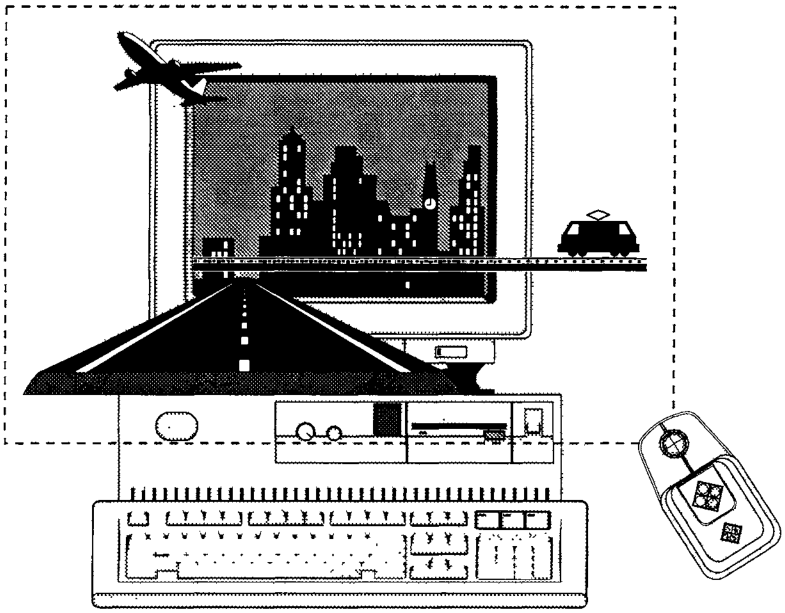
FINAL REPORT

PLANNING FOR INTELLIGENT TRANSPORTATION SYSTEMS IN SMALL URBAN AREAS



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Abstract

Intelligent transportation systems (ITS) has been a primary program focus of the U.S. DOT since its origination in ISTEA. The federal ITS program funded early deployment planning studies for the 75 largest metropolitan areas, where significant congestion and pollution problems and the size and complexity of the transportation systems presented the greatest need for operational improvements.

Recent ITS benefit studies have shown that a number of ITS technologies can have a significant effect on increasing the efficiency and safety of a region's transportation system. Now that the federal ITS program is mature, and benefits have been realized, the transportation system outside large U.S. urban areas is beginning to look toward information and communication technologies to address transportation goals. The federal government recently initiated a rural ITS program, ARTS. However, no specific program has focused on the needs of small urban areas, where 16.5% of the U.S. population lives.

The study considers how ITS planning can aid small urban areas in determining appropriate ITS solutions for their transportation networks. This was accomplished through a case study of the Charlottesville region. Based on the findings, a number of recommendations for how best to plan for ITS in small urban areas in Virginia and other areas were made. These include using the FHWA's *ITS Planning Process, Version 2.1* for small urban area ITS studies and suggesting that VDOT incorporate the method in its planning for small urban areas. Other recommendations include using an additional market package screen for the ITS Planning Process and calling for the federal ITS program to fund planning studies in small U.S. urban areas.

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ABSTRACT

Intelligent transportation systems (ITS) has been a primary program focus of the U.S. Department of Transportation since its origination in the Intermodal Surface Transportation Efficiency Act of 1991. The federal ITS program funded early deployment planning studies for the 75 largest metropolitan areas, where significant congestion and pollution problems, as well as the size and complexity of the transportation systems, presented the greatest need for operational improvements.

Recent ITS benefit studies have shown that a number of ITS technologies can have a significant effect on increasing the efficiency and safety of a region's transportation system. Now that the federal ITS program is mature, and benefits have been realized, the transportation system outside large urban areas in the United States is beginning to look toward information and communication technologies to address transportation goals. The federal government has recently initiated a rural ITS program, ARTS, to deploy ITS in rural areas. However, no specific program has focused on the needs of small urban areas, where 16.5 percent of the U.S. population lives.

This study considers how ITS planning can aid small urban areas in determining appropriate ITS solutions for their transportation networks. This was accomplished through a case study of the Charlottesville, Virginia, region. Based on the findings, a number of recommendations for how best to plan for ITS in small urban areas in Virginia and other areas were made. These results include recommending the use of the Federal Highway Administration's *ITS Planning Process, Version 2.1* for small urban area ITS studies and suggesting that the Virginia Department of Transportation incorporate the method in its planning for small urban areas. Other recommendations include using an additional market package screen for the *ITS Planning Process* and calling for the federal ITS program to fund planning studies in small urban areas throughout the United States.

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INTRODUCTION

Intelligent transportation systems (ITS) is the term for information and communication technologies that can be used to increase the efficient operation and safety of a transportation system. Originally known as Intelligent Vehicle-Highway Systems (IVHS), ITS has existed officially since the 1991 passage of the Intermodal Surface Transportation Efficiency Act (ISTEA). The federal government has put a great deal of effort and funding into initiating the ITS program, including funding for preliminary planning studies in the nation's largest 75 metropolitan areas. The Federal Highway Administration (FHWA) set up the IVHS Early Deployment Planning program in 1992 to accomplish this. In Virginia, ITS planning studies have been undertaken in three major metropolitan areas—Hampton Roads, Northern Virginia, and Richmond. The Virginia Department of Transportation (VDOT) is interested in deploying ITS in other areas of the state.

The focus of the ITS program at the federal level has been on the largest metropolitan areas (those with the highest perceived need for ITS-related capacity and pollution-reduction measures) and rural areas, where a separate program has been set up—the Advanced Rural Transportation Systems (ARTS). The needs of small urban areas, however, have not been directly addressed by the federal ITS program. Given that 16.5 percent of the U.S. population lives in small urban areas, an ITS program to help enhance these portions of the transportation system and connect with the urban and rural ITS programs appears warranted.[1]

ITS Planning

The federal ITS planning process was first introduced in April 1993. Version 1.0 was used in most of the studies that were part of the Early Deployment Planning Program (i.e., large urban areas). Revisions of the process have led to the current *ITS Planning Process, Version 2.1.*

This version incorporates the national *ITS Architecture* that was completed in 1996. Version 2.1 uses the concept of market packages (a collection of equipment capabilities that satisfy a market need and are likely to be deployed as a group) to help screen the variety of ITS technologies available for use.[2] The steps of the planning process are depicted in Figure 1.

Small Urban Areas

A small urban area (as opposed to a large urban area), for the purposes of this study, has a population between 50,000 (the high cutoff point for a rural area) and 450,000 (the low threshold of the 75 largest urban areas). Certain other characteristics describe a small urban area, including its development history and physical pattern (e.g., grid vs. suburban), the scale of development, the growth rate (e.g., vehicle miles traveled, development, population), and the transportation system characteristics (e.g., size of transit systems, number of freeways).

Based on 1990 U.S. Census figures, using population alone, this description of small urban areas accounts for approximately 205 small urban areas (of 284) in the United States.[1] The typical small U.S. urban area is experiencing growth, especially in terms of development, population, and expansion of the transportation system. The ways small areas cope with growth affect everything from the number of roads built to the density of development. These, in turn, affect everything from the potential of a transit system to the viability of walking or riding bicycles safely as an alternative to using an automobile.

To better understand the scope of areas included in this definition of small urban areas, Table 1 presents characteristics of a number of small urban areas chosen to represent the range of populations. These characteristics demonstrate some of the unique qualities of each of the small urban areas. However, the data show that although all small urban areas do not share the same characteristics, the amount they vary from the U.S. average is usually not that great.

Table 1. Small Urban Area Comparison

Central City of Small Urban Area/ Metropolitan Statistical Area (*)	1990 Population (for MSA)	Median Family Income ($)	High School Graduate/ Bachelor Degree (%)	Commute to Work: Drive Alone/ Transit (%)	Average Number of Vehicles per Household
Enid, OK	56,735	28,090	75.8/17.8	81.3/0.5	1.6
Owensboro, KY	87,189	27,892	71.8/15.3	81.1/0.5	1.5
Abilene, TX	119,655	29,373	76.0/22.0	80.9/0.6	1.7
Charlottesville, VA	131,107	33,729	75.5/34.1	60.8/6.0	1.5
Erie, PA	275,572	27,725	72.3/14.0	68.7/3.9	1.2
Colorado Springs, CO	397,014	34,113	87.8/27.5	77.9/1.3	1.7
U.S. Average	n/a	35,225	75.2/20.3	73.2/5.3	1.7

Source: *County and City Data Book 1994*, U.S. Department of Commerce.[1]
*All data are for central cities, except population, for the entire Metropolitan Statistical Area (MSA).

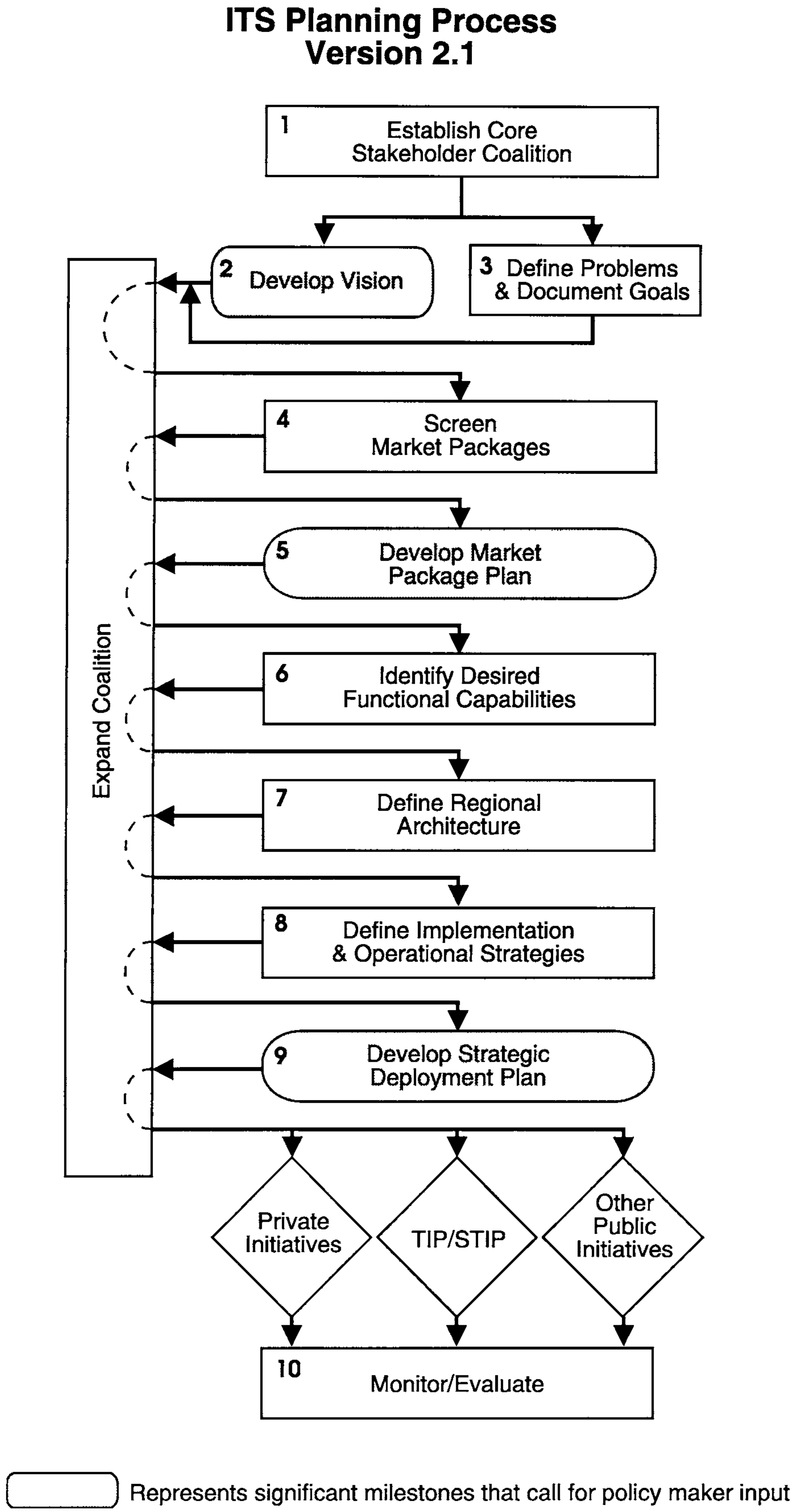

Figure 1. ITS Planning Process, Version 2.1

BACKGROUND

Three elements gave rise to this study. The first was an interest expressed within VDOT for investigating the possibility of using ITS technologies in Virginia's small urban areas. The second was an interest expressed by Charlottesville, Virginia, area planners in using ITS in the region to help improve the transportation system. These two elements gave rise to the Jefferson Area ITS Planning Study. The third element was the recent work done by researchers at the Virginia Transportation Research Council (VTRC) on the FHWA's *ITS Planning Process*. The team had recently co-authored the latest version of the process, Version 2.1, and was eager to test it by applying it in a planning study. VDOT asked the team to undertake the planning study for the Jefferson Area, providing a testing opportunity. The study team decided to focus on how planning for ITS differs in small urban areas as its research question for its report to VDOT. (The team produced separate reports for the Jefferson Area ITS Planning Study.)

PURPOSE AND SCOPE

The primary purpose of this project was to investigate how to plan for ITS in small urban areas. VDOT's desire to see how ITS can be used in Virginia's small urban areas and the lack of specific recommendations or goals in the federal government's ITS program for planning for ITS in small urban areas provided the motivation for this effort. A review of the federal ITS program and a case study of a small urban area ITS planning study were the two primary means of examining this topic. Another important purpose of this study was to test the latest version of the FHWA's *ITS Planning Process, Version 2.1*.

The scope of the project comprises a case study of a small urban area ITS planning initiative. The subject of the case study is the Jefferson Area ITS Planning Study, incorporating the Charlottesville, Virginia, region. The Jefferson Area is a grouping of primarily rural counties with a small metropolitan area of more than 130,000 people at its core. The city and parts of Albemarle County are urbanized, whereas the rest of the area is composed of rural land and small towns.

As was demonstrated in Table 1, the Charlottesville area has unique characteristics for a small urban area. A larger than average portion of the population holds bachelor degrees and uses public transportation to commute to work. In Albemarle County, the other portion of the Charlottesville Metropolitan Statistical Area (MSA), the median family income is very high ($42,661) and the average number of vehicles per household is high (1.9).[1] And, according to the Thomas Jefferson Planning District Commission (TJPDC), the Jefferson Area boasts a higher than average level of computer literacy, home computer ownership, and access to the Internet.[3] However, each small urban area represented in Table 1 has unique characteristics that vary from the U.S. averages in some categories. This makes the Jefferson Area as good an example of a small urban area as any other in the United States.

The Jefferson Area is composed of jurisdictions that are members of the TJPDC, including the City of Charlottesville and the counties of Albemarle, Nelson, Fluvanna, Louisa, and Greene. For the purposes of the ITS planning study, Madison and Orange Counties were included in the Jefferson Area. Figure 2 depicts the Jefferson Area.

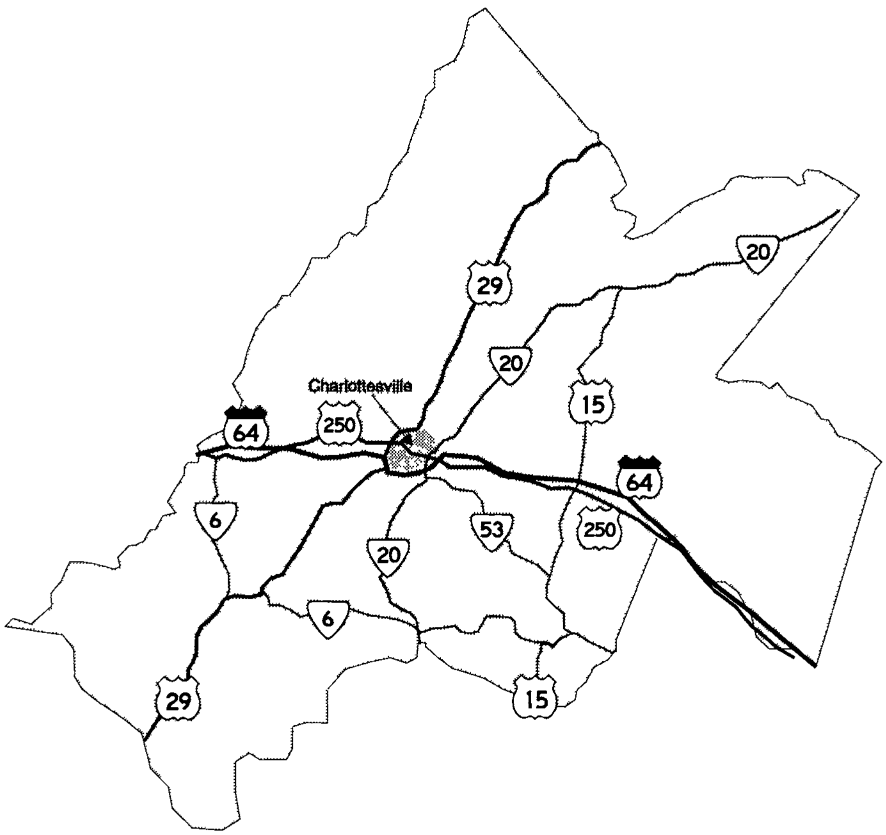

Figure 2. The Jefferson Area

The area's transportation system includes a road network made up of an interstate (I-64); a number of primary highways, including Routes 29, 250, 20, 15, and 6; and an urban road system in and around the city of Charlottesville. In addition, both the CSX Corporation and Norfolk Southern operate freight rail lines in the area, and Amtrak has a passenger station in Charlottesville. The Charlottesville-Albemarle Airport serves the Jefferson Area with numerous daily flights to destinations in the mid-Atlantic region. A number of transit systems serve the Jefferson Area, including the following: (1) the Charlottesville Transit Service (CTS), a fixed-route transit system serving Charlottesville and parts of Albemarle County; (2) the University Transit Service (UTS), another fixed-route service serving the faculty, staff, and students of the University of Virginia; (3) JAUNT, a paratransit service providing trips throughout the Jefferson Area; and (4) Greene County Transit, another paratransit service serving Greene County residents.

The Jefferson Area has had a bit of history with ITS. One of the region's paratransit services, JAUNT, was set to take a federal grant to operate a real-time rideshare program (based on ITS technologies) in 1994. However, because of local concerns over the ability of JAUNT to incorporate the operation of such a large program, the grant was not accepted. However, local officials remained eager to pursue ITS solutions to help reduce the number of single-occupancy vehicle (SOV) trips in the area while providing quality transportation service.

The major issues regarding the transportation system in the Jefferson Area, as identified in discussions with area officials prior to the start of the planning study, included reducing SOV trips and enhancing alternative modes of transportation. Major emphasis is placed on these issues in the various transportation plans for the region. A brief discussion of each issue follows.

1. Reducing SOV trips. This is desired for a variety of environmental, pollution, sustainability, congestion, and other reasons. The SOV trips in the region are one facet of growth the region's leaders would like to slow. Reducing these trips will help calm the need for more roads and more lanes on existing roads. Greater use of alternative modes would also reduce SOV trips.

2. Enhancing alternative modes. The area is very interested in improving the services provided by transit and paratransit services as well as introducing more bicycle paths and pedestrian walkways. The goal is to help reduce SOV trips by offering reasonable options for the region's citizens.

METHODOLOGY

Literature Review

The literature review concerned the federal ITS program. Its history and primary program focus were documented. The National ITS Program Plan, National ITS Architecture, and various versions of the *ITS Planning Process* were reviewed, with an eye toward seeing how they might or might not help in planning for ITS in small urban areas. We also looked at the results of a large urban area ITS planning study (the Hampton Roads Early Deployment Planning Study). This information was compared with the results of the small urban area case study.

Case Study

The case study was based on the experiences and results of the Jefferson Area ITS Planning Study. This task involved reporting the results of the planning study, focusing first on elements that are unique to small urban areas and then on the application of the *ITS Planning Process, Version 2.1.* The major steps of the planning process were used to organize the discussion:

1. Organize the study.

2. Develop a vision, and gather problems and goals.

3. Screen the ITS market packages.

4. Create market package plan.

5. Determine functional capabilities.

6. Develop a regional architecture.

7. Define operational and implementation elements.

8. Create a strategic deployment plan.

RESULTS

Literature Review

Transportation planning "has been reactive, for the most part, attempting to increase or maintain mobility and travel safety in the face of rapid population growth."[4] The objectives of ITS are identical with those of the traditional transportation planning method—to increase the operational efficiency and safety of U.S. highway and transit systems. However, the major difference is that ITS application was being accomplished through technology application to the operational side of transportation systems, rather than through changes to the physical infrastructure, the focus of the traditional planning process.

The Federal ITS Program

ITS, as a descriptive term and federal program, did not exist prior to 1991. In that year, ISTEA was passed by Congress, which included the creation of an IVHS program. Although the name was changed to ITS, the goals set up for the program in this legislation have guided the development of ITS planning, research, and deployment.

In 1992, the FHWA initiated the ITS Early Deployment Planning Program, which authorized the funding of planning studies as a means of stepping up efforts to utilize ITS technologies to improve regional transportation systems. A number of documents have been released by the federal government explaining its program goals for helping initiate ITS throughout the United States. The first of these was the *National ITS Program Plan*, based on the requirements outlined in the ISTEA legislation.

ISTEA and the National ITS Program Plan

ISTEA calls for "the promotion of compatible standards and protocols to promote widespread use of IVHS technologies, the establishment of evaluation guidelines for IVHS operational tests, and the establishment of an information clearinghouse."[5] This language emphasizes design and planning, rather than construction or eventual deployment of ITS. The legislation also stated that planning grants would be available to state and local governments for studying the feasibility for developing and implementing ITS.[5] The *National ITS Program Plan* outlined how the U.S. Department of Transportation (U.S. DOT) proposed to tackle these legislative requirements.

ISTEA authorized more than $600 million for the federal ITS program over 6 years. Including other funds, the total ITS funding through FY 1995 was $787.3 million. Of this total, $26.2 million went to deployment planning through the Early Deployment Planning Program. It was anticipated that 75 early deployment planning projects would be initiated or in place by 1996.[6]

IVHS Planning and Project Deployment Process

In April 1993, the FHWA released the *IVHS Planning and Project Deployment Process, Version 1.0.* The document provided a planning process intended to "serve as a tool for organizations to systematically plan for, and implement, IVHS technologies as part of an integrated transportation system."[7] More specifically, the final product of the planning process, the Strategic Deployment Plan, "will identify various projects incorporating IVHS applications, their phasing, priorities, costs, and how they help meet previously set goals and objectives."[7]

Version 1.0 of this planning process categorizes ITS technologies as "user services." The "users" include car drivers and transit riders, and "services" include such items as trip planning or traffic control. The focus of the process is on providing services that the users of the transportation system need, not "what new technologies can be incorporated into the system."[7] This planning process has been revised twice since its introduction. The latest version, 2.1, is discussed later in the literature review.

National ITS Architecture

After releasing the *National ITS Program Plan* in 1994, the next significant step for the federal government was to help move ITS in the direction of standardization. *Standardization* refers to the creation of sets of standards for the various ITS technologies and subsystem interfaces that allows ITS projects to be simplified and work well together. The national *ITS Architecture* documents—a large collection of information providing a common structure for the design of intelligent transportation systems throughout the nation—were released in June 1996. Further elucidation of the goals for the federal ITS program was included in these documents:

1. Increase operational efficiency and capacity of the transportation system.

2. Enhance personal mobility and the convenience and comfort of the transportation system.

3. Improve the safety of the nation's transportation system.

4. Reduce energy consumption and environmental costs.

5. Enhance the present and future economic productivity of individuals, organizations, and the economy as a whole.

6. Create an environment in which the development and deployment of ITS can flourish.[8]

The national architecture's *Implementation Strategy* document includes guidance on planning for ITS, using information from FHWA's *Interim Handbook on ITS Planning*. This interim handbook includes Version 2.1 of the *ITS Planning Process*. Version 2.1 takes into account the national *ITS Architecture* and includes enhancements to better integrate ITS planning with the traditional transportation planning process. An interesting statement is made in this document: "The ITS Planning Process explicitly recognizes that ITS is not the only means of mitigating transportation problems, nor is it cost-effective for all regions and for all problems."[2] Stating the fact that ITS is not "cost-effective" for all regions and all problems is a good way to reduce expectations, but there is no accompanying explanation of why this is the case. This also demonstrates that the federal ITS program has not focused on all areas of the United States.

ITS Planning Process, Version 2.1

The most recent version of the original *IVHS Planning and Project Deployment Process* was created through two studies. One was an evaluation of the original process that resulted in a revised process, Version 2.0, and the other was a part of a larger study looking at ITS planning and how to incorporate it into the regular transportation planning process. The results of these two federally funded studies were combined in the *ITS Planning Process, Version 2.1.* (Smith and Taylor were co-authors of the first study.)

The focus of the planning process changed somewhat from Version 1.0. Whereas Version 1.0 was more oriented toward inventories, providing "user services," and creating projects, the "objective of the revised *ITS Planning Process* is to provide guidance for developing action-oriented plans that lead directly to the deployment of integrated ITS."[9] The "user services" were replaced by 52 market packages, as defined in the national *ITS Architecture*. An ITS market package is a "collection of equipment capabilities that satisfy a market need and are likely to be deployed as a group."[2] The revised process focuses on education, local input, and a detailed implementation plan for the ITS projects chosen for the region.

The new version of the planning process is, like Version 1.0, based on systems analysis and takes an iterative, top-down approach. The process is meant to be used in regional planning studies to help determine the most appropriate ITS technologies for use in enhancing the region's transportation system. It is a flexible process in that the steps are provided for guidance, but it does not require an exact sequence of steps to deliver a useful, implementable plan. Finally, it incorporates the national *ITS Architecture*, providing compatibility with other systems and a framework for ITS project integration. (See Figure 1 for a diagram of the steps of the planning process.)

ITS in Urban Areas

It can be seen that a primary focus of the federal ITS program since its inception in 1992 has been using ITS as a way to help solve congestion and air quality problems in large urban areas. This focus is due primarily to the fact that urban areas represent a very large portion of vehicle miles traveled in the United States and an equally large portion of transportation funding. The Intelligent Transportation Infrastructure elements, which were introduced to help guide initial ITS deployment in regions, include the following elements that focus on urban areas:

1. *Traffic Signal Control Systems.* Obviously, there are more traffic signal systems in urban areas than in rural or small urban areas. Greater efficiencies in providing improved signal control will be in the larger, more complex systems.

2. *Freeway Management Systems.* Freeways are primarily located in urban areas to provide capacity between city centers and the outlying suburbs. Freeway management in these regions is what is being referred to in this element (such as ramp metering, congestion information, video monitoring).

3. *Transit Management Systems.* Large urban areas have the largest and most effective transit systems in the United States. It appears that ITS technologies, such as automated vehicle location (AVL) and related operational software, will create excellent operational benefits for these large, complex systems.

4. *Incident Management Programs.* Incidents can have very severe effects on traffic flow. In urban areas, the ability of the road network to provide alternative routes provides a number of ITS possibilities.

5. *Electronic Fare Payment Systems.* These systems are being used primarily on transit systems and sometimes for parking payment (in large urban areas).

6. *Electronic Toll Collection Systems.* These systems provide smoother traffic operation on toll roads by providing travelers the ability to pay tolls without coming to a complete stop. Many toll roads are located in urban areas; they provide additional capacity when regular transportation funding is unavailable.

7. *Regional Multimodal Traveler Information Centers.* These centers provide up-to-date information on the transportation options available in a region.[10]

Planners can use these elements as a guide in an ITS planning study, so that the urban region will have the necessary infrastructure to build on in the future. The infrastructure elements will also help solve a number of problems and situations that are currently facets of urban life. The national *ITS Architecture Mission Statement* laid out a scenario that listed some of these problems in urban areas. The elements were as follows:

- High population density
- Large existing transportation and communications infrastructures
- Extensive arterial network, saturated at peak travel times
- Extensive freeway network, saturated and often congested
- Underutilized/non-optimized mass transit
- Heavy commuter traffic and large latent demand
- Recurring and non-recurring congestion
- Extensive local pick-up/delivery activity
- Major terminus for goods shipping/receiving
- Air quality concerns
- More motor vehicle crashes
- High crime areas
- Limited land availability for additional facilities
- Multimodal transportation.[8]

These scenario elements point transportation officials toward the appropriate types of ITS solutions. Each urban area will have its own special problems and priorities, but this general scenario offers a set of problems and conditions that can be used by planners to educate their clientele on problems and the applicable ITS solutions. It is obvious by looking at this scenario why a major focus of the ITS program has been on urban areas.

Results of a Large Urban Area ITS Planning Study

The final report of the Hampton Roads COMPARE ITS Early Deployment Planning Study was released in October 1995. This particular plan was used because the authors were members of the steering committee and because it represents a rather typical set of ITS projects for a large urban area. The primary results of the COMPARE study included enhancements of the surveillance system in the region, upgrades of the information processing and communications capabilities of VDOT's regional traffic management system (TMS), a traveler information system, and extended traffic control and management systems. The specific projects from the implementation plan were as follows:

- *Surveillance*—coordinate bridge and tunnel data with regional TMS (traffic management system); extend VDOT surveillance systems along interstate in the region; extend/upgrade surveillance systems along regional/arterial highway system.

- *Communication*—develop regionwide communications network; develop Information Exchange Network.

- *Information Processing*—develop manual input to Clearinghouse for regional data; expand VDOT TMS to meet regional architecture needs; upgrade and automate VDOT/regional TMS system.

- *Traveler Interface Systems (TIS)*—implement highway advisory radio (HAR) regionwide and upgrade to AHAR (Automated HAR); implement interactive kiosks at key public locations; implement variable message signs (VMS) at major locations; upgrade phone-based traveler information; promote commercial TV usage for traveler information purposes.

- *Traffic Control and Management*—expand existing signal systems regionwide; expand number of signal timing plans and traffic responsive features on these systems; expand emergency vehicle preemption region-wide; provide signal coordination/cooperation across jurisdictional boundaries; implement automated incident detection algorithms for interstates and regional arterial network; implement regional ramp metering; develop computer-aided dispatch (CAD) for emergency response of highway incidents region-wide; automate regional traffic diversion plans.[11]

ITS in Rural Areas

The rural area scenario, as presented in the national *ITS Architecture*, includes the following characteristics:

- Mix of users (rural-based and urban-based users traveling through)

- Secondary roads with less frequent maintenance

- Steep grades/blind corners/curves/few passing lanes

- Large disparity in travel speeds (frequent passing)

- Long travel distances
- Fewer convenient detour options
- Adverse road surface and weather conditions
- Few navigational signs
- Less existing infrastructure
- Light usage/large geographical areas impede rapid emergency detection and response
- Lack of enforcement invites safety infractions/excess speed
- More motor vehicle deaths
- Recreational travelers that demand traveler information services.[8]

These scenarios, among other information, are being used to guide the ARTS program, a part of the federal ITS program. Rural areas, as defined in the ARTS program, are areas not urban, with small towns, of less than 50,000 population. The ARTS program was recently initiated to help guide ITS deployment toward rural areas following the initial federal emphasis on large urban areas.

The ARTS program has developed a strategic plan, a draft of which was made available in December 1996. The vision for rural ITS, as outlined in the plan, is an "enhanced quality of life for rural residents through safer, more secure, available and efficient movement of people and goods in Rural America through the judicious application of advanced ITS technologies."[12] The use of the word *judicious* is interesting, most likely reflecting the view that several ITS technologies are not applicable or cost-effective for use in rural areas.

The draft strategic plan also includes the goals of the ARTS program, which include some that are similar to the overall ITS goals as presented in the National Program Plan for ITS. The goals are as follows:

- *Safety & Security*—Improve the safety and security of users of the rural transportation system.
- *Mobility and Convenience*—Enhance personal mobility and accessibility to services, and enhance the convenience and comfort of all users of the transportation system.
- *Efficiency*—Increase operational efficiency and productivity of the transportation system, focusing on system providers.

- *Economic Vitality and Productivity*—Enhance economic productivity of individuals, businesses, and organizations.

- *Environmental Conservation*—Reduce energy consumption and environmental costs and negative impacts.[12]

The focus on mobility and convenience takes on a slightly different meaning in rural areas. When travel distances are longer and densities are lower, the enhancement of personal mobility is much more difficult to provide than in an urban area. There was little evidence of completed rural ITS planning studies in the literature. However, as large urban areas complete the initial ITS planning, more funding may become available for rural areas.

ITS in Small Urban Areas

> Early ITS efforts were driven by the desire to address growing transportation problems in urban areas and in interurban corridors. While many of the technologies and systems aimed at solving these problems also have application outside urban settings, the market structure, application logistics, and motivating factors underlying their deployment vary considerably from urban to rural areas.[10]

This statement, from the FHWA's *Report to Congress on ITS Implementation*, clearly shows the early focus of the federal ITS program. However, the scenarios in the national *ITS Architecture* include a third (in addition to urban and rural) set for inter-urban areas. These elements stress the mix of users; long-haul commercial vehicle use; and high-speed, long-distance travel. Although an inter-urban corridor may include several small urban areas in addition to rural and large urban areas, the focus here is on trips *between* large urban areas. Although the federal program does not explicitly exclude small urban areas, the focus on large urban areas may obscure the realities of transportation systems in small urban areas that make them inherently different in terms of scale and needs. In the near future, the federal program may be gearing up to focus more on small urban areas.

ITS Planning in the Near Term

Included in the U.S. DOT's 1995 report to Congress on ITS is a discussion of where the ITS program is heading in the near term (5 years). "The Department will focus on facilitating the national deployment of available public infrastructure that can save lives and increase the capacity and efficiency of the highway, transit, and emergency response systems."[6]

Further, the future holds the following challenge for the nation: "to ensure consistency in architecture and standards development so that initial deployments form a foundation for the evolution of more sophisticated future systems."[6] The effect of having standards in place for a number of ITS technologies will facilitate the ease with which a planning study can be completed.

The federal ITS programs have relied heavily on ITS planning. Yet another revision to the *ITS Planning Process* will be included in the FHWA's interim transportation planners handbook entitled *Integrating ITS within the Transportation Planning Process*. One of the primary focuses of this handbook will be making ITS planning fit into the traditional metropolitan transportation planning processes.[13] Since ITS was initially planned and funded through the federal ITS program, it has not been fully integrated into the normal long- and short-term transportation planning process. However, as "the dependence on set-aside federal funding for ITS potentially diminishes in the future, the coordination of ITS projects with other transportation programs is vital to optimizing the benefit of those programs and to the success of ITS."[14]

Summary

The elements presented in the literature review are meant to give a good indication of the goals and focuses of the federal ITS program over the years. In this summary section, comments on the results of the literature review and their effect or influence on small urban area ITS planning are discussed.

One ITS architecture goal is to use ITS as a way to increase capacity without actually adding lanes to roads or highways. The greatest need for capacity improvements is in already congested (and usually large) urban areas. Smaller urbanized areas often have less congestion overall, although car use in these areas is also increasing. Another challenge facing small urban areas is how to increase the efficiency and capacity of transit services even as they lack the population density to make them work at the highest levels of efficiency.

The primary purpose of the national *ITS Architecture* is to aid ITS development and nationwide compatibility. The *ITS Planning Process* uses the architecture as a way to integrate the desires of the local region into the national ITS program. Regarding the near-term future focus of the federal ITS program, if the additional ITS deployment described is undertaken, the continued presence of ITS planning will be ensured and will need to include small urban areas.

Finally, considering the way operational improvements to the transportation system have been accomplished in the past (reactively), the proactive nature of ITS operational improvements sets the stage for incorporation into the traditional transportation planning process. The way in which other non-traditional elements have been added to the transportation planning process could also apply to these ITS operational improvements. In ISTEA, air quality and transportation enhancements were added as separate funding categories and are now a part of the traditional planning processes in states across the nation. The need for ITS planning, once it is undertaken for the educational purposes throughout the United States, will most likely end.

The Jefferson Area Case Study

The Jefferson Area ITS Planning Study was initiated by VDOT and Charlottesville, Virginia, area planners in the spring of 1996. The primary focus was to investigate what ITS technologies could be used cost-effectively to help improve the area's transportation system. The study team from the VTRC, Brian Smith, Rich Taylor, Mike Demetsky, and Melissa Mawyer, led the effort. The planning study was funded by VDOT, FHWA, and the Virginia Department of Rail and Public Transportation (VDRAPT).

Meetings were held with representatives of the local transportation agencies, the TJPDC, VDOT, VDRAPT, and the study team to initiate the study. The focus of the planning study, the issues involved, and an initial discussion of opportunities for ITS in the region were discussed. It was decided that there should be public meetings of some sort (workshop format was chosen) held to coincide with each of the three major milestones of the planning process. Those milestones were the development of the vision, the Market Package Plan, and the Strategic Deployment Plan.

Another major order of business was to create a solid, core coalition of transportation stakeholders to be involved in the planning study. Each attendee of the preliminary meetings suggested stakeholders who should be involved in the study. Out of this core stakeholder coalition, a 20-member study steering committee was established to guide the study. Other stakeholders were made aware of the study through the three public workshops. Relevant stakeholders were slated to be interviewed during the study for their input into the SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis and other important steps. Additional stakeholders were added to the steering committee whenever it was deemed necessary to do so.

Steering committee meetings were held approximately once a month, except during those months that public workshops were held. By the end of the study in May 1997, seven steering committee meetings and three public workshops had been held. The goal of the study team was to spend approximately one half of the study on the steps leading up to and including the Market Package Plan and the second half on developing ITS projects and the Strategic Deployment Plan. The results are presented next, in order of the steps of the *ITS Planning Process, Version 2.1*. The key lessons learned during each step are presented in the findings section of this report.

Step 1—Establish Core Stakeholder Coalition

The first step of the planning process involves "identifying and involving those who will play a significant role in the deployment and use of ITS in the region."[9] A list of the agencies represented on the steering committee is presented in Table 2. Those with an asterisk (*) were added during the course of the study, as the "Expand Coalition" step of the planning process calls for. A list of potential stakeholders was also developed to be used as the basis for invitations to the public workshops held throughout the study.

Table 2. Agencies Represented on Planning Study Steering Committee

Local Land Use Planning/ Community Development
TJPDC
Albemarle County
City of Charlottesville
Regional Sustainability Council

Local Transportation Planning
City of Charlottesville
Albemarle County
VDOT Charlottesville Residency
TJPDC

Transportation Agencies
VDOT
- Transportation Planning
- Traffic Engineering/ITS
- Culpeper District (Planning, Traffic Engineering)
- VDRPT
- FHWA

Local Traffic Engineering
City of Charlottesville
Traffic Signals Operations

Local Transit/Rideshare
CTS
UTS
JAUNT (paratransit)
Greene County Transit (paratransit)
RideShare

Local Emergency Services
Emergency Communications Center

Regional Economic Development
Thomas Jefferson Regional Partnership

Local Information Systems
Monticello Avenue (a community Internet network in Charlottesville and Albemarle)

The steering committee was designed to include those agencies and representatives that would actually be operating and/or implementing potential ITS projects. The composition included representatives of agencies and governments in the metropolitan planning organization (MPO), since they were the group that requested the planning study. However, representatives from surrounding counties were invited to participate through the public workshops, and were represented in part through the VDOT district representatives and the TJPDC representatives on the steering committee.

The emphasis while organizing the study was on small urban area problems and transit, particularly the paratransit service that serves the rural counties. (The emphasis on transit improvements was at least partially due to the greater than average use of transit in Charlottesville for commuting to work.) The region's goals to reduce SOV trips and enhance alternative modes of transportation were also stressed by the steering committee leaders.

Steps 2 and 3—Develop Vision and Define Problems and Document Goals

The second and third steps of the *ITS Planning Process* entail developing a vision and documenting local goals and problems. A vision "conceptually defines how the core coalition [steering committee] expects ITS to function in the regional transportation system." The development of the vision was accomplished through by holding a Visioning Workshop and through interviews with local transportation officials.

The Visioning Workshop was held with two basic purposes in mind. The first was to introduce the ITS planning study to the public (transportation stakeholders) and to provide them with a bit of ITS education. The second was to have the attendees help develop a vision for ITS in the future regional transportation system. The visioning process followed some of the suggestions embodied in the *ITS Planning Process*. The 27 attendees were divided into three different groups for breakout sessions. The goal was to get a broad set of representation (e.g., transit, highway, planners, emergency services, and a member of the public) in each group to allow for more wide-ranging brainstorming to take place.

The breakout sessions were led by members of the study team with experience in ITS, which allowed them to guide the sessions efficiently and to answer questions attendees had. The session leaders were asked to get "visions" from the groups relating to the following four areas: operational strategies, emergencies and incidents, public transportation, and traveler information. The leaders stressed brainstorming to begin with, asking attendees what they foresaw in the future transportation system. After the initial brainstorming, the four more specific areas were introduced, leading to more detailed discussion.

According to the session leaders, the format worked well and the attendees were usually very talkative and offered good ideas. The results of the three separate breakout sessions were tabulated and the major themes and ideas that were developed were gathered into a Vision Document. This document included the three major theme areas for the vision: alternative transportation modes, safety and efficiency, and economic development. Each theme was also depicted in a visual diagram. (The Vision Document can be found in the Jefferson Area ITS Planning Study *Market Package Plan.*[15])

The resulting themes and elements presented in the Vision Document served as the first milestone in the planning study. The vision was presented to various agency groups and the MPO by steering committee members and the study team to introduce ITS and the planning study to the community. Another major benefit of the vision was that it served as a benchmark for the remainder of the planning study. If any element came up that did not mesh with the vision, it was obvious to the study team that the study was off track.

The third step of the planning process "links the ITS planning effort directly to the established, agreed upon regional transportation goals. In addition, it seeks to identify specific transportation problems in the region that may be addressed by ITS."[9] Documenting local goals and problems was accomplished through steering committee meetings, interviews, and gathering of local and regional comprehensive and transportation plans.

Step 4—Screen Market Packages

An ITS market package is defined as "a collection of equipment capabilities which satisfy a market need and are likely to be deployed as a group."[2] This step involves looking at the 52 market packages and determining, through a series of screens (criteria that must be met for a market package to "pass"), those that will be most appropriate and beneficial for the region being studied (keeping in mind that the market packages selected will eventually be developed into actual projects for the region).

Screening of the market packages entailed a nationwide review of ITS projects, a local examination of ITS opportunities, and mapping the market packages to the region's transportation goals. The study team also chose to add a fourth screen, which is not specifically mentioned in the *ITS Planning Process*, that involved matching the market packages to the vision developed earlier in the study.

As a result of comments made at the Visioning Workshop and by the steering committee, the Jefferson Area created its own market package, *Speed Enforcement*, to be considered in the screening process. The definition of the Speed Enforcement market package is as follows:

> This market package was designed through comments made by stakeholders in the Jefferson Area. Much emphasis was placed on the need to reduce speeding and the running of red lights in the areas. In particular, speeding through school zones was mentioned as a high priority. This market package will incorporate technologies to identify speeders (or red-light running vehicles) and then notify them (through on-site signage or mailed notice) that they were identified as speeding (or running a red light).[15]

The study team completed the initial first screening and presented it to the steering committee for comments. A second screening was then undertaken with the remaining market packages, and the results of this screen were presented at the second public workshop, which dealt with the draft Market Package Plan. The four screens were as follows:

1. Environmental Scan. The environmental scan screen is essentially scanning the world for good (and bad) examples of ITS project deployments. A wide-ranging review of ITS projects throughout the United States and the world was undertaken.[16] The three main focuses of this review were to (1) determine what ITS projects have been implemented successfully; (2) determine possible costs/benefits of such projects; and, most important; (3) determine its applicability to the Jefferson Area. The results of this review were used to screen the 53 market packages (52 from the National ITS Architecture and 1 Jefferson Area package).

2. SWOT Analysis. The SWOT analysis screen incorporated interviews with local officials as well as the discussions held during steering committee and organizational meetings. Since SWOT stands for strengths, weaknesses, opportunities, and threats, questions for the interviewees focused on these topics. The results of the meetings with local transportation officials, planners, VDOT officials, and many others were used to screen the 53 market packages again. The following are examples of the types of input that were gained through this process:

- *Strengths*—There was a good amount of local interest in the possibilities presented by ITS technologies. Local governments and agencies had already worked together on a number of projects, including an Internet information service, Monticello Avenue, showing potential for interagency and interjurisdictional cooperation.

- *Weaknesses*—The main weakness apparent in the Jefferson Area is the scale of its transportation system. The area does not have miles of freeway or a large fixed-route transit service. In fact, the University of Virginia is the major employer in the area, and runs its own transit service to accommodate its students and employees. The other three transit services in the Jefferson Area operate (and are funded) independently.

Although some cooperation exists between the services, the desire of some for a regional transit agency has borne little progress. These circumstances are by no means detrimental to ITS deployment, but they do present certain challenges for the area.

- *Opportunities*—The community is in the process of significantly upgrading its Emergency Communications Center. The possibility exists for incorporating this new system with ITS projects in a number of interesting ways, including direct sharing of incident information and coordination during transportation system events, among others.

- *Threats*—Unlike the other terms, *threats* makes the task at hand sound quite daunting. Threats would seem to be more serious than weaknesses; therefore, funding and interjurisdictional and interagency cooperation seem to be the primary threats to ITS deployment in the Jefferson Area. The Jefferson Area is no different from other areas in the United States where jurisdictions and agencies operate on their own. Sharing information and providing operational control to others does not always seem like a smart management decision. This threat (along with very limited funding) is not debilitating, but it must be considered in whatever ITS projects are developed for the area. Making this information easily accessible to the agency that creates or initially collects it should alleviate many of the problems with sharing data.

3. Goals Mapping. The region's transportation plans as well as county and city comprehensive plans were gathered to determine the transportation goals of the region. The screening involved determining whether or not each market package was able to contribute significantly to meeting at least one of the goals for the region. This screen was somewhat difficult from that standpoint, since any number of market packages dealing with AVSS (Advanced Vehicle Safety Systems) could help increase the safety of the transportation system—a common goal. However, it was determined in the environmental scan that these market packages were being researched and implemented in the private sector. Therefore, the market packages failed the opportunity portion of the SWOT Analysis, since there was no opportunity to implement this market package at the local level. For that reason, the AVSS market packages were not "passed" in this screening.

The following are examples of the goals mapping screen:

- *Goal: Integrate and promote alternatives to the automobile.*[17] Almost all of the Advanced Public Transportation Systems market packages mapped well to this goal. Any market package that enhanced the operation of transit would definitely be considered as a way of reaching that goal.

- *Goal: The Charlottesville-Albemarle metropolitan area transportation system will support and enhance a vital local and regional economy.*[17] Any market package that has the potential to involve the private sector in a possible money-making venture will meet this particular goal. This could potentially include the provision of traveler information.

4. *Vision Matching.* The study team added this screen to the process based on the importance of the vision document as a milestone in the planning process. It was decided that making sure the market packages fit into the future regional transportation system vision would be worthy of its own screen. This step is similar to goal mapping in that the 53 market packages were mapped to the list of future ITS transportation services from the vision document. If the market package did not show up in the vision, it was noted in this screen. For example, the importance of providing better transit information was stressed in the vision. Any market package dealing with traveler information or transit automated vehicle location systems would meet this screen's criteria.

The steering committee chose 12 market packages for the area based on the results of the screening process. The first 6 market packages were overwhelmingly picked, so these were labeled "high-priority" and were slated to be developed into ITS projects. The other 6 market packages were listed as "future planning," which indicated that information on these market packages would be provided in the final report, but no project would be developed. The final step in screening the market packages was to present them to the public. The second public workshop was held to accomplish this and is discussed in the next section. Refer to the Jefferson Area ITS Planning Study *Market Package Plan* for more details.[15]

Step 5—Develop Market Package Plan

The second milestone of the *ITS Planning Process* is the Market Package Plan, which discusses, in-depth, the market packages chosen to be developed into projects for the study region. The plan should "thoroughly document and support the market packages selected for regional implementation."[9] The plan should include performance criteria for each selected market package, attempt to show potential benefits to the region, and demonstrate how the particular market package may help meet regional transportation goals.

The study team chose to hold its second public workshop to present the draft results of the Market Package Plan. At this workshop (with 23 attendees), six high-priority market packages, as selected by the steering committee, were discussed in some detail. The results of the workshop were very beneficial in finalizing the Market Package Plan. Workshop attendees made one significant change, moving the *Speed Enforcement* market package from a high-priority to a future planning market package. This meant that information regarding ITS technologies that help identify traffic violations would be presented in the Strategic Deployment Plan, but no speed enforcement project would be developed.

The steering committee approved five market packages for projects: *Network Surveillance*, *Traffic Information Dissemination*, *Surface Street Control*, *Transit Operations (Transit Vehicle Tracking)*, and *Interactive Traveler Information*. These packages can all be considered basic, even elemental ITS deployments. Most of them are mentioned as early deployment priorities in the list presented in the national *ITS Architecture*. The steering committee's focus appeared to be on improving the transportation system with ITS technologies that could provide immediate benefits and be upgraded in the future.

The nature of the Jefferson Area played a large role in the market package selections. Being a small urban area meant that a number of ITS options were not considered, because of complexity and cost. Others did not match the characteristics of the region's transportation system. The simplicity of the majority of the market packages (data collection, processing, and dissemination) and the necessity of improving the efficiency of the paratransit service in both the rural and urban areas were the main criteria.

The interactive traveler information market package was seen as a way to both disseminate the transportation system information gathered by other ITS market packages and gather in one place (the Internet) all of the transportation options available. A large market for this information was not apparent to the steering committee, and, therefore, a more extensive collection of market packages in the information provision category was not chosen.

The selected market packages seem to relate well to the major issues of this study. The transit operations and interactive traveler information market packages have the potential to improve the service and marketing of transit services in the region, and therefore the potential to attract new riders. Enhancement of alternative modes may indeed be possible by offering enough information to travelers to make more informed decisions before traveling in the Jefferson Area.

One element that the study team did not include at this point was performance criteria. Although performance criteria are important, the study team did not feel that they had to be present at this point in the planning study. The focus was on keeping the Market Package Plan simple for presentation to decision makers.

Step 6—Identify Desired Functional Capabilities

The second half of the *ITS Planning Process, Version 2.1* focuses on developing actual ITS projects for the study region based on the selected market packages. This initial step in project development is meant to help the study "move beyond market packages, which are generic descriptions of ITS capabilities, to a more detailed description of the functional capabilities of the region's ITS vision."[9]

The work on this step began during the second half of the draft Market Package Plan workshop in December 1996. Workshop attendees were asked to help move the focus from market packages to the development of projects. The functional capabilities for each project were developed through comments received at the steering committee meetings, the two public workshops, and investigative work done by the study team. The process of coming up with the functional capabilities was definitely one of iteration.

The study team chose to look at how the projects would work together by developing a conceptual architecture prior to specifically defining all of the functional capabilities. This led to more iterations, since the steps were done out of the order presented in the *ITS Planning Process*. However, given the fact that this was a small urban area and new ideas for how to link the ITS projects together were needed, this proved to be a useful adaptation of the planning process.

The study team looked at each project (network surveillance and traffic information dissemination were combined into the Transportation Information Center [TIC] project; surface street control was renamed the Traffic Signals project; the Transit Operations project and the interactive traveler information became the Trip Planning project) and developed a list of what it should be able to do. The full list of functional capabilities is provided in Appendix A.

Step 7—Define Regional Architecture

The "purpose of defining a regional architecture is to provide a framework for the delivery of the market packages identified in the Market Package Plan."[9] The regional architecture is created using the documents of the national *ITS Architecture*. The architecture takes the transportation functions to be performed in the region, allocates them to systems and subsystems, and defines the flows of information and the interfaces between the subsystems and components.[11]

The regional architecture was based on the conceptual diagram presented to the steering committee after the Market Packages Plan was completed. The main components of the regional architecture are the physical and logical architectures. The logical architecture depicts the data flows between each of the project components. The Jefferson Area logical architecture is shown in Figure 3.

The physical architecture is based on the use of 19 subsystems; for example, a vehicle subsystem (in-vehicle displays) or roadside subsystem (toll collection, surveillance, etc.). The Jefferson Area's projects are not very complicated, and the subsystems do not relate exactly to transportation system operations in the Jefferson Area, so the subsystem designation was not used in the study. However, an example diagram depicting the major systems, subsystems, and equipment packages, as they would be developed by following the national *ITS Architecture*, was developed by the study team to make sure the Jefferson Area study was in line with the National Architecture. This is shown in Figure 4.

The study team developed the regional architecture diagram (based on the conceptual architecture), depicting information simply, which is appropriate for presentation to both steering committee members and decision makers. The specific operation centers (physical architecture) are shown, as are the information flows between them (logical architecture). Some project responsibilities are also shown.

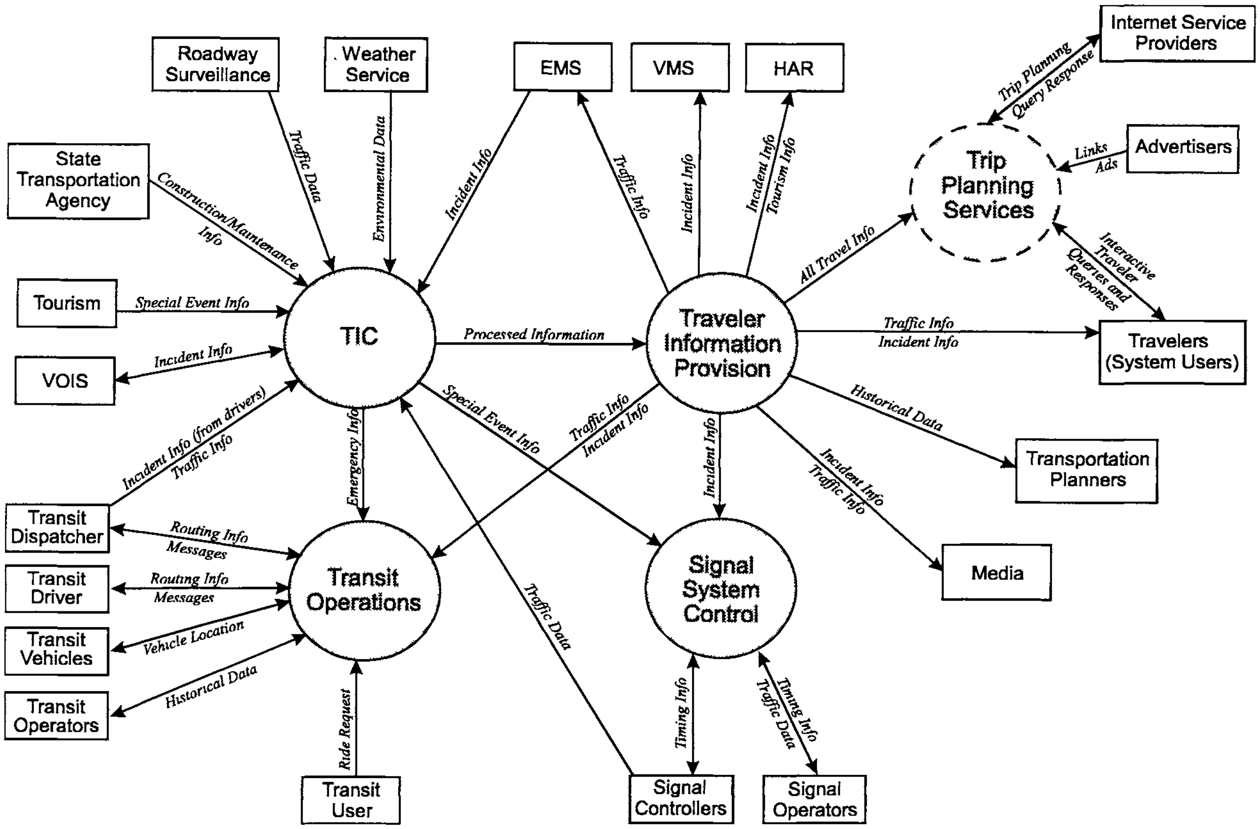

Figure 3. Jefferson Area Logical Architecture

The architecture, as shown in Figure 5, is centered on the TIC. The TIC is the central location where the duties described for the network surveillance, traffic information dissemination and some of the interactive traveler information project would be performed.

The traffic signal systems operation and transit operations would remain with the appropriate agencies. The reason for this separation of projects was the scale of the agencies in the Jefferson Area—the transit systems are relatively small and the number of traffic signals is relatively small. Currently, there is not the desire (or funding) in the area to coordinate all of these operations into a central location.

The interactive traveler information project (shown as Trip Planning on the diagram) would also be handled primarily outside the TIC architecture. The actual development of the web site, except for the transportation information page created through the TIC, would be done by a private or public/private group.

Along with the regional architecture, the study team created a location map for potential detector and information locations in the Jefferson Area. This map, shown in Figure 6, depicts the locations determined by the steering committee and study team where detectors, highway advisory radio, and portable variable message signs should be located. This map shows those locations that are most likely to provide relevant data for the most congested and/or high volume roads in the region.

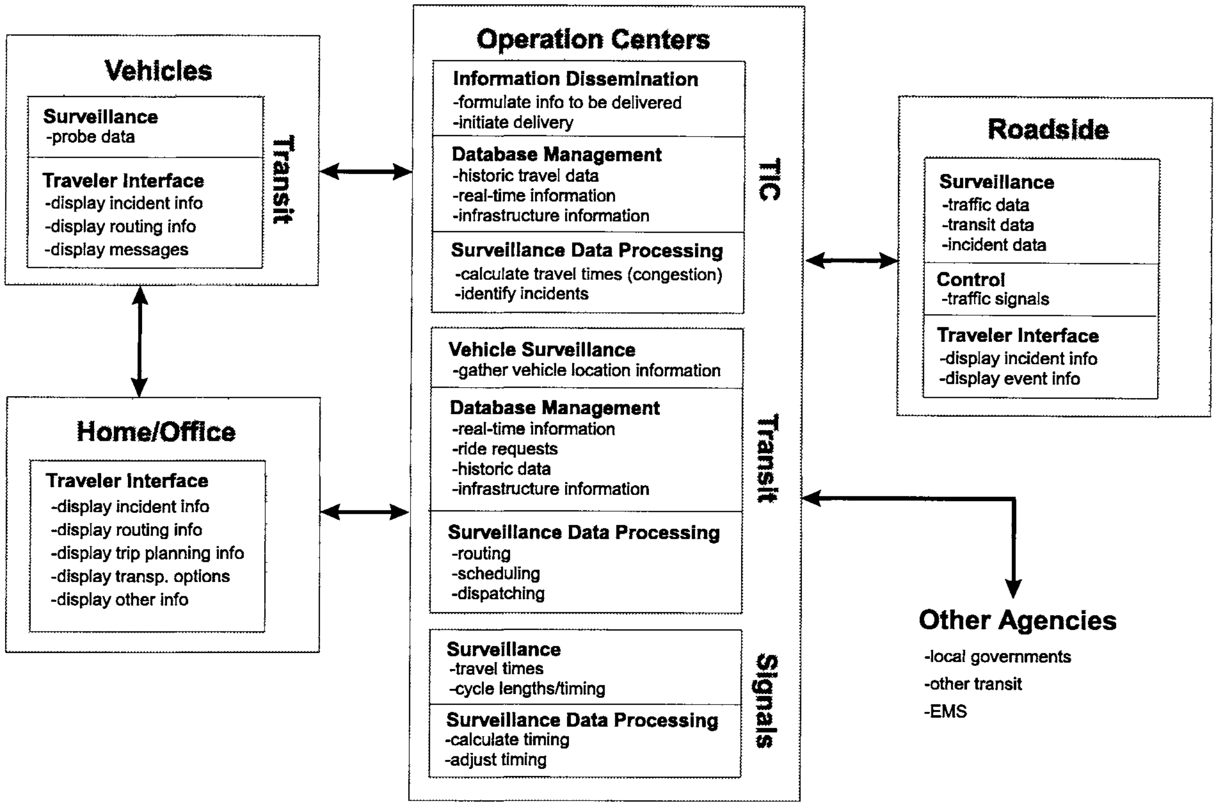

Figure 4. Physical Architecture

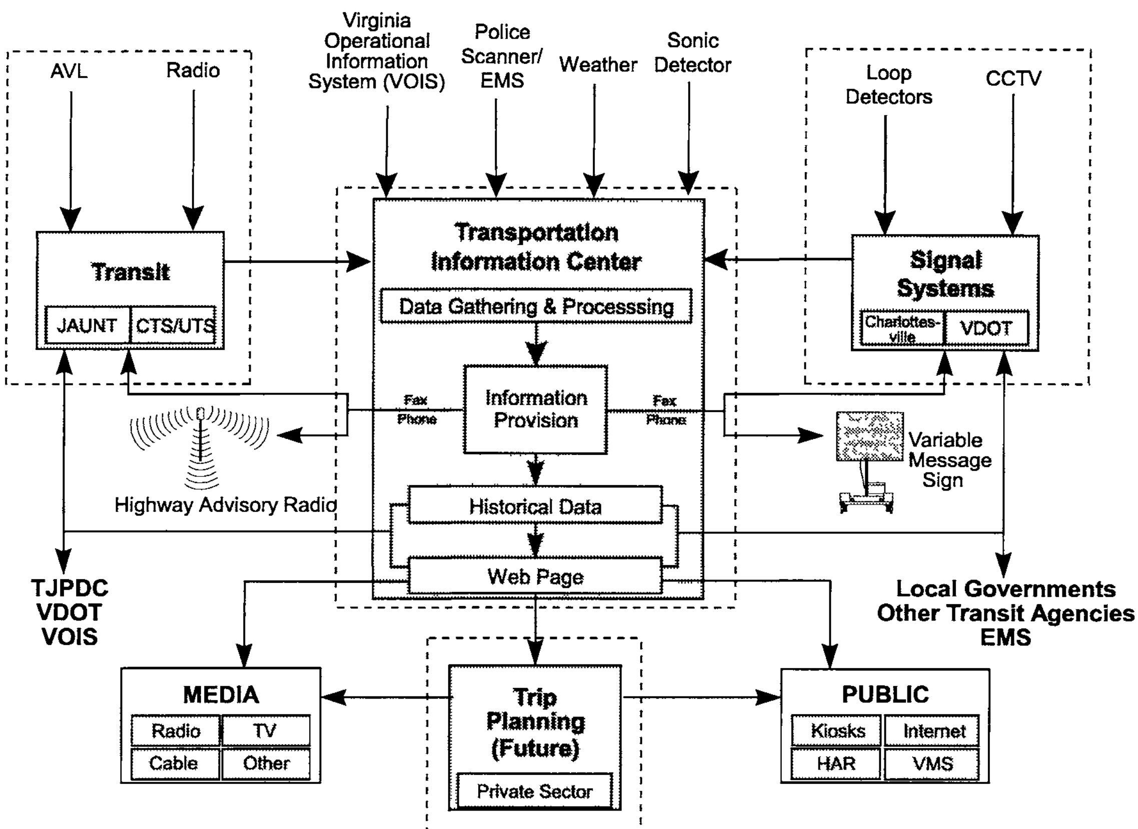

Figure 5. Regional Architecture

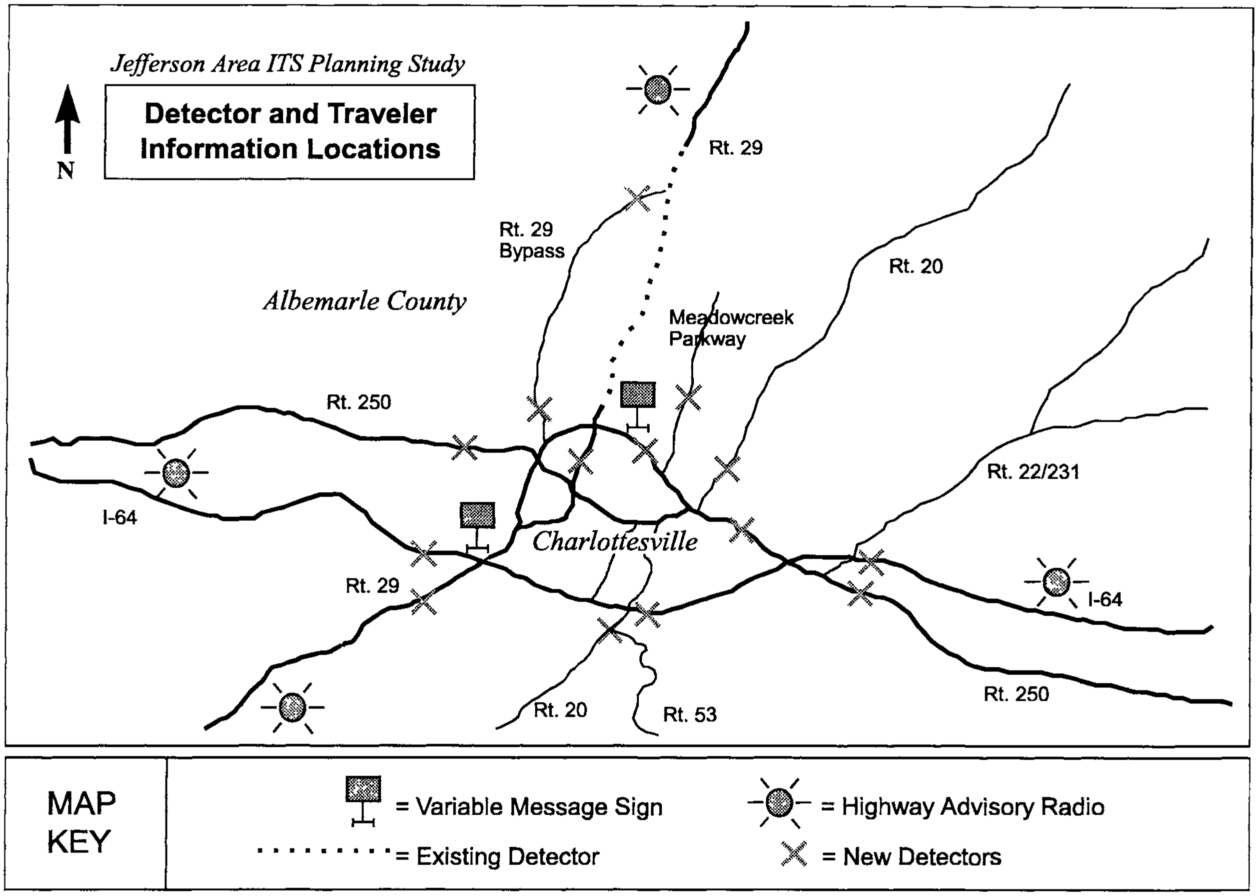

Figure 6. Detector and Traveler Information Locations

Step 8—Define Implementation & Operational Strategies

The focus of this step is to determine how the projects are going to be operated, what costs will be associated with each, and how to get the projects implemented. The implementation elements include funding, interagency agreements, and others necessary to move the projects into reality.

Final decisions regarding location and agency responsibility for the TIC had not yet been determined at the time of the writing of this report. However, implementation task groups have been organized through the steering committee to oversee the major project implementations, the TIC, and transit operations. Trip Planning will be incorporated into the TIC task group once the TIC is developed. These groups will be responsible for making final decisions on the location of the TIC, who will be responsible for personnel, and other administrative matters.

The study team performed a cost analysis for each project that can be found in Appendix B. The project costs are based on averages from a variety of projects already implemented in Virginia and around the country. The study team also looked at the benefits literature for ITS, and used it to help estimate the potential benefits of the proposed ITS projects for the region. The primary result of the benefit and cost analysis undertaken was a 3.5 to 1 benefit to cost ratio for the ITS projects developed for the Jefferson Area. The benefit and cost analysis is found in Appendix B.

Step 9—Develop Strategic Deployment Plan

The final product of the planning study is the Strategic Deployment Plan. "This step pulls together the efforts of the planning process to clearly document an action-oriented ITS implementation plan. Although the earlier steps establish *what* ITS elements will exist, this step explains *how* to develop, operate, and maintain the system."[9] The Strategic Deployment plan includes the following elements (as outlined in the *ITS Planning Process*) for each project: project description, expected benefits, responsible organizations, estimated capital/construction costs, estimated annual operations and maintenance budget, and funding sources.

The Strategic Deployment Plan for the Jefferson Area provides some options for projects, such as an extensive (high-end) project versus a basic (low-end) project. Funding opportunities are presented in the Strategic Deployment Plan, although the actual allocation of funding will have to be sought out by the implementation task groups. One such opportunity is the development of the TIC by a group of systems engineering students at the University of Virginia. This approach would be cost-effective principally because labor is provided free of cost; the only costs would be those for equipment and annual operation and maintenance. This option is presented in the Strategic Deployment Plan.

The one area that had not been decided upon by the end of the planning study is organizational responsibility. Some projects will definitely be housed within certain agencies (e.g., transit agencies will house their AVL operations); the location and responsibility of the TIC may not be determined until the implementation task group meets and settles the issue.

Also included in the Strategic Deployment Plan for the Jefferson Area is further information for the ITS market packages not developed into projects, but still of interest to the region. These include speed enforcement, traffic network performance evaluation, emergency response, transit fare management, multimodal coordination, ITS planning, dynamic rideshare, and transit security. (See the Jefferson Area ITS Planning Study *Strategic Deployment Plan* for more information.[18])

FINDINGS

Literature Review

The literature review presented information on a federal ITS program that focused initially on providing solutions for those areas with the most severe congestion-related transportation problems—large urban areas. As the program grew and matured, focus started shifting to other areas, such as inter-urban corridors and rural areas. The one area that was rarely specifically mentioned was small urban areas.

Small urban areas were never excluded from the ITS literature by name; it was through the primary focus of the *National ITS Program Plan* and the National *ITS Architecture* that revealed the large urban area bias of the program. The primary finding of the literature review is that small urban areas were not focused on in the federal ITS program, but neither were they summarily excluded. The future might hold more emphasis for small urban areas, however.

The Jefferson Area Case Study

A number of lessons were learned throughout the planning study. These are categorized by *ITS Planning Process* steps.

Establish Core Stakeholder Coalition. Attempting to get all of the necessary stakeholders involved in the planning study was found to be much more difficult than merely formulating a list. Participation by all localities, agencies, and important private sector stakeholders can be affected by a number of factors, including personnel turnover, personal interest, value of time, and by other elements, such as perception of power. The best way found to deal with this is to spend time one on one with those who are not participating and attempt to emphasize their importance in the success of the study. Otherwise, participation will most likely not improve.

Although all of these factors cannot be overcome, an effort should be made to at least get input from those who need to be involved, even if that does not include attending steering committee meetings. This was done for the traffic signal project; however, the involvement by transit agencies was never complete. The study team should have made further efforts to involve these non-participants, but they did not, mainly because of time constraints. If the ideas and projects are based on stakeholder input, then eventual implementation should prove less difficult.

Develop Vision and Define Problems and Document Goals. Since the vision is a central focal point of an ITS planning study, it is important to develop it appropriately. A solid effort at involving a cross-section of transportation stakeholders and the public should be made. Even more important is to have someone with a good working knowledge of ITS on hand to lead the brainstorming session.

One element of the vision document for the Jefferson Area was extremely helpful. Providing a visual depiction of the elements of the vision proved to be a very useful tool—the vision document's diagrams received positive feedback from a number of local officials. The ability to *see* the potential for ITS was an excellent promotional item.

Screen Market Packages. The screening process can become quite involved and time-consuming if an attempt is made to be all encompassing. Using the professional judgment of the study team and a summary of ITS literature and a review of projects should suffice for the Environmental Scan. The SWOT Analysis should, at the very least, include more in-depth interviews with steering committee members and other *critical* stakeholders. Goals Mapping and Vision Matching are relatively straightforward.

Iterating the screening process proved useful. The study team iterated the screening process once in the Jefferson Area study to include new information and opinions expressed by the steering committee. Iterating should prove much more useful than spending twice as much time on the initial screening.

Develop Market Package Plan. Presenting the Market Package Plan in a concise, easy-to-understand format is important. The plan will be used repeatedly to inform decision makers and the public about ITS and the planning study. Technical jargon and complex diagrams will not aid in this endeavor. The key is to present in a clear fashion how ITS (the selected market packages) can make a difference in the region's transportation system. Although the Jefferson Area ITS Planning Study did not include them in the Market Package Plan, performance criteria should be defined at some point in the planning study for each project.

Identify Desired Functional Capabilities. Although this step was completed out of order, the results seem to have proved useful. In reality, the study team and steering committee developed the functional capabilities and architecture together without using the specific directions and categorizations offered in the national *ITS Architecture*. This was a helpful change for the steering committee, because it got them involved in the projects right off the bat, with the conceptual architecture providing a clearer understanding of how it would all work together.

Define Regional Architecture. The development of the architecture is a very time consuming endeavor made somewhat easier by the national *ITS Architecture* documents. However, given the scope of the projects chosen for the Jefferson Area, the study team determined that a full-scale architecture development (the full slate of categorizations, diagrams, and flow charts) was not necessary. The study team did develop diagrams and made sure that the simplified methodology did not compromise the intent of the national *ITS Architecture*. Developing the architecture in a more simplistic fashion than is called for in the national *ITS Architecture* also helped the study team in explaining the architecture to the steering committee and decision makers.

Define Implementation & Operational Strategies. The steering committee was determined to have a benefit/cost analysis. At the local level, the funding for ITS operations will, at the very least, have to be matched with local funds. These funds are competing with local schools and police. Without a powerful argument (benefit and cost analysis), the local governments will not be as willing to pursue these ITS projects.

It is now easier to develop ITS benefits based on the examples recently published by the FHWA. It is important to take the benefits in context; assumptions must be based on the characteristics of the area under study.

Develop Strategic Deployment Plan. Although the development of the Strategic Deployment Plan is laid out in a number of steps in the planning process, the actual implementation of the ITS projects should be focused on as the planning study comes to an end.

The focus on implementation in the last months of the study should help the agencies and decision makers move more smoothly towards an operational ITS system for the Jefferson Area.

Overall Findings of Planning Study

The overall result of the planning study is a group of projects with options for implementation and operation. The plan will not be able to implement itself, and that is why the implementation task groups were organized. The groups should be able to use the results of the planning study to put an ITS system in place in the Jefferson Area.

An additional benefit of the entire planning study is the education of the Jefferson Area about ITS. Through articles in local media and participation in public workshops, the residents of the Jefferson Area have been introduced to the possibilities associated with ITS. Finally, the study presented another opportunity for agencies and local governments to work together for the benefit of the entire region.

The weaknesses of the results of the planning study dealt with the ability to have a completely implementable plan finalized by the end of the planning study. The steering committee attempted this, but because of the nature of local politics and funding cycles, all of the organizational responsibilities and funding were unable to be completed by the end of the study. The lesson learned through this is obvious—the ability to determine organizational responsibilities during the planning study will greatly enhance the likelihood of successful ITS project implementation.

CONCLUSIONS

ITS Planning in Small Urban Areas

1. *ITS plans for a small urban area differ greatly in scale and scope from those for large urban areas.* The ITS market packages are generally geared toward complex systems where the information and communication technologies can have great impacts on operational efficiencies. Some market packages, such as freeway ramp metering or a high-tech, computer-operated areawide traffic signal system, are not really applicable (due to large infrastructure costs) or appropriate (due to transportation system characteristics) in small urban areas. However, components, or less complex parts, of these systems can have a positive effect on improving the efficiency of the small urban area's transportation system. Simply having the ability to communicate with traffic signals can provide the option of changing signal timings to help improve traffic flow. Knowing about an incident on a roadway before leaving home or work can help save time and frustration for travelers. ITS, scaled-down from the large metropolitan area deployments, presents a good group of potential solutions for the smaller-scale problems and needs of a small urban area.

2. *ITS technologies are in use in many small urban areas.* These technologies are typically not categorized as ITS technology, however, because they are not being used in conjunction with the operation of the transportation system. Emergency 911 centers use a number of ITS-related technologies, including computer-aided dispatch-based AVL location systems with routing capabilities. If these technologies are recognized as ITS, the appropriate coordination with the region's transportation system might be easier.

3. *Cooperation and coordination are essential to planning for ITS solutions that will provide the highest level of benefits to a region.* ITS revolves around information and communication. Therefore, the most successful implementations are going to be where agencies and jurisdictions communicate and share information about their portions of the transportation system for the betterment of the entire system. Although this does not directly imply that the transportation system should be operated cooperatively, it is an option worth exploring. Cooperation and coordination are especially important to transit services.

4.

ITS Planning Process, Version 2.1

1. *Successfully organizing the core coalition is crucial.* Although steering committee attendance varied in the Jefferson Area study, with some members attending only one or two meetings, the core group that helped organize the study (and can be considered the study's "champions") remained interested, attentive, and involved throughout the planning process. Although some interests that may have benefited were not well represented throughout the process, it is hoped that the education and awareness provided by the planning study will prove useful in the future by getting more people involved in ITS solutions.

2. *Education is the key component to a successful ITS planning study.* It is important to focus on the currently available ITS technologies in a planning study, rather than the more futuristic technologies (such as an automated highway system). This will assist local officials and residents in understanding today's potential for ITS. If a local resident asks whether a car is going to drive itself on a local road, the educational component of an ITS planning study is probably not getting the point across. Although automated highway systems is a component of ITS, the best focus of ITS education is on what is available to help operate the region's transportation system more effectively *today.* There are now enough examples of successful real-world ITS examples that can provide the majority of ITS education. This grounds ITS in reality, where local officials are dealing with the problems for which they need solutions.

3. *Creating a vision is very important to the entire planning study.* The vision (defining the role of ITS in the future regional transportation system) is an extremely valuable step in the planning process. The study team in the Jefferson Area study used the vision in a number of ways: as an additional screen for the market packages, as a focus for project functional capabilities, and as a promotional and education tool. These uses of the vision are predicated on it being developed by a cross-section of transportation stakeholders in the region.

4. *Performance criteria can be difficult to define in small urban area planning studies.* One aspect of the planning process that the study team did not follow was determining performance criteria for the market packages as part of the Market Package Plan. Linking performance criteria with the market packages is a good idea, but determining the most appropriate criteria when functional capabilities have yet to be defined is rather difficult. Given the constraints of funding and the relatively small scope of the transportation system in a small urban area, it could not be assumed that network surveillance, for example, would be anything more sophisticated than people calling in road information on cellular telephones. The direct effect of this on travel time, for example, would be extremely difficult to corroborate. The Jefferson Area study team chose to bypass this element, instead looking at the general potential benefits of each market package. However, the exclusion of performance criteria may inhibit implementation and evaluation of the ITS projects.

5. *Iteration is a valuable tool and should be used as often as necessary during the planning study.* The study team for the Jefferson Area study changed the order of or iterated steps based on new information a number of times. The team decided to examine how an architecture might work for the Jefferson Area prior to defining the exact functional capabilities of each project. The main reason for this was that the market packages chosen by the steering committee called for some type of central information location. Given that these facilities in other cities are typically large, expensive, and complex centers, the study team wanted to first determine whether something like this would work on a smaller scale. After preparing a conceptual architecture (including the TIC), the team went back and more clearly delineated the functional capabilities of the all the projects. This proved to be a successful way to reach the solution.

Jefferson Area ITS Planning Study

1. *Transit improvements were an important component of the study.* The Jefferson Area's focus on enhancing alternative modes of transportation (and greater than average use of transit to commute to work) led to a great deal of interest and involvement by two of the area's transit agencies. Although the planning study results will not get every driver in the area out of their cars, the AVL, operational, and information improvements should help make transit service better and also help with marketing. Since the Jefferson Area is a small urban area with a relatively simple transportation system, the focus was on getting the most out of a small investment. One of the proven benefits of ITS for transit systems comes from being able to reduce the fleet size of transit services that use AVL technology. Of the Jefferson Area transit agencies, it appears that the region's paratransit service, JAUNT, will see the greatest benefit from installing AVL systems in its 55 vehicles. Of course, the provision of traveler information will provide additional benefits for all of the transit services, so the benefits from ITS projects will not accrue just to JAUNT.

2. *It is important to start an ITS deployment with elements from the basic (or core) ITS infrastructure.* The solutions proposed for the Jefferson Area are good projects with which to begin an ITS program. The provision of information on the transportation system—through

data gathering, processing, and dissemination—is the first step in building an even stronger ITS system. With an information infrastructure, future ITS applications, whether they include computer models and simulations or other unforeseen technologies, have great potential.

3. *The Jefferson Area's small urban area characteristics necessitated creativity in planning for ITS.* The fact that the Jefferson Area is a mixture of small urban and rural areas can be seen in the ITS solutions picked for the area. The TIC is definitely based on the urban-oriented Traffic Operations Centers (TOC) or TMS. However, it also breaks out of those molds. The TOC or TMS are often located in separate buildings with large video walls, many employees, and high levels of processing power. The TIC, on the other hand, is basically a single person taking existing surveillance and a few additional sources and creating information during the traveling day for the traveling public. The use of the Internet as the basic means of presenting transportation information to the public (at least initially) is based on one of the area's unique characteristics—the higher-than-average per capita ownership of home computers. Small urban areas will require creative interpretations of large urban area ITS projects in order to scale them to the study region.

4. *ITS benefits literature is useful.* The literature on ITS benefits describes some excellent successes in other areas of the country. If the Jefferson Area is able to reap nearly the same level of benefits, ITS will truly pay its own way (as the estimated 3.5 to 1 benefit to cost ratio attests). It is important, however, to adapt the benefits realized in other areas to the characteristics and conditions in the study area. Otherwise, the calculated benefits will not be accurate. It is important to note that in the case of the Jefferson Area, the local government officials insisted on having benefit information. The reality of small urban area government budgets and competing needs made this step mandatory.

RECOMMENDATIONS

1. *VDOT should incorporate small urban area ITS planning into its Smart Travel Program.* Federal ITS funding and/or general planning funds should be used to undertake these studies throughout the Commonwealth. The benefits of undertaking ITS planning studies in these areas of the Commonwealth are at least two-fold: (1) a coordinated, statewide ITS program would be established (including large urban and rural areas), and (2) education of transportation users and officials in small urban areas will help move ITS into the traditional transportation planning process.

2. *The ITS Planning Process, Version 2.1 should be amended to include a fourth screen, Vision Matching, in the fourth step, Screening Market Packages.* This screen was used in the Jefferson Area study as a necessary means of ensuring that the ITS market packages were an appropriate fit for the region.

3. *The ITS Planning Process, Version 2.1, as amended, should be used by small urban areas for ITS planning.* The process provides a reliable combination of structure and adaptability that will be useful in any small urban area application.

4. *The federal ITS program should include funding for small urban area ITS planning studies.* The educational and basic infrastructure benefits of such planning studies will help these areas incorporate ITS operational improvements in the future. Considering that many foresee ITS becoming yet another part of the traditional transportation planning process in the near future, the education obtained through these planning studies will be crucial for the successful future use of ITS.

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APPENDIX A—FUNCTIONAL CAPABILITIES

From the Jefferson Area ITS Planning Study Strategic Deployment Plan.[18]

Transportation Information Center Project

Functional Capability	Description
Gather roadway surveillance data.	Collect information on the roadway, such as traffic volumes and speeds.
Gather other surveillance data.	Collect information on the transportation system from police scanners, transit radio, and other in-place providers.
Transmit surveillance data.	Send pertinent surveillance data to the TIC for further use.
Gather data from surveillance sources.	Store data sent from surveillance sources for processing.
Process data.	Process data to determine such information as speeds, volumes, and congestion or congestion-causing incidents.
Develop information provision.	This is done through two primary means. The first is developing a map of the region showing traffic flows indicated by surveillance data and specific points of interest due to incidents, construction, or the like. The second step is to create text descriptions of the important information.
Deliver information.	This delivery process can be undertaken through a variety of means: sending map and text to an Internet home page, faxing text data to media and agencies, telephoning urgent information to the appropriate agencies, and sending out recorded announcements to highway advisory radio and written messages to variable message signs.

Traffic Signals Project

Functional Capability	Description
Control traffic signals from central location.	Provide communication links to allow signal controller to be operated off-site (from central operation location).
Update signal controllers.	Signal controllers need to have the ability to be operated from an off-site location, communicate with other signals, and accept signal preemptions
Communicate between controllers.	Allows controllers to adjust timings based on other signals actions; aids in smoothing the traffic flow along corridors.
Provide ability to actuate signals.	Actuate all left turns and other low-volume maneuvers to increase efficiency of signal system.
Use surveillance data to adjust signal timings.	TIC information can be used to adjust timings based on incidents and recurring congestion.

Transit Operations Project

Functional Capability	Description
Transmit location of transit vehicles.	Real-time location of transit vehicles is transmitted to transit operations center for use in a number of ways.
Provide two-way communications between dispatcher and vehicles.	Allows for data/message transmission between drivers and dispatchers, including real-time location data and updated routing information.
Enhance operations through use of real-time location data.	Use location data to enable tracking of schedule adherence; route adjustments based on user demand; adjustments of fixed-route routing and scheduling based on historic data.
Provide ability to match real-time locations with map.	Allow dispatcher to see location and provide appropriate algorithms to compute shortest routes and other elements.

Trip Planning Project

Functional Capability	Description
Present transportation information provided by the TIC.	The cornerstone of the trip planning project is the information provided by the TIC. This would be the sole location on the Internet to display this information.
Provide other transportation-related information.	Other transportation information for the Jefferson Area should be displayed, including transit schedules, bike paths, etc.
Provide trip planning services.	Private sector initiative could provide such services as purchasing and reserving tickets on planes, trains, and buses; reservations at local hotels and restaurants; tourism tickets; etc.

APPENDIX B: BENEFIT AND COST ANALYSIS

From the Jefferson Area ITS Planning Study Strategic Deployment Plan.[18]

Costs

The study team looked at the costs associated with the functional capabilities for each of the ITS projects. The costs are averages based on examples from other projects across the nation and, therefore, should not be considered concrete. They are provided as guides for the implementation groups who will be seeking funding and approval of the projects. More cost estimates will be provided in the Strategic Deployment Plan for each project.

The initial cost estimates were broken down according to two different scenarios: a high-end and low-end initial ITS deployment. The costs include both project capital costs and one year of operations. A description of each scenario and tables with potential costs are presented below.

Low-End System

A low-end initial ITS deployment for the Jefferson Area might include the following components: 2 acoustic detectors with cameras, 4 loop detectors (9 lanes), and a police scanner for network surveillance; the entire TIC for information dissemination, including one HAR and one portable VMS; two-way radio links to provide signal communication on West Main Street along with three 170 signal controllers to update technology; Internet service for the transportation information web page; and AVL on 10 transit vehicles along with the operations software.

The estimated costs for this system are presented in tables 1 and 2.

Table 1. Estimated Low-End System Capital Costs.

System	Cost Per	Number	Total Cost
Acoustic Detector	$6,000	2	$12,000
Loop Detectors	1,000	9	9,000
Police Scanner	250	1	250
TIC Computer	3,000	2	6,000
Software	2,500	2	5,000
Phone Inst.	30.63	2	61.26
HAR	15,000	1	15,000
VMS	50,000	1	50,000
Controllers (170)	3,800	3	11,400
Radio Links	12,500	1	12,500
AVL/Software	4,000	10	40,000
Total:			**$161,211.26**

Table 2. Estimated Low-End System Operational Costs.

System		Cost Per	Number	Total Cost
TIC	Personnel	$40,000	2.5	$100,000
	Phone	30.63	24	735.12
HAR	Cellular	70	12	840
VMS	Cellular	70	12	840
Radio Link	Phone	30.63	12	367.56
Internet		40	12	480
Total:				**$103,262.68**

High-End System

A high-end initial ITS deployment for the Jefferson Area might include the following components: the same components presented in the low-end system with the addition of 7 acoustic detectors with cameras (for a total of 9), 10 loop detectors (for a total of 14 across 42 lanes), 2 closed-circuit television (CCTV) cameras for network surveillance; 3 additional highway advisory radio units (4 total) and 1 additional portable variable message sign (2 total); and AVL on an additional 45 transit vehicles for a total of 55.

The estimated costs for this system are presented in tables 3 and 4.

Table 3. Estimated High-End System Capital Costs.

System		Cost Per	Number	Total Cost
Acoustic Detector		$6,000	9	$54,000
Loop Detectors		1,000	42	42,000
CCTV		50,000	2	100,000
Police Scanner		250	1	250
TIC	Computer	3,000	2	6,000
	Software	2,500	2	5,000
	Phone Inst.	30.63	2	61.26
HAR		15,000	4	60,000
VMS		50,000	2	100,000
Controllers (170)		3,800	3	11,400
Radio Links		12,500	1	12,500
AVL		1,500	55	82,500
AVL Software		50,000	1	50,000
Total:				**$523,711.26**

Table 4. Estimated High-End System Operational Costs.

System		Cost Per	Number	Total Cost
TIC	Personnel	$40,000	3	$120,000
	Phone	30.63	24	735.12
HAR	Cellular	70	48	3360
VMS	Cellular	70	24	1680
Radio Link	Phone	30.63	12	367.56
Internet		40	12	480
Total:				**$126,622.68**

Benefits

The study team also looked at potential benefits in relation to the costs outlined for the high-end system.[18] The information on ITS benefits came from a report completed for the FHWA by Mitretek Systems.[19] The report contains documented benefits from ITS implementations in various localities in the United States. Of course, the primary assumption of the analysis is that ITS implementation in the Jefferson Area will result in similar benefits, as witnessed in other areas of the country. Benefits were considered in four categories: information delivery, transit operations (with AVL), signal systems, and environmental. The results are presented below.

Information Delivery

There were two specific areas of benefits under information delivery. One area has to do with the effect information provision has on tourist travel. The second area has to do with collision reduction when information is provided.

The first example involves tourist travel. The Travtek program noticed a 10 percent reduction in tourist travel time due to increased tourist information.[8] In order to develop the benefits in terms of dollars for the Jefferson Area, other inputs are needed. The cost associated with time spent in traffic is estimated as $13.50 per car.[20] The cost in fuel for time spent in traffic is estimated as $0.70 per hour.[21] The Charlottesville Visitors Bureau provided the number of tourists that visit Monticello per year: 520,537. Assuming this is the number of tourists (and cars) in the area in a given year, an admittedly low estimate, and given the other figures above, the following formula will provide estimated costs savings, based on an estimated average of 45 minutes of tourist travel in the area (with the 10 percent reduction, there is a savings of approximately 5 minutes per tourist):

Time Savings:

$$(time\_saved) \times (\#tourists) \times (\$savings) = \left(\frac{5\,\text{min.}}{60\,\text{min.}}\right) \times (520{,}537) \times (\$13.50 / hour) = \$585{,}604$$

Fuel Savings:

$$(time\_saved) \times (\#tourists) \times (\$savings) = \left(\frac{5\,\text{min.}}{60\,\text{min.}}\right) \times (520{,}537) \times (\$0.70 / hour) = \$30{,}364$$

The total savings due to the effect of information delivery on tourist travel is $615,968 for a one year period.

The second benefit area is in collision reduction. According to the 1995 *Virginia Crash Facts*, there are an average of 1,690 injury accidents in Charlottesville and Albemarle annually.[22] The 1993 cost for property damage (including minor injury) for each accident is $5,800.[22] Based on a 2 percent reduction in collisions in the Transguide program (based on ITS-provided traveler information), the following costs savings would be realized in the Jefferson Area:[8]

Accident Reduction Savings:

$$(\#accidents) \times (reduction) \times (\$damage) = (1{,}690) \times (0.02) \times (\$5{,}800) = \$196{,}040$$

Signal Systems

The city of Abilene, Texas (metropolitan area population of 119,655 as compared with the Charlottesville metropolitan area with 131,107) was able to see a reduction of 14 percent in travel time where coordinated signal systems were in operation.[1,8] Applying this to the Jefferson Area, where there is a coordinated signal system on Route 29 North in Albemarle County, the cost savings can be estimated. Route 29 carries approximately 53,000 vehicles per day between the University of Virginia and the Forest Lakes subdivision. During the peak hour (when a trip takes approximately 30 minutes), there would be approximately 10 percent of the daily traffic on the road, or 5,300 vehicles. Assuming a time savings per trip of 4.2 minutes (14 percent reduction of the 30 minute trip), the following formula determines time savings with a coordinated signal system:

Time Savings:

$$(\#vehicles)\,X\,(\$saved)\,X\,(time\_saved)\,X\,(\#days)\,X\,(\#week\_year) =$$

$$(5{,}300) \times (\$13.50) \times \left(\frac{4.2\text{ min.}}{60\text{ min.}}\right) \times (5\,weekdays) \times (52\,weeks) = \$1{,}302{,}210.00$$

Transit Operations

According to the report on ITS benefits, transit systems that operate with AVL systems reduce their fleet size by 8 percent on average.[8] Using local transit services JAUNT and CTS as examples, the following cost savings can be calculated based on fleet reduction.

- **JAUNT** currently has 55 vehicles, so this would mean the fleet would be reduced by approximately 3 vehicles. Given an operating cost of $32,727 per vehicle, the savings for JAUNT would total $98,181.
- **CTS** currently has 16 buses. The fleet could be reduced by approximately one vehicle. Given an annual operating cost of $78,279 per vehicle (after a 25 percent reduction for administrative overhead), the total savings per year for CTS would be $78,279.

Environmental

One area that relates to the environment is the amount of fuel savings possible given the use of certain ITS technologies. Using the example of tourist travel from above, the reduction in travel time would save 24,421 gallons per year. For coordinated signal systems, a 6 percent reduction in fuel consumption where a system is operating has been determined.[8] If this reduction is computed for the trip on Route 29 north from the example above, then 50,129 gallons of gas would be saved in a year on just this segment of road.

Projects in Seattle and Boston looked at the changes in travel behavior when traveler information is available.[8] Changing travel behavior can lead to a reduction in SOV trips, one of the goals in the Jefferson Area. In Seattle and Boston, it was found that 30-40 percent of travelers frequently adjusted travel patterns based on the traveler information provided. Of these travelers,

- 45 percent change route of travel
- 45 percent change time of travel
- 5-10 percent change mode of travel.

Given these savings associated with in-place ITS systems, given that all of the savings are not accounted for, and given the conservative assumptions, ***the benefit to cost ratio is estimated to be 3.5 to 1***. This type of ratio speaks greatly of the ability of the ITS systems developed for the Jefferson Area to have a significant impact on the region, even if implementing the higher-priced high-end system.