuters in all modes of travel. MS Widows-based program.	Seal Beach, CA		
Geosystems	Information Kiosk Software	Customized Core Mapping, Locating and Directional Software for Use in Information Kiosks.	227 Granite Run Drive Lancaster, Pennsylvania 17601	717-293-7500	Perry Evans, VP Sales and Marketing
Golden Screens America	Electronic Information Kiosk	A stand-alone electronic information medium accessible by the public for the purpose of providing transit, traffic, or other related information.	60 E. 42nd Street, Suite 546 New York, NY 10165	212-983-5212	Neil Fink, Sales Rep.
Sirius Solutions, Ltd.	Go Time	Reel-time Fixed Route Transit Fleet Management and Public Information System. Provides Public Information on the Actual Departure Times of the Next 2 Buses for Each Route on Any Stop. can Be Accessed by Phone, Color Graphics Display Terminals or Kiosks.	One Research Drive, Suite 215 Dartmouth, Nova Scotia B2Y 4M9 Canada	902-465-2328	

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-2-G

INVESTIGATED ITS COMMUNTCATIONS TECHNOLOGIES

FHWA Technology Area	Description	Maturity	Work Scope Technology Area	Project(s)
Payment	Technologies which enable secure automated financial transactions in conjunction with information management and communications technologies above. Magnetic strip cards and Smart Card technologies are examples. Roth contact and contactless technologies may be used.	Mature with rapid innovation		• ATMS1.3 • ATMS2.1 • ATMS.2 • ATMS2.3 • ATMS2.4 • ATMS2.5 • ATMS10.1 • ATMS102 • ATMS10.3 • ATMS10.4 • APTS2.3 • APTS4.2

Vendor	Product	Description	Address	Telephone	Point-of-Contact
Amtech Systems Corporation	Intellitag 2000; Dynicash; Intellitag; Toll Tag	Vehicle-Roadside Communication System; Secure, Private and Autonomous Smart Card Payment System; Read-Write Electronic Toll & Traffic Management (ETTM) Product; Widely Used ETTM Product.	17304 Preston Road E-100 Dallas, Texas 75252	214-733-6600	
AT/Comm, Incorporated	RF Tags and Readers for ETTM Applications	Type III smart transponders with unique read-write capabilities, a microprocessor. large memory storage, an LCD viewscreen, audio speaker, and touchpad.	30 Doaks Lane Marblehead, MA 01945	617-631-1721	Tod Hannaway
AT&T	Smart Card	Smart card intermodal access systems spanning electronic toll collection, fare collection, and commercial vehicle uses.	Suite 150 2343 Alexandria Drive Hohndel, NJ 07733-3030	908-949-2117	Sunil K. Tewarson, ITS Global Marketing Manager
Delco Electronics Corporation	Sightlinc	In-vehicle transponder for electronic tolling and traffic management.	Mail Station CT 16A One Corporation Center Kokomo, IN 46904 9005	317-451-0657	RobLeggat, Manager of Public Affairs
Fastoll Customer Service Center	Automated Toll Collection	Administrative Services.			
GEMPLUS Card International	Smart card	Smart cards with integrated computer (IC) chip for data storage and elctmnic payment.	656 Quince Orchard Road Suite 610 Gaithersburg, MD 20878	301-990-8800	Gilles Lisimaque, Executive Vice President, Advanced Development

TABLE A-2-G (Continued)

INVESTIGATED ITS COMMUNICATIONS TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Hughes Transportation Management systems	RF Tags and Readers	RF tags and reader systems for ETC, deployed for Ontario Government's Highway 407 Project (North America's first completely electronic toll mad) and Advantage I-75/AVION weigh station by-pass project.	P.O. Box 3310 Fullerton, CA 92634 3310	714-446-2255	Philip Davy, Vice President, Marketing
Marconi Communications	RF Tags and Readers	RF Tags and Readers for ETTM Applications.	11800 Sunrise Valley Drive Tenth Floor Reston, VA 22091	703-620-0333	Richard T. J. Baker, Vice President, Business Development
Mark IV Industries, Ltd.	RF Tags and Readers	RF tags and readers for Electronic Toll and Traffic Management (ETTM) systems.	6020 Ambler Drive Mississauga, Ontario L4W 2PI	905-624-3025	Paul Manuel, Marketing Manager, IVHS Division
Nippondenso Co. Ltd.	Nippondenso Electronic Toll Collection System	Electronic Toll Collection Systems.	No. 16 Kowa Building l-9-20 Akasaka Minato-ku Tokyo 107 Japan	+81-566-25-6939	
Saab Systems, Inc. / Combitech Traffic systems Division	PREMID Non-stop Electronic Toll Collection system	Electronic Toll Collection Systems.	21300 Ridgetop Circle Sterling, VA 20166		
Syntonic	Developer of FASTOLL Electronic Toll Collection System	Electronic Toll Collection Systems.	10260 Campus Point Dr. MS-G2 San Diego, CA 92121-1522		
Texas Instruments	RF Tags and Readers	RF Tags and Readers for ETTM Applications			

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-3-A

INVESTIGATED ITS USER INTERFACE TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Driver Interface	Audio, visual, and tactile interface technologies appropriate for interaction with drivers during vehicle operation. Console displays (LED, LCD, etc.) heads-up displays and synthesized speech are primary examples of mature technologies. Technologies enabling voice input and non-distracting visual enhancement of the driver's view are less mature.		Mature with rapid innovation		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-contact**
Delco Electronics Corporation	Eyecue	A family of head-up display products for eyes-on-the-road viewing of vehicle information.	Mail Station CT 16A One Corporation Center Kokomo. IN 46904-9005	317-451-0657	Rob Leggat, Manager of Public Affairs
Systems Technology, Inc.	Driver/System Interface	Currently researching and developing driver/system interface technologies, concentmting on system functional characteristics and performance.	13766 Hawthorne Boulevard Hawthorne, CA 90250	310-679-2281	R. Wade Allen, President
Zexel USA (Corporation	Man-Machine Interface	Man-machine interface system of an easy-to-learn, simple to use navigation system.	37735 Enterprise Court Farmington Hills, Ml 48331	810-553-9930	Robert Borcherts, Vice President

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-3-B

INVESTIGATED ITS USER INTERFACE TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Traveler Interface	Same technologies as for driver interface with other, varied constraints. Extreme portability requirements restrict interface options for hand-held devices. Additional capabilities, including hard copy options, for fixed presentation devices.		Mature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
See Table 7-5-A INVESTIGATED ITS USER INTERFACE TECHNOLOGIES - Driver Interface					

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-3-C

INVESTIGATED ITS USER INTERFACE TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Operator Interface	Same as for Traveler Interface		Mature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
See Table 7-5-A INVESTIGATED ITS USER INTERFACE TECHNOLOGIES - Driver Interface					

This list should. not be considered all-inclusive and is not an endorsement of any product.

TABLE A-4-A

INVESTIGATED ITS CONTROL TECHNOLOGIES

FHWA Technology Area	Description		Maturity	Work Scope Technology Area	Project(s)
Signals	Control signals, barriers, or other physical control devices and supporting electronics.		Mature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-Contact**
BiTran Systems, Inc.	Ramp metering systems	Traffic control devices	510 Bercut Drive Suite R Sacramento, CA 95 184	916-441-0260	Jerry Bloodgood
MATRIX Corporation	Smart ATC	An advanced traffic controller and communications system that is scalable, modular, adaptive, and utilizes real-time technology which can, be deployed for a variety of applications, including adaptive intersection control, integrated corridor management, others.	1203 New Hope Road Raleigh, NC 27612	919-231-8000	Lisa Williams, Marketing and Communications Manager
Wapiti Micro systems Corp.	Ramp metering systems	Traffic control devices	5451 Mill Creek Road Prinvill, OR 97754	541-447-6448	Mike Daeges

This list should not be considered all- inclusive and is not an endorsement of by product.

TABLE A-4-B
INVESTIGATED ITS CONTROL TECHNOLOGIES

FHWA Technology Area	Description	Maturity	Work Scope Technology Area	Project(s)
Signs	Variable Message Signs including those which include interface to vehicle-roadside communications technologies enabling complementary in-vehicle displays.	Mature		

Vendor	Product	Description	Address	Telephone	Point-of-Contact
AGS Group / Amsign Corporation	VMS for Highway and Street Application Changeable Message Signs/Automated Blank Out Signs; Electronic Parking Systems (MNDOT, first in U.S.)	Design, manufacture, install and service LED variable message signing, information and message systems for American States and Municipalities.	749 New Ludlow Road P.O. Box 817 South Hadley, MA 01075	800-VMS-SIGN (800-867-7446)	Pierre Olivier Billy
Data Display, nc.	Permanent, Transit Stop, and Traffic Guidance VMS	Static message signs or beacons along roadways and at transit centers giving motorists andlor transit users real-time transit, parking, and other information.		516-98l-8384	
dark IV ndustries, Ltd.	VMS	VMS for traffic management applications.	6020 Ambler Drive Mississauga. Ontario L4W 2Pl	905-624-3025	Paul Manuel, Marketing Manager; IVHS Division
Minnesota Guidestar	Advanced Parking Information System	A "wayfinder" system consisting of 46 static and ten electronic signs that guide motorists to available parking.	Minnesota Department of Transportation Mail Stop 230 117 University Avenue St. Paul, MN 55155	612-282-5317	Samuel J. Boyd
Precision Solar Controls	Message Signs	Solar-powered message signs (Bashing beacons).	2915 National Court Garland, TX 75041	214-278-0553	Al Butler
Vultron, Inc.	VMS Products	Reflective Disk, LED, Fiber Optic, LED-dot, and Fiber-dot VMS systems and software; Lane Control Displays; Bridge, Tunnel, and Toll Booth Signage.	2600 Bond Street Rochester Hills, MI 48309	810-853-2200	Suzanne DuBois

This list should not be considered all-inclusive and is not an endorsement of any product.

TABLE A-4-C

INVESTIGATED ITS CONTROL TECHNOLOGIES

FHWA Technology Area	Description		Moturity	Work Scope Technology Area	Project(s)
Vehicle Control	**Vehicle control** system actuators and supporting processing technologies.		Immature		
Vendor	**Product**	**Description**	**Address**	**Telephone**	**Point-of-contact**
Calspan SRL Corporation	**Advanced** Vehicle Control and Safety Systems	Currently researching and developing (funded projects) advanced technologies for automated collision notification, automated highways, collision avoidance countermeasures, and commercial vehicle safety.	P.O. Box 400 Buffalo, NY 14225	716-631-6754	Edward A. Starosielec, Jr.
Mazda R&D North America	Vehicle Control Concepts	Currently researching and developing vision-based automatic vehicle control concepts.	22000 Gibraltar Road Flat Rock, MI 48134	313-782-7137	Tim Warner
Systems Technology, Inc.	Advanced Vehicle Control Systems	Currently researching and developing AVCS technologies.	I3766 Hawthorne Boulevard Hawthorne, CA 90250	310-679-22 81	R. Wade Allen, President
Toyota Motor Corporation	Advanced Vehicle Control and Safety Systems	Currently developing Advanced Vehicle Control and Safety Systems.	1, Toyota-cho Toyota-shi Aichi. 471	81-565-28-2121	Masami Konishi , Managing Director, Board Member

This list should not be considered ail-inclusive and is not an endorsement of any product.

TABLE A-5

ITS TECHNOLOGY PROVIDERS

	Company	Address	Telephone	Point-of-Contact
A	AGS Group/Amsign Corporation	749 New Ludlow Road P.O. Box 817 South Hadley, MA 01075	800-VMS-SIGN (800-867-7446)	Pierre Olivier Billy
	AMP, Inc. Piezo Film Sensors	P.O. Box 799 Valley Forge, PA 19482	61O-666-3500	Donald L. Halvorsen, Program Manager
	Amtech Systems Corporation	17304 Preston Road, E-100 Dallas, Texas 75252	214-733-6600	
	Andrew Corporation	10500 W. 153rd St. Orland Park, IL 60462	800-255-1479	
	AT&T	Suite 150 2343 Alexandria Drive Holmdel, NJ 07733-3030	908-949-2117	Sunil K. Tewarson, ITS Global Marketing Manager
	AT/Comm, Inc.	30 Doaks Lane Marblehead, MA 01945	617-631-1721	Tod Hannaway
B	B M W A G Information	P.O. Box 50-20-44 D-80972 Munich Germany		
	Burle Philips Communication & Security Systems (CSS), Ind.	1004 New Holland Ave. Lancaster, PA 17601-5606	800-326-3270	C.L. (Herk) Rintz, Manager
	Calspan SRL Corporation	P.O. Box 400 Buffalo, NY 14225	716-631-6754	Edward A. Starosielec, Jr.
	Cobra Electronics Corporation	6500 W. Cortland St. Chicago, Il. 60635	312-889-8870	John Pohl, VP, Marketing
	Cohu, Inc.	5755 Kearny Villa Road San Diego, CA 92123	619-277-6700	
	Control Technologies, Inc.	9015 Rhode Island Ave. College Park, MD 20740	301-513-5353	Warren Wayland
D	Data Display, Inc.		516-981-8384	

TABLE A-5 (Continued)

ITS TECHNOLOGY PROVIDERS

Company		Address	Telephone	Point-of-Contact
D	Delco Electronics Corporation (a subsidiary of Hughes Electronics Corporation)	Mail Station CT 16A One Corporation Center Kokomo, IN 469049005	317-451-0657	Rob Leggat, Manager of Public Affairs
E	Echelon Industries, Inc.	556 N. Diamond Bar Blvd.: Suite 202 Diamond Bar, CA 91765	909-861-3881	Ray Rebeiro
	Econolite Control Products, Inc.	3360 LaPalma Ave. Anaheim, CA 92806-2856	714-630-3700	
	Ecotek Technology Solutions	Seal Beach, CA		
	Electronic Integrated Systems, Inc. (EIS)	1401 Rockville Pike, Suite 500 Rockville, MD 20852	301-738-6900	
F	Fastoll Customer Service Center			
G	GEMPLUS Card International	656 Quince Orchard Road Suite 610 Gaithersburg, MD 20878	301-990-8800	Gilles Lisimaque, Executive Vice President, Advanced Development
	Geosystems	227 Granite Run Drive Lancaster, Pennsylvania 17601	717-293-7500	Perry Evans, VP Sales and Marketing
	Golden Screens America	60 E. 42nd Street, Suite 546 New York, NY 10165	212-983-5212	Neil Fink, Sales Rep.
H	Hughes Transportation Management Systems	P.O. Box 3310 Fullerton, CA 92634-3310	714-446-2255	Philip Davy, Vice President, Marketing
I	II Morrow, Inc. (A United Parcel Service Company)	2345 Turner Rd SE P.O. Box 13549 Salem, Oregon 97309	503-581-8101	
	Image Sensing Systems, Inc.	500 Spruce Tree Centre 1600 University Avenue West St. Paul, MN 55104	612-603-7700	Lisa Dumke, Director of Sales and Marketing

TABLE A-5 (Continued)

ITS TECHNOLOGY PROVIDERS

	Company	Address	Telephone	Point-of-Contact
I	Israel Aircraft Industries, Ltd.	TAMAM Division Electronics Group/OFEK Technologies, Ltd.	703-875-3777	
	Javelin Systems	324 Maple Ave. Torrance, CA 90503-2602	800-421-2716	Raymond Payne, Executive Vice President, Engineering
M	Marconi Communications	11800 Sunrise Valley Drive Tenth Floor Reston, VA 22091	703-620-0333	Richard T. J. Baker, Vice President, Business Development
	Mark IV Industries, Ltd.	6020 Ambler Drive Mississauga, Ontario L4W 2Pl	905-624-3025	Paul Manuel, Marketing Manager, IVHS Division
	Mazda R&D North America	22000 Gibraltar Road Flat Rock, MI 48134	313-782-7137	Tim Warner
	MATRIX Corporation	1203 New Hope Road Raleigh, NC 27612	919-231-8000	Lisa Williams, Marketing and Communications Manager
	Microwave Sensors, Inc.	7885 Jackson Road Ann Arbor, MI 48103	800-521-0418	Bob Hunter, Sales Manager
	Minnesota Guidestar	Minnesota Department of Transportation Mail Stop 230 117 University Avenue St. Paul, MN 55155	612-282-5317	Samuel J. Boyd
	Modulation Sciences, Inc.	12A World's Fair Drive Somerset, NJ 08873	800-826-2603	Judy Englert, Sales & Marketing
N	Nippondenso Co. Ltd. Electronic Toll Collection	No. 16 Kowa Building l-9-20 Akasaka Minato-ku Tokyo 107 Japan	+8l-566-25-6939	

TABLE A-5 (Continued)

ITS TECHNOLOGY PROVIDERS

	Company	Address	Telephone	Point-of-Contact
N	Northrop Grumman Corporation	Advanced Technology and Development Center 8900 E. Washington Blvd., MS: N560/XA Pico Rivera, CA 90660-3783	31O-942-5230	Richard Raiford, Manager, New Product Development
	NuMetrics	Box 518 University Drive Uniontown, PA 15401	412-438-8750	Barbara Kovell, Vice President/ Marketing
O	Odetics, Inc.	1585 South Manchester Ave. Anaheim, CA 92802-2907	714-758-0100	Mike Juha, Manager Marketing
	Orbital Sciences Corporation	20301 Century Boulevard, MS B-14 Germantown, MD 20874	30l-4286023	
P	PAT Traffic Control Corporation	1665 Orchard Drive Chambersburg, PA 17201	717-263-7655	Joseph R. Cal, Director of Sales and Marketing
	PEEK Traffic	1500 N. Washington Blvd. Sarasota, FL 34236	800-245-7660	TESCO Mark R. Robinson 703-548-5858
	Perceptics Corporation	725 Pellissippi Parkway Knoxville, TN 37932-3350	615-966-9200	Terry Gibson
	Precision Solar Controls	2915 National Court Garland, TX 75041	214-278-0553	Al Butler
R	Rafael	Rafael Dept. 4P Haifa POB 2250 Israel 31201	01l-972-4-879-2342	Eli Tamir
	Rockwell International Corp.	3370 Miraloma Avenue Anaheim, CA 92803	610-328-4040	General Highway Products, Inc. 500 C. Abbott Drive P.O. Box 596 Broomall, PA 19008 (6 10) 328-4040
S	Saab Systems, Inc. / Combitech Traffic Systems Division	21300 Ridgetop Circle Sterling, VA 20166		

TABLE A-5 (Continued)

ITS TECHNOLOGY PROVIDERS

	Company	Address	Telephone	Point-of-Contact
	Scientific-Atlanta, Inc.	3845 Pleasantdale Rd. Atlanta, GA 30243	404-903-2603	Contact: E. Scott Wood, Director of Communications
	Seiko Communications Systems, Inc.	1625 Amber Glen Ct., Suite 140 Beaverton, OR 97006	503-531-1530	Gary Gaskill
	Siemens ITS North America	2400 Executive Hills Drive Auburn Hills, MI 48326-29-80	810-253-1000	Ronald P. Knockeart, Vice President, ITS North America
S	Sirius Solutions, Ltd.	One Research Drive, Suite 215 Dartmouth, Nova Scotia B2Y 4M9 Canada	902-465-2328	
	Syntonic	10260 Campus Point Dr. MS-G2 San Diego, CA 92121-1522		
	Systems Technology, Inc.	13766 Hawthorne Boulevard Hawthorne, CA 90250	310-679-2281	R. Wade Allen, President
R	3M Traffic Control Systems	3M Safety and Security Systems Division 3M Center Building 225- 4N14 St. Paul, MN 55144-1000	612-736-2588	Peter Smith
	Texas Instruments			
	Toyota Motor Corporation	1, Toyota-cho Toyota-shi Aichi, 471	81-565-28-2121	Masami Konishi, Managing Director, Board Member
	VORAD Safety Systems, Inc.	10802 Willow Court San Diego, CA 92127	619-674-1450	Jerry Woll, Senior Vice President, Engineering
	Vultron, Inc.	2600 Bond Street Rochester Hills, MI 48309	810-853-2200	Suzanne DuBois
	Zexel USA Corporation	37735 Enterprise Court Farmington Hills, MI 48331	810-553-9930	Robert Borcherts, Vice President

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APPENDIX B
HISTORICAL TRAFFIC VOLUMES

City of Richmond, Virginia
Traffic Engineering

HISTORICAL TRAFFIC VOLUMES ON FREEWAY FACILITIES

FREEWAY LOCATION	CALENDAR YEAR					
	1990	1991	1992	1993	1994	1994 vs 1990
ROUTE I-64						
I-64 (Parham Rd. to West City Line)	90,000	104,000	107,000	113,000	120,000	33%
I-64 (West City Line to I-64 / I-95 WJCT)	108,950	128,000	130,000	135,000	143,000	31%
I-64 / I-95 (WJCT to I-64 / I-95 EJCT)	97,000	110,000	116,000	120,000	136,000	40%
I-64 / I-95 (EJCT o US 360)	88,250	85,000	86,000	83,000	85,000	-4%
I-64 (US 360 to VA 33)	66,570	76,000	79,000	81,000	83,000	25%
SUBTOTAL - (I-64)	450,770	503,000	518,000	532,000	567,000	26%
AVERAGE - (I-64)	90,154	100,600	103,600	106,400	113,400	26%
ROUTE I-95						
I-95 (US 1 to WJCT I-95 / I-64)	73,910	81,000	84,000	90,000	94,000	27%
I-95 / I-64 (WJCT to EJCT)	108,950	110,000	116,000	120,000	136,000	25%
I-95 (EJCT I-95 / I-64 to US 250)	91,780	90,000	93,000	97,000	115,000	25%
I-95 (US 250 to Maury St.)	84,000	83,000	86,000	90,000	106,000	26%
I-95 (Maury St. to VA 161 Bells Rd.)	78,750	74,000	78,000	80,000	92,000	17%
SUBTOTAL - (I-95)	437,390	438,000	457,000	477,000	543,000	24%
AVERAGE - (I-95)	87,478	87,600	91,400	95,400	108,600	24%
ROUTE I-195						
I-195 (I-64 / I-95 WJCT to US 250)	69,340	61,000	68,000	70,000	72,000	4%
I-195 (US 250 to Monument Av.)	70,690	74,000	75,000	78,000	79,000	12%
I-195 (Monument to VA 6 Patterson Av.)	75,650	81,000	85,000	88,000	88,000	16%
I-195 (VA 6 Patterson Av. to VA 147 Cary St.)	57,850	61,000	68,000	71,000	71,000	23%
I-195 (VA 147 Cary St. to McCloy St.)	34,750	28,000	31,000	37,000	37,000	6%
SUBTOTAL - (I-195)	308,280	305,000	327,000	344,000	347,000	13%
AVERAGE - (I-195)	61,656	61,000	65,400	68,800	69,400	13%
ROUTE VA 195 RMA DOWNTOWN EXPRESSWAY						
VA 195 RMA Expressway (I-95 to McCloy St.)	43,600	48,000	51,000	55,000	56,000	28%
SUBTOTAL - (VA 195)	43,600	48,000	51,000	55,000	56,000	28%
AVERAGE - (VA 195)	43,600	48,000	51,000	55,000	56,000	28%
ROUTE VA 76 POWHITE PARKWAY						
VA 76 (I-195 West side U of R Stadium to VA 150 Chippenham Py)	69,770	70,000	71,000	74,000	73,000	5%
VA 76 (Chippenham Py to Rt 686 Jahnke Rd.)	36,485	37,000	40,000	44,000	43,000	18%
VA 76 (Rt. 686 Jahnke Rd. to US 60 Midlothian)	29,280	34,000	36,000	41,000	40,000	37%
SUBTOTAL - (VA 76)	135,535	141,000	147,000	159,000	156,000	15%
AVERAGE - (VA 76)	45,178	47,000	49,000	53,000	52,000	15%
ROUTE VA 146						
Route VA 146 Connector (I-95 to VA 76 Powhite Py)	22,000	23,000	25,000	27,000	25,000	14%
SUBTOTAL - (VA 146)	22,000	23,000	25,000	27,000	25,000	14%
AVERAGE - (VA 146)	22,000	23,000	25,000	27,000	25,000	14%
GRAND TOTAL	1,397,575	1,458,000	1,525,000	1,594,000	1,694,000	21%
AVERAGE OF ALL FREEWAYS	232,929	243,000	254,167	265,667	282,333	21%

NOTE : The Grand Total includes the common link of I 64 / I 95 under both the I-64 corridor and the I-95 corridor. Accordingly, some groups may wish to subtract one set of numbers for the volumes on the common link of I-64 / I-95 between the WJCT and EJCT.

TE : 10/27/95
File : FRWYVOL.XLS

APPENDIX C
ACCIDENT DATA

TABLE C-l

MOTOTR VEHICLE ACCIDENT DATA IN THE TRI-CITIES AREA

Local Jurisdiction	1993			1994			1995			Total		
	Crashes	Fatalities	Injuries	Crashes	Fatalities	Injuries	Crashes	Fatalities	Injuries	Crashes	Fatalities	Injuries
Town of Ashland	59	0	38	89	0	47	94	0	44	242	0	129
City of Colonial Heights	305	3	211	379	0	266	340	1	241	1024	4	718
City of Hopewell	407	2	231	424	0	287	424	1	324	1255	3	842
City of Petersburg	724	4	657	735	8	626	916	4	739	2375	16	2022
City of Richmond	6095	20	3948	6555	12	4029	6604	10	4109	19254	42	12086
County of Charles City	96	5	84	87	6	78	108	5	83	291	16	245
County of Chesterield	3905	6	2304	4396	18	2590	4240	12	2522	12541	36	7416
County of Dinwiddie	354	3	284	367	9	310	442	14	376	1163	26	970
County of Goochland	286	7	238	331	2	243	338	5	273	955	14	754
County of Hanover	1178	13	735	1334	20	839	1437	11	1063	3949	44	2637
County of Henrico	3951	21	2641	4412	22	2764	4437	28	2890	12800	71	8295
County of New Kent	328	5	240	277	4	194	326	4	257	931	13	691
County of Powhatan	193	4	139	204	2	144	228	5	191	625	11	474
County of Prince George	441	7	412	434	13	395	453	9	434	1328	29	1241
Total	18,322	100	12,162	20,024	116	12,812	20,387	109	13,546	58,733	325	38,520

APPENDIX D
PROJECT COSTS

PROJECT: Establish the TEOC as the Centralized Information Manager

COSTS OF SIMILAR SYSTEMS

Location	Type of Organizations to which Traffic information is Provided	Number of Personnel	Days and Hours of Operation	Annual Operating and Maintenance Budget
1. Monitor Traffic Operations Center, Milwaukee County, WI	Radio traffic reporters, traffic information service, TV station	4 traffic engineers; 1 traffic technician; 2 dispatchers; 2 electronic/computer engineers; 1 office manager	5am-7pm, M-F	$1 Million
2. Traffic Systems Management Center, Seattle, WA	Traffic operators (radio); TV stations; state patrol; metro transit; large businesses	9 traffic engineers; 3 traffic technicians; 12 dispatchers / systems operations specialists; 2 programmer specialists	6 am to 7 pm M-F; 9 am to 6 pm Sat &Sun Radio/Tunnel operations 24 hrs/day, 7 days/week	$1.3 Million (for center only)
3. Bridgeport Operations Center, Bridgeport, CT	State police; Newington operations; State of CT Maintenance; Smartroutes	2 traffic engineers; 1 project manager; 1 operation supervisor; 8 full-time operators; 3 part-time operators	24 hours/day; 7 days/week	$1 Million
4. Traffic Systems Center, Oak Park, IL	Media (TV and radio); police; tollway authority; transit agencies; universities; other state agencies	2 traffic engineers; 3 traffic technicians; 4 electrical technicians; 2 electrical engineers; 2 computer engineers; 1 secretary	operates 24 hours daily but only staffed 5am-7pm, M-F	$1 Million
5. Anaheim Traffic Management Center, Anaheim, CA	State; Police; Media	2 traffic engineers; 2 interns	7 am to 5:30 pm, M-F (plus events)	$1 Million
2. Irvine Traffic Research and Control Center (ITRAC), Irvine, CA	N/A	3 traffic engineers; 6 traffic technicians	7 am to 6 pm, M-F	$1 .5 Million
7. San Francisco Bay Area Interim TMC (California Coastal Region), Oakland, CA	Media--TV and radio	2 traffic engineers; 6 traffic technicians; 6 CHP/Media Info. Officers	24 hours/day, 7 days/week	$1 .4 Million

Source: *Transporratron Management centers,* The Urban Transportation Monitor, Sept. 15, 1995, pp. 9-l 1 and Sept. 29, 1995, pp. 7-l 1

PROJECT: Develop System for Exchanging Data Among Local Agencies	
ASSOCIATED COSTS	
Technology	Average Unit Cost
Electronic Bulletin Board System Software (BBS)	$21,500

PROJECT: Install Incident Detection System

Installation Costs for Microwave Detection

Item	Standard Unit Price
Sensor Unit	$3,500.00 EA
Adaptor Cable	$200.00 EA
Test Box	$200.00 EA
Detector In-Lead Cable	$1.50 LF
2" Conduit	$13.00 LF
Riser	$300.00 EA
20" Pull Box	$500.00 EA
Software	N/A

Installation Costs for Acoustic Detection

Item	Standard Unit Price
Sensor Assembly	$1,500.00 EA
Controller Card Assembly	$700.00 EA
Transition Module Assembly	$100.00 EA
Cables and Hardware	$1.50 LF
2" Conduit	$13.00 LF
Riser	$300.00 EA
20" Pullbox	$500.00 EA

Installation Costs for External Video Image Detection

Item	Standard Unit Price	
	Tracking	Tripline
Video Detector	$24,000.00 EA	$28,000.00 EA
Software	No Charge	$800.00 LS
Camera Package	$1,200.00 EA	$2,700.00 EA
Cables & Package	$2,500.00 EA	$200.00 EA
2" Conduit	$13.00 LF	$13.00 LF
Riser	$300.00 EA	$300.00 EA
20" Pullbox	$500.00 EA	$500.00 EA

Installation Costs for Integral Video Image Detection

Item	Standard Unit Price
	Tracking
Video Detector	$3,800.00 EA
Software	No Charge
Cables & Hardware	$1.50 LF
2" Conduit	$13.00 LF
Riser	$300.00 EA
20" Pullbox	$500.00 EA

Installation Costs for Inductive Loops

Item	Standard Unit Price
Loop	$465.00 EA
20" Junction Box	$500.00 EA
2" Conduit	$12.50 LF
2 Conductor #12	$1.45 LF
2 Channel Loop Detector Amplifier	$250.00 EA

Installation Costs for Magnetometers

Item	Standard Unit Price
Probe	$110.00 EA
20" Junction Box	$500.00 EA
2" Conduit	$12.50 LF
Lead-In Cable	$0.37 LF
2 Channel Digital Detector Amplifier	$500.00 EA

PROJECT: Develop and Implement Coordinated HAR and VMS Systems	
Associated Costs	
Technology	**Average Unit Cost**
HAR Field Equipment - Digital Recorder	$3,000
HAR Field Equipment - Ground System	$1,000
HAR Field Equipment - HAR Antenna	$750
HAR Field Equipment - HAR Assembly	$66,800
HAR Field Equipment - HAR Control Cabinet	$3,000
HAR Field Equipment - HAR Sign Assembly	$19,000
HAR Field Equipment - HAR Transmitter	$4,200
HAR Field Equipment - HAR Transmitter Assembly	$142,350
HAR Field Equipment - Monitoring Receivers	$200
HAR Software	$100,000
VMS - Installation on New Structure	$28,000
VMS - Install Sign on Existing Bridge Structure	$56,000
VMS - Installation on Existing Structure	$5,000
VMS - LED Controller and Software	$1,500
VMS - LED Sign and Controller (6 units)	$227,000
VMS - LED Sign Matrix and Housing	$95,000
VMS - Portable	$20,925
VMS - Portable Flip Disk	$24,013
VMS - Portable Solar Powered	$50,000
VMS - Cantilever Sign Support Structure	$60,000
VMS - Cantilever Foundation	$7,630
VMS - Support Structure	$12,500
VMS - Central Software	$30,500
VMS - Controller Software	$60,000
VMS - Software	$65,000
VMS - Computer	$6,200

Note: The prices in this list may not reflect the true cost of an item, nor do they guarantee what contractors will bid on different projects in different regions of the country.

PROJECT: Develop Region-Wide or Statewide Standard for Electronic Toll Collection

ASSOCIATED COSTS

Lane Type versus Lane Equipment

Lane Type	Lane Equipment (Cost per Lane)*
Manual	$58,500
Automatic	$58,000
Manual / Automatic	$107,500
Manual / ETC	$72,000
Automatic / ETC	$69,500
Manual / Automatic / ETC	$121,300
ETC Dedicated	$15,400
Express ETC	$15,400

*These numbers do not include plaza or host computer equipment.

Lane Type versus Operating and Maintenance Costs

Lane Type	Operating & Maintenance (Cost per Lane)
Manual	$141,900
Automatic	$43,300
Manual / Automatic*	$111,000
Manual / ETC	$146,100
Automatic / ETC	$47,500
Manual / Automatic / ETC	$115,200
ETC Dedicated	$4,200
Express ETC	$4,200

*Based on operation of 16 hours manual and 8 hours automatic coin machine.
Note: These numbers do not include plaza or host computer equipment.

Source: *Electronic Toll Collection Systems*, Center for Transportation Research, Bureau of Engineering Research, The University of Texas at Austin, May 1995

Equipment per Lane Type

Equipment	Lane Type		
	Manual	Automatic	Dedicated ETC
Lane Controller	✓		
Toll Terminal	✓		
Receipt Printer	✓		
Slot Reader	✓		
Patron Fare Display	✓		
Loop Detectors	✓	✓	✓
Automatic Vehicle Classifier	✓		
Canopy Signal Light	✓	✓	✓
Toll Booth	✓		
Contact Treadles	✓	✓	
Automatic Coin Machine		✓	
Exit Gate		✓	
Island Traffic Signal		✓	✓
ETC Reader			✓
ETC Reader/Controller			✓
CCTV Violation Camera			✓

PROJECT: Provide Real-Time Transit Schedule/Location Information						
ASSOCIATED COSTS						
Computer-Aided Dispatch Systems	Automated Passenger Counts	AVL Systems - Signpost-based	AVL Systems - GPS-based	Radio Comm. - Trunked	Radio Comm. - Digital	Electronic Fare Payment Systems
Average: $2,300 per vehicle Range: $600-$7,500 per vehicle	Average: $9,000 per vehicle Range: $4,000-$15,000 per vehicle	Average: $10,100 per vehicle Range: $4,000-$15,000 per vehicle	Less than 150 vehicles: Average: $6,200 per vehicle Range: $$3,800-$9,300 per vehicle Greater than 150 vehicles: Average: $16, 400 per vehicle ange: $6,700-$28,000 per vehicle	Average: $3,500 per vehicle Range: $1,100-$7,700 per vehicle	Average: $2,400 per vehicle Range: $300-$4,500 per vehicle	Magnetic Stripe - Swipe Average: $2,800 per vehicle Range: $1,100-$4,000 per vehicle Magnetic Stripe - Insertion $9,500 per vehicle Smart Card - Contactless $5,500 per vehicle

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ACRONYMS

AAA	American Automobile Association
ADA	Americans With Disabilities Act
ADR	Automatic Data Recorder
AICP	American Institute of Certified Planners
AM	Amplitude Modulation
APTS	Advanced Public Transportation System
ATC	Advanced Traffic Controller
ATIS	Advanced Traveler Information System
ATM	Asynchronous Transfer Mode
ATMS	Advanced Traffic Management System
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
AVSS	Advanced Vehicle Safety Systems
BCS	Bridge Control System
CAD	Computer Aided Dispatch
CBD	Central Business District
CCTV	Closed Circuit Television
CDPD	Cellular Digital Packet Data
CMAQ	Congestion Mitigation and Air Quality
CMS	Congestion Management System
COG	Council of Governments
CPDC	Crater Planning District Commission
CTPP	Census Transportation Planning Package
CVO	Commercial Vehicle Operations
DEQ	Department of Environmental Quality
DGPS	Differential Global Positioning System
DGSC	Defense General Supply Center
DMV	Department of Motor Vehicles
DSRC	Dedicated Short Range Communications
EIS	Emergency Information System
EM	Emergency Management
ETC	Electronic Toll Collection
ETTM	Electronic Toll and Traffic Management
FHWA	Federal Highway Administration
FM	Frequency Modulation
FRH	Frederic R. Harris, Inc.
GIS	Geographic Information System
GPS	Global Positioning System

GRTC	Greater Richmond Transit Company
HAR	Highway Advisory Radio
HAZMAT	Hazardous Material
HOV	High Occupancy Vehicle
IC	Integrated Circuit
ICS	Incident Command System
IDOT	Illinois Department of Transportation
IEN	Information Exchange Network
IP	Internet Protocol
IR	Infrared Red
ISDN	Integrated Services Digital Network
ISP	Information Service Provider
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
IT1	Intelligent Transportation Infrastructure
ITS	Intelligent Transportation System
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LOS	Level of Service
MBTA	Massachusetts Bridge and Tunnel Authority
MNDOT	Minnesota Department of Transportation
MOE	Measure Of Effectiveness
MPO	Metropolitan Planning Organization
MS	Microsoft ™
NHS	National Highway System
NPP	National ITS Program Plan
NTCIP	National Transportation Communications for ITS Protocol
PAT	Petersburg Area Transit Authority
PC	Personal Computer
PCS	Personal Communication Services
PDC	Planning District Commission
PDN	Public Data Network
PE	Professional Engineer
RF	Radio Frequency
RMA	Richmond Metropolitan Authority
RRPDC	Richmond Regional Planning District Commission
PSDN	Packet-Switched Data Network
RWIS	Runway Weather Information Systems
SCOOT	Split, Cycle, Offset Optimization Technique
S D H	Synchronous Digital Hierarchy
SIM	Statewide Incident Management
SONET	Synchronous Optical Network
STAR	Specialized Transportation Assistance for Richmond

TEOC	Transportation Emergency Operations Center
TICC	Transportation Information Coordination Center
TIP	Transportation Improvement Program
TMA	Transportation Management Associations
TM	Traffic Management
TMC	Traffic Management Center
TMS	Traffic Management System
TOC	Traffic Operations Center
T T I	Traffic Technology International
TV	Television
USDOT	United States Department of Transportation
VCIS	Virginia Criminal Information System
V D E Q	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VID	Video Image Detection
VMS	Variable Message Sign
VOIS	Virginia Operational Information System
VRC	Vehicle-Roadside Communication
VSP	Virginia State Police
VTDS	Video Traffic Detection System
WAN	Wide Area Network
WIM	Weigh-In-Motion