Piedmont Regional Report

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Getting You There Safely

North Carolina Statewide Intelligent Transportation System Strategic Deployment Plan

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List of Abbreviations/Acronyms[1]

APTS	*Advanced Public Transportation Systems*. FTA program to focus R&D and funding efforts on ITS technologies composed of five main areas: vehicle operations and communication, high occupancy vehicles, customer interface, rural transportation, and market segment development.
ARTS	*Advanced Rural Transportation Systems.*
ATIS	*Advanced Traveler Information Systems*. Vehicle features that assist the driver with planning, perception, analysis, and decision-making.
ATMS	*Advanced Traffic Management Systems*. An array of institutional, human, hardware, and software components designed to monitor, control, and manage traffic on streets and highways.
AVL	*Automatic Vehicle Location*. The installation of devices on a fleet of vehicles (e.g. buses, trucks, or taxis) that enable the fleet manager to determine the location of specific, AVL-equipped vehicles in the road network.
CARAT	*Congestion Avoidance and Reduction for Automobiles and Trucks*. ATIS/ATMS system in Charlotte, NC involving an advanced transportation management center (TMC) and a subscription-based advanced traveler information system (ATIS) that will provide incident location and response as well as consumer information to its users. This is the original acronym/name for the system and has been replaced with the name "Metrolina Regional Transportation Management System".
CBD	*Central Business District*.
CCTV	*Closed Circuit Television*.
Clearinghouse	A clearinghouse stores real-time data for traveler information. The system will include data from system loops, intersections, a detector station, posted incident reports, IMAP incident reports, and real-time bus schedule information. All information whether it is stored locally or remotely, will be accessible from a central location.
CVO	*Commercial Vehicle Operations*. The application of ITS technology to commercial vehicles.
CVISN	*Commercial Vehicle Information Systems and Networks.* Refers to the ITS information system elements that support CVO.

[1] A number of the definitions regarding communications devices and protocols are from, "Newton's Telecom Dictionary," 16th Edition, Harry Newton, Telecom Books, February 2000.

DMS	*Dynamic Message Signs*.
DMV	*Department of Motor Vehicles*.
DSL	*Digital Subscriber Line*. A generic term for a family of digital lines that provide high-speed data transfer rates across standard telephone lines. Typical bit rates on a DSL connection range from 128kbs to 8Mbs.
FHWA	*Federal Highway Administration*.
HAR	*Highway Advisory Radio*. The transmission of localized traffic advisory messages using 520 AM and 1610 AM frequencies.
HOV	*High Occupancy Vehicle*. Any vehicle containing more than one person.
IMAP	*Incident Management Assistance Patrol.* A service run by the NCDOT to identify freeway incidents and assist emergency personnel.
Incident	Any accident, stalled vehicle, or other delay-causing problem on a street or freeway.
ISDN	*Integrated Services Digital Network*. Leased-line data network over telephone lines. A typical ISDN line connects at 128kbs but is more costly in both the end equipment and monthly cost.
ISP	*Information Service Provider.*
ISTEA	*Intermodal Surface Transportation Efficiency Act*, passed by Congress and approved by the President in December of 1991, becoming Public Law 102-240.
Kbs	*Kilobytes per second*.
Kiosk	An interactive information center for traffic or travel data located in shopping malls, parking decks, hotels, airports, businesses, transit terminals, etc. It always has interactive computer capability and sometimes has communications linkage to real-time traffic data.
Market packages	The FHWA has identified 56 market packages that describe projects in general terms and identifies the information that must be shared between the various components.
Mbs/Mbps	*Megabits per second*.
MDT	*Mobile Dispatch Technology*.
MPO	*Metropolitan Planning Organization*.
MRTMC	*Metrolina Regional Transportation Management Center*

Multimodal	The use or ability to use multiple modes of transportation; i.e., automobiles and buses.
Multiplexers	Electronic equipment that allows two or more signals to pass over one communications circuit.
NIA	*National ITS Architecture.* The NIA is a framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.
PART	*Piedmont Authority on Regional Transportation.* Regional Transportation between Winston-Salem, Greensboro, and the regional hub at Greensboro Regional Airport.
RSVP	*Ride Sharing Vehicle Program*.
RWIS	*Roadway Weather Information System.*
Smart Card Technology	A regional electronic payment system that permits the same method of payment for all transit systems in the region. In addition to permitting travelers to use multiple bus systems without a complicated payment system, Smart Cards enable the various transit and planning agencies to better track ridership, transfers, and other information that can be used to plan for future transit enhancements.
T-1	A digital transmission link with a total signaling speed of 1.544 Mbps.
TAC	*Transportation Advisory Committee*.
TCC	*Traffic Control Center*. Sometimes used interchangeably with Traffic Operations Center (TOC). Strictly defined, TCCs primarily control traffic while TOCs are headquarters for enforcement, operations, and maintenance personnel. TCCs and TOCs often are combined functionally.
TCC	*Technical Coordinating Committee*.
TEA-21	*Transportation Equity Act for the 21st Century*
TMC	*Transportation Management Center*.
TMS	*Transportation Management System.*
Traffic Signal Systems	A system of interconnected traffic signals (signal controllers) whose major objective is to support continuous movement and minimized delay along an arterial or a network of arterials.
TRTMC	*Triangle Regional Transportation Management Center*

TTA	*Triangle Transit Authority*.
User Packages	A list of 63 technology groups that define ITS elements and projects. Where a Market Package defines a general goal of ITS, User Packages define the technologies and deployments that compromise the Market Package.
VRAS	*Voice Remote Access System*.
VMT	*Vehicle Miles Traveled*
WIM	*Weigh-In-Motion*.

Executive Summary

The North Carolina Department of Transportation (NCDOT) is developing a statewide Intelligent Transportation Systems (ITS) Strategic Deployment plan. The purpose of this plan is to develop a structured implementation of ITS projects by addressing the immediate and long-term transportation needs of the state.

Developing any statewide plan requires input from many sources, not just from a statewide board or agency. The statewide plan, therefore, is the result of several regional plans, developed through an aggressive stakeholder outreach program that invited the input from well over 1,500 people of different backgrounds. This document represents responses to the statewide plan from the stakeholders in the Piedmont Region

The process that was used throughout the development of the regional and statewide ITS deployment plans follows the requirements and direction of the National ITS Architecture (NIA), a framework that describes ITS components by their functionality and defines how these components are to work together as a system. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the systems, subsystems, and individual elements.

The Piedmont Region includes Rockingham, Moore, Stanly, Lee, Chatham, Franklin, Richmond, Granville, Stokes, Vance, Scotland, Person, Davie, Hoke, Anson, Montgomery, Caswell and Warren Counties and portions of Randolph, Rowan, Surry, Nash, Robeson, Yadkin, Halifax and Northampton Counties. The Piedmont Region includes the area surrounding the cities of Asheboro, Salisbury, Pinehurst, Oxford, Henderson and Laurinburg. Other cities in the Piedmont Region include: Reidsville, Eden, Southern Pines, Albemarle, Sanford, Pittsboro, Siler City, Louisburg, Rockingham, Hamlet, Roxboro, Mount Airy, Mocksville, Raeford, Spring Hope, Wadesboro, Pembroke, Yanceyville and Yadkinville. Although ITS is relatively new, there are many ITS deployments that are either fully functional, in construction, or in the planning stages throughout the Piedmont Region

From the stakeholder input process, the ITS Strategic Deployment Plan process identified 73 transportation needs. These needs were ranked by the regional transportation leaders to identify the most pressing issues, which in turn, permitted the use of the NIA to develop a regional ITS deployment plan and architecture that addressed these needs. From this process, it was determined that traveler information, truck safety, and commuter traffic were the most urgent issues. Short- and long-term project plans were then determined from the needs. The key component of the Piedmont Region ITS Deployment plan is the development of a central database of traveler information to be disseminated to motorists throughout the Region.

The concept of the Piedmont Regional architecture is that NCDOT controls most of the traffic operations equipment in the Region through rural workstations. External inputs, such as from the local signal systems, the Incident Management Assistance Patrol (IMAP) program and traffic information from the other traffic operations centers needs to be accessed, but not generated or stored locally. The concept of the architecture is that the NCDOT will share information both regionally and statewide to provide information that can be easily accessed from one concise front end.

Introduction

ITS are applications of advanced traffic operations and communications technologies used to improve safety, relieve congestion, and provide better information to travelers. The NCDOT has determined that a blueprint is needed to guide future deployment of ITS throughout the state. This guided deployment of ITS will result in an integrated, cost-effective plan that will increase motorist safety and security, preserve infrastructure and services, ensure transportation system efficiency, provide information, and increase economic development opportunities throughout North Carolina.

The statewide ITS Strategic Deployment plan will consist of a compilation of statewide needs and the needs gathered in nine Regional ITS Strategic Deployment Plans. This Piedmont Regional ITS Deployment plan represents one of those nine regional reports. To guide the future deployment of ITS technology in the state, NCDOT is developing a statewide ITS Strategic Deployment plan. This planning process has developed a structured implementation of ITS projects by addressing the immediate and long-term transportation needs in the state. The Department is committed to improving the safety and efficiency of North Carolina's transportation systems, including transit, rail, aviation, bicycle, and pedestrian, as well as highways.

Developing a statewide plan of any sort requires input from a broad base of stakeholders across the board, not just from a statewide board or agency. The statewide plan, therefore, will be the result of three rural and six urban regional plans. Each of these independent but coordinated plans has been developed through an aggressive stakeholder outreach program that invited input from approximately 1,500 people from different backgrounds who have important influence over or opinion on North Carolina's transportation system. This deployment plan takes into account the issues of previously developed area-wide plans as well as multi-modal plans from local agencies.

This is one of the three rural regional ITS Strategic Plans that is being developed in the state. The three rural regions are:

- Western Region
- Piedmont Region
- Eastern Region

The Piedmont Regional ITS Plan is intended to be a living document that represents a consensus of ideas and concerns from municipalities and other entities in this Region, the Division and other NCDOT representatives, and from a diverse group of stakeholders in the North Carolina transportation system.

Introduction to ITS

Increasing the capacity of the transportation network has traditionally been the responsibility of transportation planners, highway designers, and road builders. When a roadway neared capacity, the most frequent response by the NCDOT and other public agencies was to add additional lane miles. Today, as development increases, it is becoming increasingly difficult to add additional lanes without expensive right-of-way acquisitions. ITS has evolved over the last decade to describe a federal emphasis area for transportation systems. ITS also denotes a body of knowledge and discipline area among transportation systems, vehicle systems, and communication systems engineers. The federal program

was first authorized by the 1991 Intermodal Surface Transportation Act (ISTEA) and continued by the 1998 Transportation Equity Act for the 21st Century (TEA-21).

ITS is supported by all modal administrations within the United States Department of Transportation (USDOT), and by a broad-based professional association called ITS America, which acts as an official advisor on the ITS program to the USDOT and the various administrations of that department and other entities. The National Program Plan for ITS identified the following goals for the national program:

1. Widespread implementation of ITS to enhance the capacity, efficiency, and safety of the federal-aid highway system; to serve as an alternative to additional capacity of the federal-aid highway system; and to enhance development of intermodal connectivity.
2. Enhance, through the more efficient use of the federal-aid highway system, the efforts of several states to attain air quality goals established pursuant to the Clean Air Act.
3. Enhance the safe and efficient operation of the nation's highway system, particularly system aspects that will increase safety. Identify system aspects that may reduce safety.
4. Develop and promote ITS and the ITS industry in the United States.
5. Reduce social, economic, and environmental costs associated with traffic congestion.
6. Enhance U.S. industrial and economic competitiveness and productivity.
7. Develop a technology base for intelligent vehicle-highway systems and establish the capability to perform demonstration experiments, using existing national laboratory capabilities, where appropriate.
8. Facilitate the transfer of transportation technology from national laboratories to the private sector.

ITS, in short, is the use of advanced traffic operations technologies and communication technologies that help increase throughput on existing facilities, improve safety, and provide better and more accurate traveler information to the public.

Additional throughput occurs in many ways. Advanced traffic surveillance and signal control systems, for instance, have resulted in travel time improvements ranging from 8 to 25%. Incident management programs can reduce delay associated with congestion caused by incidents by as much as 45% and freight mobility systems have shown productivity gains of more than 25% per truck per day.

The following two examples illustrate the beginnings of ITS programs in North Carolina. At the rest areas associated with some of the welcome centers on interstate highways entering the state, traveler information kiosks promote tourist attractions, highway safety messages, highway construction zones, highway services, hotels, restaurants, etc.

These interactive traveler information kiosks provide printed directions to destinations and have the capability of downloading html files that could convey weather information, real-time traffic conditions, incidents, etc. They are a basic, in-place building block for an Advanced Traveler Information Systems (ATIS) in this Region. The same type of facility exists at several welcome centers in North Carolina and Tennessee. This private-sector partnership with the state is an excellent example of how ITS is already deployed, and is extremely popular with the tourism industry in the state.

The second example of an in-place component that relates to the ITS program is a freeway assistance service operated by the NCDOT along various portions of I-40 and I-85 in North Carolina. These service

patrols (part of the statewide IMAP service that exists in various districts of the NCDOT) provide emergency services such as gasoline, emergency starts, communications, etc. for stranded motorists. They also help to direct traffic around incidents. NCDOT trucks are equipped with communications equipment that could make them effective "vehicle probes" that provide traffic condition information to an information clearinghouse or to one or more of the regional Transportation Management Centers (TMC) in the Triangle, the Triad, or Charlotte (Metrolina).

Introduction to the ITS Strategic Planning Process

The process that is used throughout the development of the regional and statewide ITS deployment plans follows the requirements and direction of the NIA. The NIA is a framework that describes what ITS elements and systems do and how the different elements and control centers function together. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.

This section describes the process used to develop the deployment plan in the Piedmont Region.

ITS Planning Process

The general ITS planning process is shown in **Figure 1**. This methodology is described in detail in "Integrating Intelligent Transportation Systems within the Transportation Planning Process: An Interim Handbook" (FHWA, January 1998) and in the "Implementation Strategies" volume of the National Architecture. This process follows a direct path towards the development of a deployment plan.

The Regional and Statewide ITS Deployment Plans were developed through a multi-step process that meets the goals and objectives of the NIA. This process invites many stakeholders from multiple agencies to provide input into the planning process. In turn, this input is reduced into general and specific projects that form the overall regional and statewide plans.

It is the intent of the NIA that these regional and statewide plans consist of more than individual projects and technologies. The NIA was developed in response to the deployment of systems that were not compatible with one another by many state and local agencies. In addition, as these systems were being planned, designed, and deployed, neither future expansion nor interagency coordination were considered.

The NIA, therefore, is being used to foster communications between agencies with the goal of developing regional and statewide plans that facilitate interagency communication and coordination, as well as long-range visions that accommodate the future integrated growth of ITS in the Piedmont Region.

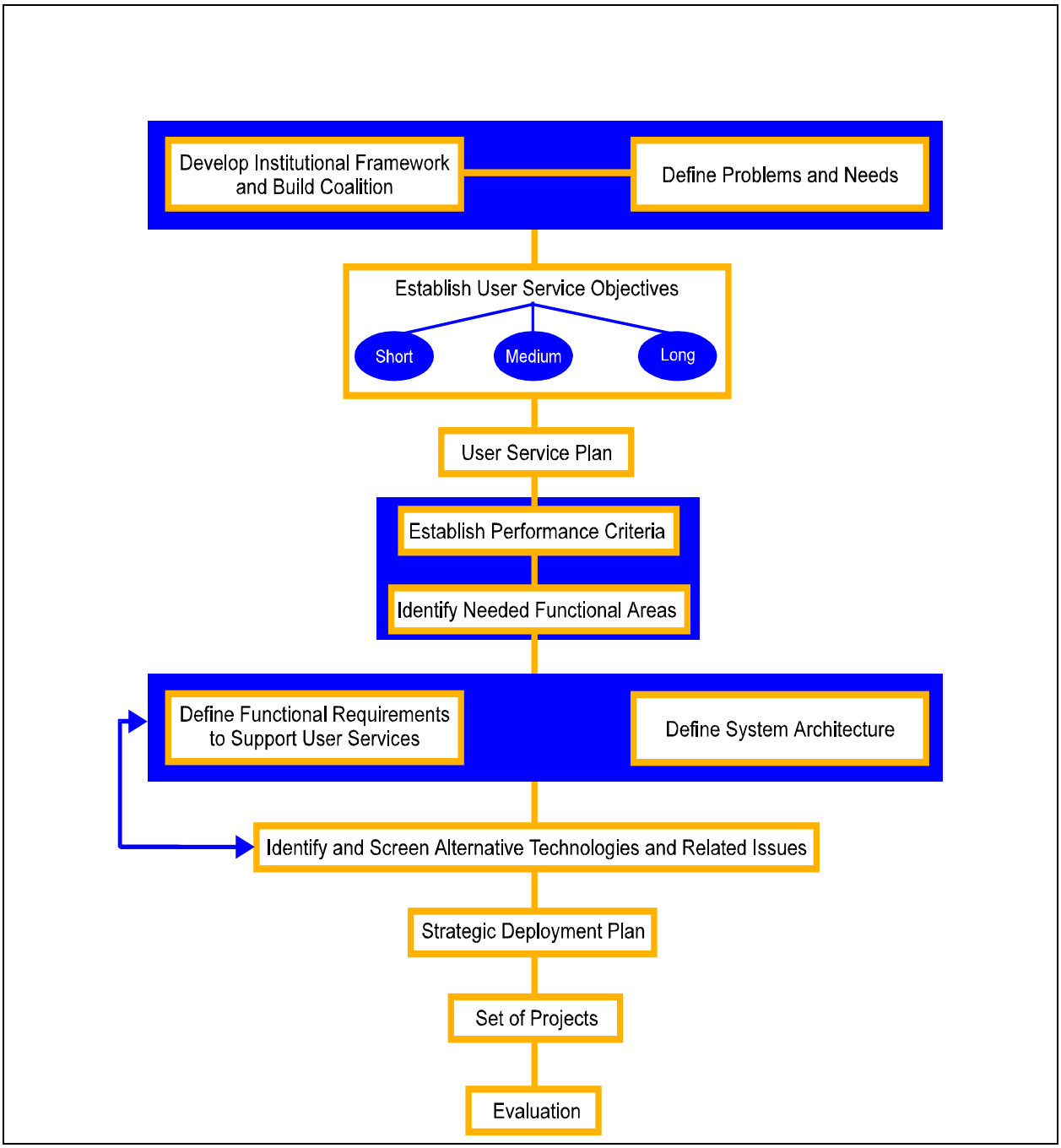

Figure 1. ITS Planning Process

Background

Project Background

Statewide

The population of North Carolina is growing. As the population grows, so, too, does the demand on the transportation system. This demand is seen throughout the state every day during the peak periods as commute times to and from work continue to increase. Recreational areas are experiencing similar congestion. The projected growth in vehicle miles traveled is shown in **Figure 2**.

The Federal Highway Administration (FHWA) has identified ITS as one of the key responses to congestion mitigation and incident response. ITS is typically more cost-effective than traditional methods of congestion mitigation, such as the addition of new lanes. It also provides tangible side benefits, such as constant data collection for use in planning and operational models.

The NCDOT has identified the need to continue expanding ITS throughout the state. Although there are pockets of deployments (such as traffic signal systems and freeway management systems), these deployments have not been coordinated and do not address all the statewide needs.

The purpose of this document is to demonstrate the need to improve the transportation system, identify ITS solutions, and provide a framework for continued deployment throughout the Region and state. This document will be used as part of an overall statewide plan.

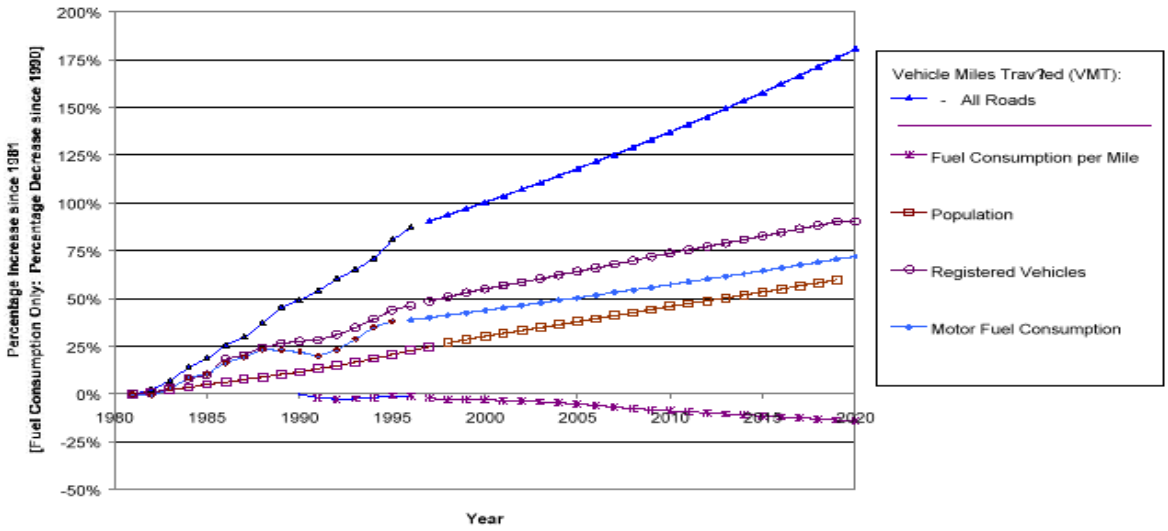

Figure 2. Projection of Key Transportation Indicators for North Carolina.

NCDOT Regional Plans

The North Carolina ITS Strategic Deployment Plan comprises nine regional plans, as shown in **Figure 3**. (the I-95 Region is included in the Statewide Report in the interstate system). These regions are grouped according to the ITS needs within each region. For instance, the needs in the Piedmont Region focus on commuter traffic and traveler information, while needs in the Interstate region focus on Commercial Vehicle Operations (CVO) and a combination of out-of-state travelers, local commuter travel, and truck routes. Each of the regions is comprised of multiple stakeholders and jurisdictions. These stakeholders include cities, counties, several field divisions within NCDOT, and metropolitan planning organizations (MPOs) for the state's 17 urban regions. Other interested organizations in rural regions include police, sheriff's departments, fire departments, county emergency management agencies, and rural transit agencies.

Through this process, nine regional plans will be developed (the Interstate Region is included as part of the Statewide Plan). All of these plans will be combined to develop a Statewide ITS Deployment Plan that will guide each of the agencies involved as well as NCDOT in the deployment of ITS in the coming years.

Project Goals and Objectives

The Piedmont Regional ITS Deployment Strategy must be compatible not only with the regional and local goals set forth by municipalities and counties in the region but also with statewide transportation goals and objectives and the national ITS goals.

Goals of the National ITS Program

The National ITS program was initially created through the ISTEA of 1991, when Congress recognized the critical need to address the aging transportation network. ITS was identified as one of the methods of improving the network.

Since then, the FHWA has been actively pursuing ITS as a key means to improving the safety and efficiency of the transportation system. The National ITS program also has been instrumental in developing the NIA. The NIA is a response to the increased deployment of ITS without clearly defined interoperability between either systems or subsystems.

The program was extended by the ITS Act of 1998, which was a part of TEA-21. This guidance has been effective in the ongoing development and integration of ITS elements.

TEA-21 contained four provisions concerning ITS, which provides funding for the six fiscal years covered by the Act:

- ITS Deployment – small incentive grants to states and local governments to encourage ITS integration and CVO infrastructure deployment

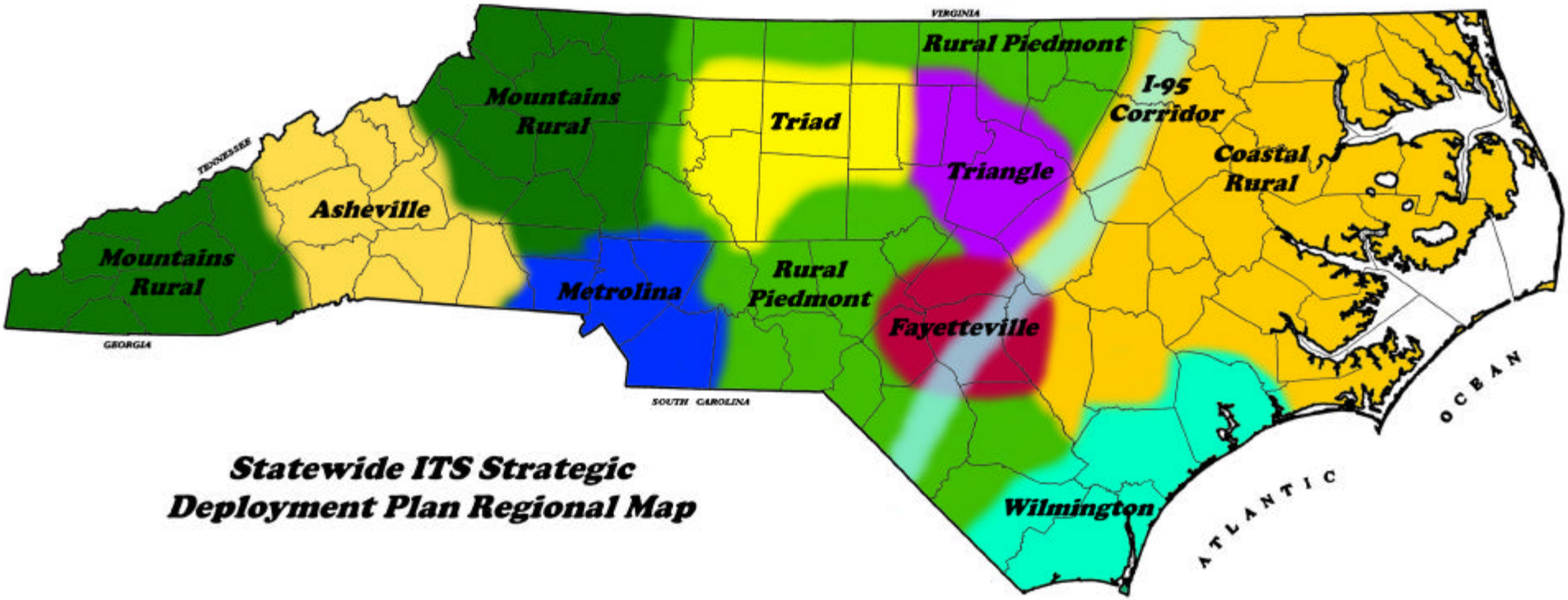

Figure 3. North Carolina ITS Strategic Deployment Plan Regions

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- ITS Integration – acceleration of the integration and interoperability of ITS
- CVO Infrastructure Deployment – advancing technological capability and promoting ITS in the trucking industry
- ITS Research and Development – specifically includes funding for ITS services, among other program areas

TEA-21 lists several requirements for project funding, including:

- Contribute to national deployment goals and objectives
- Demonstrate strong commitment among stakeholders
- Maximize private sector involvement
- Demonstrate conformity to NIA and approved ITS standards and protocols [2]
- Be included in statewide or metro area transportation plans
- Ensure continued long-term operations and maintenance
- Demonstrate that personnel have necessary technical skills

Statewide ITS Goals

The overarching goal of NCDOT's ITS program is to support the Department's mission to "provide and support an integrated transportation system and related services that enhance the State's well-being."

Adding specific goals for the statewide ITS program to this mission statement, the following guiding principles that support this overall mission have been identified:

- Increase motorist safety and security
- Preserve infrastructure and services
- Ensure transportation system efficiency
- Increase economic development opportunities
- Incorporate the ideas and concerns of a broad cross-section of stakeholders in the State's transportation system
- Provide both static and dynamic transportation information, including road conditions, closures, and incident status updates
- Develop a mechanism to facilitate the sharing of information between NCDOT and other public and private agencies

[2] Note that at the time of passage of TEA-21, and at present in early 2001, the NTCIP Protocols and other ITS Standards are not all in place and established standards

In addition to these seven goals that have guided the preparation of each of the nine regional ITS Strategic Plans in the State, there is an element of incorporating ITS technologies into the overall toolbox of solutions to transportation problems. The eight goals of the Department, and the objectives that ITS helps to fulfill to meet those goals, are as follows:

- Goal 1: Provide a safe and well-maintained transportation system that offers modal choices for the movement of all people and goods.

  ITS Objective: Use ITS technologies to provide information among modes of routes, schedules, incidents, fares, real-time vehicle tracking, and other traveler and shipper information.

- Goal 2: Provide quality customer service.

  ITS Objective: Use advanced technologies available in ITS solutions to provide "user friendly" interface between users and transportation systems and services.

- Goal 3: Develop efficient processes to provide quality transportation services.

  ITS Objective: Investigate ITS technologies and applications in appropriate projects to provide innovative and flexible solutions and incorporate those technologies where cost-benefit ratios are greater than other solutions.

- Goal 4: Demonstrate responsible stewardship of fiscal resources.

  ITS Objective: Compare ITS solutions to new capacity solutions in order to obtain the most cost-effective use of available funding.

- Goal 5: Demonstrate responsible stewardship of other resources.

  ITS Objective: Assess the environmental, energy consumption, aesthetic, and other impacts of ITS technology deployment as compared to other transportation solutions.

- Goal 6: Support the development of sustainable, vibrant communities.

  ITS Objective: Incorporate the entire ITS stakeholder base into local community efforts to support sustainable community initiatives.

- Goal 7: Maintain a quality workforce.

  ITS Objective: Use the technological skills of communications and electronics engineers to upgrade the level of technical expertise in the Department and upgrade other disciplines with cross-training in ITS technology applications.

- Goal 8: Make decisions in a manner that builds trust and mutual respect.

  ITS Objective: Develop strong, effective partnerships within the various units of the Department.

Regional ITS Goals

Two types of regional goals are identified in this document: short-term and long-term.

Short-term (2001-2006)

Short-term goals focus on improving safety and security for the traveling public in all modes of surface transportation, and increasing the quantity and quality of relevant, timely travel and traffic information to the public. Short-term goals also concentrate on building up the "human capital" resources with improved training of personnel in technical disciplines and the development of better, cost-effective ways of establishing partnerships among public agencies and between the public and private sectors to deploy ITS projects in the state. Specific short-term principles to apply as goals include:

- Increasing motorist safety and security
- Preserving infrastructure and services
- Ensuring transportation system efficiency
- Incorporating all stakeholders' input in the planning process

Long-term (2006-2010)

Long-term goals involve many larger projects that actually start in the short-term. These larger scope projects require a significant investment in infrastructure, planning, and coordination. A new, regional TMC, a network of advanced weather information stations, or a statewide weigh-in-motion (WIM) and truck safety system will be considered projects that fit under long-term ITS goals.

For example, in rural Arizona, the long-term goal is to deploy overhead dynamic message signs (DMS) at strategic locations with no more than approximately 50-mile intervals on all sections of rural interstate. These large, visible electronic signs would be used to convey weather information (critical in Arizona) and traffic information.

Long-term goals include all the principles applied in the short-term, plus:

- Increase opportunities for economic development

National ITS Architecture

All projects that will use federal ITS funds require the development of a regional and/or statewide ITS architecture that meets the needs and criteria set forth by the NIA. As such, the regional and statewide deployment plans require that an ITS architecture be developed. The process of developing an architecture is briefly discussed earlier in this document, in the ITS Planning Process section.

Stakeholder Input Process

Figure 1 shows the multiple steps that are involved in the stakeholder input process. The first step is to establish a stakeholder coalition to develop the vision and define the goals and objectives of the plan, as well as to identify any problems. The stakeholder input process involved multiple meetings and forums with key persons and agencies. Further information on the meetings and attendees is provided in the Appendix.

Despite differences among the regions with respect to how many meetings were held, in general, the meetings in each region occurred in the following order:

Regional Kick-Off/Consensus-Building Meeting. The first task in each region was to hold a regional kick-off/consensus-building meeting. These meetings typically included NCDOT representatives from the region, city and local transportation planners and engineers, and other interested key individuals. The intent of these meeting was to briefly introduce the project and overall statewide goals, customize the deployment planning process for each region, and identify the key public and private stakeholders within the region.

Planning Sessions. Multiple presentations occurred after the project kick-off meeting and prior to the summit meeting in each region. These presentations typically included briefings of the Technical Coordinating Committee (TCC) and Transportation Advisory Committee (TAC) in each region, and the presentation of ITS information to other key transportation groups and officials in the region. The purpose of these presentations and briefings was to promote ITS goals, provide a brief overview of the benefits of ITS, and inform people about the upcoming summit in the region.

Regional Summit. Regional summits were held in eight of the nine regions. Stakeholders in the regions were invited to these half-day events that featured a presentation of the project background, information regarding the benefits of ITS, and an opportunity for the stakeholders to share and document their key issues. Due to the size of the Piedmont Region, a summit was not held for the Region as attendance from a broad base of stakeholders was not likely. Therefore, user needs in the Piedmont Region were derived from several meetings with stakeholders throughout the Region.

Typical Needs Identified by Travelers in Rural Areas

A project in Ohio, along a rural 100-mile stretch of I-77 performed in late 1998 interviewed a random sampling of drivers comprising approximately 200 privately owned vehicle operators and 100 commercial vehicle operators, about the needs of travelers in rural areas.

The following tables are representative of the concerns of travelers on rural interstate highways. I-77 from Columbus to Cleveland is a 100-mile stretch through a major agricultural region of Ohio. This section of interstate has a high level of truck traffic of about 35 percent, and does not pass directly through any urban area throughout its entire 100-mile length.

Table 1. Problems Identified by POV Travelers[3]

Identified Problems	Frequency of Travel on this Interstate Highway		
	> once per week	1 to 4 times per month	< once per month
	Percent identifying problem		
None identified	39	41	40
Lack of maintenance	17	26	19
Construction zones	21	3	11
Differential speed limits	4	-	5
Accidents	9	9	-
Too strict enforcement	4	3	2
General congestion (over capacity)	-	20	10
Wide load/heavy machinery transport	4	-	-
Signs	-	3	8
Uneducated or inattentive drivers	-	9	6
Ramps/bridges	13	3	-
Truck-related	13	26	15

Table 2. Solutions Suggested by POV Travelers [3]

Suggested Solutions	Frequency of Travel on this Interstate Highway		
	> once per week	1 to 4 times per month	< once per month
	Percent identifying solution		
None mentioned	56	65	54
Better maintenance	4	3	2
Project scheduling	4	-	-
Construction at night	4	-	-
Uniform speed limit	4	-	-
Uniform 65 mph	4	-	3
Restrictions on oversized loads	4	-	-
More enforcement	-	3	2
3 lanes	17	22	8
Truck lane	9	3	5
Trucks drive at night	-	3	-
Better/more signs	-	9	6
High-speed rail	-	3	2
Driver education	-	3	-
More interchanges	4	-	-
Aesthetic improvement	-	3	-

[3] Based on interviews performed by Kimley-Horn with 200(+) rural Interstate travelers in Ohio in 1998

Table 3. Problems Identified by Truck Travelers[3]

Identified Problems	Frequency of Travel on this Interstate Highway		
	> once a week	1 to 4 times per month	< once a month
	Percent identifying problem		
None identified	14	13	24
Lack of maintenance	15	3	7
Construction zones	26	20	7
Differential speed limits	47	43	38
Accidents	7	4	-
Too strict enforcement	13	20	3
General congestion (over capacity)	35	33	28
Wide load/heavy machinery transport	4	-	7
Signs	-	1	3
Uneducated or inattentive drivers	25	9	3
Ramps/bridges	1	-	-
Weather-related	10	3	-
Over-crowded weigh stations	6	6	3
Crime in rest areas	7	1	-
Truck stop/rest area parking capacity	-	15	10

Table 4. Solutions Suggested by Truck Travelers[3]

Suggested Solutions	Frequency of Travel on this Interstate Highway		
	> once a week	1 to 4 times per month	< once a month
	Percent identifying problem		
None mentioned	21	39	34
Better maintenance	8	5	7
Construction at night	3	-	-
Uniform speed limit	28	20	24
Increased truck speed limit	18	20	21
Better incident management	-	-	3
Reduced enforcement	7	10	3
3 lanes	25	15	17
Truck lane	3	3	-
Alternate route	1	1	-
Pull-off areas	-	1	-
Better/more signs	-	1	3
Variable message signs	-	-	7
Real-time radio reports	1	-	-
Electronic clearance/weigh-in-motion	6	4	3
Driver education	6	3	3
Require CDL for RVs	1	-	-
Improve interchanges	1	-	-
Increase capacity at rest areas	-	8	10

The questionnaire used on these rural travelers was open-ended with respect to the identification of both problems and solutions. Based on the results of the survey, the commercial vehicle operators were more inclined to identify realistic solutions to problems they encountered. Several of the solutions identified by this group of 104 truckers related to possible application of ITS technologies.

These solutions include applications of separate truck lanes, alternate routing, variable message signs, real-time radio reports, electronic clearance, weigh-in-motion, use of rest areas, and better incident management. Approximately 50 mentions of these types of solutions (in 104 interviews) indicates a fairly high level of trust and interest in applications of advanced technology to make highway travel safer and more efficient.

User Services and Market Packages

The goal of the stakeholder process was to develop a strategic plan of projects that can be implemented that also meet the transportation needs expressed by the stakeholders. Through the development of the NIA, the FHWA has identified 31 user services for urban areas, and 63 market packages that describe projects, and also identifies the information that must be shared between the various components. The process of identifying user services is shown in **Figure 4**.

Selecting the appropriate user services and market packages can develop the overall system architecture. Grouping these market packages together produces the overall system architecture and shows the data that must pass between elements and agencies. The user services generate categories of projects, such as traveler information. The market packages are more specific types of projects.

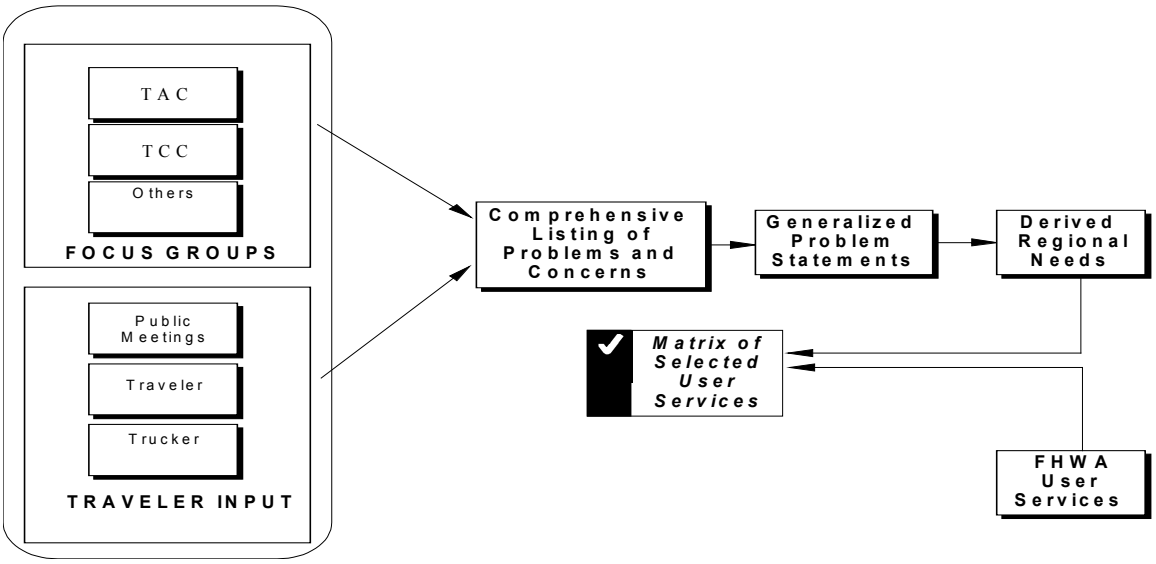


Figure 4. Identification of Needs and User Services

There are some differences between ITS programs and technologies deployed in rural and smaller urban areas than in the major urban areas of this state or any other state. The emphasis areas in urban regions focus on incident management and congestion relief. In rural areas, the emphasis is on providing additional information to tourists and other travelers, advising travelers of approaching weather conditions, and reaching accident victims in remote locations. The differences in the urban area user service groups and the rural market clusters are defined in **Table 5**.

Table 5. Listing of User Service Groups and Rural Critical Program Areas

User Service Groups	Rural Critical Program Areas
Travel and Transportation Management	Traveler Safety and Security
Travel Demand Management	Tourism and Travel Information Services
Urban Transit Systems	Public Traveler/Mobility Services
Emergency Notification & Emergency Management	Emergency Services
Electronic Payment Services	Fleet Operations & Management
Commercial Vehicle Operations (CVO)	Commercial Vehicle Operations (CVO)
Advanced Safety and Control Systems	Infrastructure Operations and Maintenance

There are seven critical program areas within ITS. Those seven programs are:

Traveler Safety and Security - Technologies use a in-vehicle sensors and information systems to alert drivers to hazardous conditions and dangers. This program features wide-area information dissemination of site-specific advisories and warnings.

Tourism and Travel Information Services - Use in-vehicle navigation and roadside communication systems to provide information to travelers who are unfamiliar with the local areas. These services can be provided at specific locations, en-route, or prior to departure.

Public Traveler/Mobility Services - Improves the efficiency of transit services and their accessibility to residents. These services include better scheduling, improved dispatching, Smart Card readers and payment, and computerized ride-sharing systems.

Emergency Services - Use satellites and advanced communications systems to automatically notify the nearest police, fire, or rescue squad in case of collision or other emergency.

Fleet Operations and Management - Improves the efficiency of fleets of vehicles that operate in urban and rural areas, such as utility readers, package delivery services, mail carriers, law enforcement, etc.

CVO - Satellites, computers, and communications systems manage the movement and logistics of commercial vehicles, and locate and track these vehicles during emergencies.

Infrastructure Operations and Maintenance - Improve the ability of highway workers to maintain and operate urban and rural streets more efficiently. These services include severe weather information and immediate detection and alerting the public to dangers such as the presence of work zone crews.

The NIA list 63 potential ITS market packages to go with these critical program areas. A list of the 28 market packages (out of the 63) that are potentially applicable to North Carolina's Piedmont Region include those shown, following, in **Table 6**:

Table 6. Probable ITS Market Packages Based on Typical Needs in Rural Areas

Critical Program Areas	**Specific Rural ITS Market Packages** (Taken from the *ITS National Program Plan and National Architecture*, as amended)
Traveler Safety and Security	Traveler Security Intersection Safety Warning Intersection Collision Avoidance
Tourism and Travel Information	Broadcast Traveler Information Interactive Traveler Information Yellow Pages and Reservations Autonomous Route Guidance In-vehicle signing
Public Traveler/Mobility Services	Multimodal Traveler Information Demand Response Transit Operations Transit Passenger and Fare Management Transit Security Transit Maintenance
Commercial Vehicle Operations	CVO Fleet Administration/Coordination Freight Administration Fleet Administration Electronic Clearance HAZMAT Management
Emergency Services	Emergency Response Emergency Routing MayDay Support
Infrastructure Operations and Maintenance	Incident Management Traffic Information Dissemination Probe Surveillance Traffic Forecast and Demand Management Advanced Railroad Grade Crossing Road Weather Information System
Other	ITS Planning

The following example illustrates the benefit of this categorization of market packages. The Piedmont Region identified the issue of providing traveler information by using kiosks. Various types of two-way communications devices were discussed. These transportation information needs were translated into consolidated information that can be provided to the traveling public with two-way capability. One of the affected ITS critical program areas includes Tourism and Traveler Information as the major component.

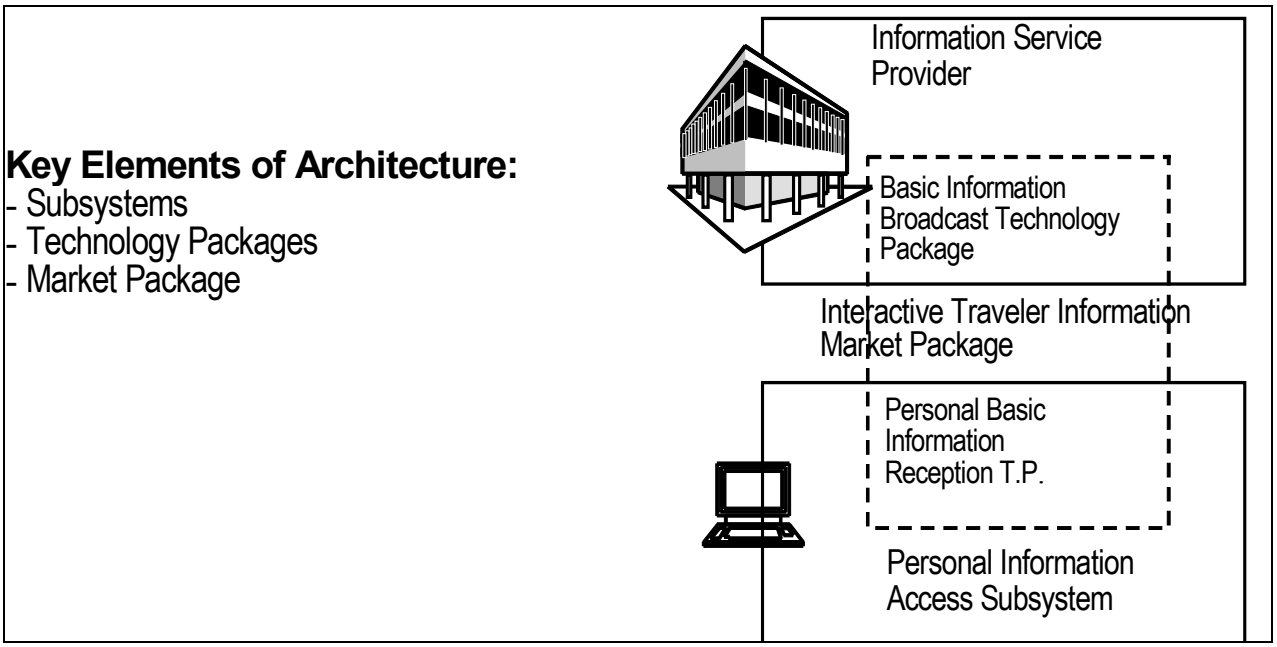
Within the Tourism and Traveler Information program area, for example, the following market packages were determined to be applicable:

- Broadcast traveler information
- Interactive traveler information
- Yellow pages and reservations
- Autonomous route guidance
- In-vehicle signing

By identifying these five as the primary market packages to meet the needs of rural area travelers, the specific data and communication issues can be identified at an early step. The way that subsystems, technology packages, and market packages fit together in a regional ATIS architecture is shown in **Figure 5**.

The interactive traveler information market package exemplifies the market packages that are applicable to rural regional ITS architectures. This market package provides tailored information in response to traveler requests. Users can request and obtain current information on traffic conditions, traveler services, and parking. A range of two-way, wide-area wireless, and wireline communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route including plain old telephone (POT) service; traveler information kiosks in welcome centers, truck stops, etc.; Personal Digital Assistant (PDA); home computers; and a variety of in-vehicle devices.

Figure 5. Relationship of Market Packages, Technology Packages, and Subsystems.



The successful deployment of this market package relies on the availability of real-time transportation data from the Transportation Management System (TMS) or Transportation Regional Management System (TRMS). This market package also requires an entity (or entities) to process and disseminate the information - the information service provider (ISP). The ISP interfaces with the remote traveler support subsystem and personal information access subsystem to receive individual travelers' requests and respond with information.

Figure 6 shows the Interactive Traveler Information market package. Note that the information flows to the vehicle are displayed with dotted lines. This interface will probably not be available until the mid- or long-term timeframe (depending upon how quickly services become available nationally).

The user services and market packages are traceable directly to the architecture definition. Once a market package is selected for implementation, the required subsystems, equipment packages, and interface requirements may be identified. The benefit of this approach is that it allows the agency or organization deploying the technology to first consider deployment options and later concentrates on those pieces of the architecture necessary to support the selected deployment.

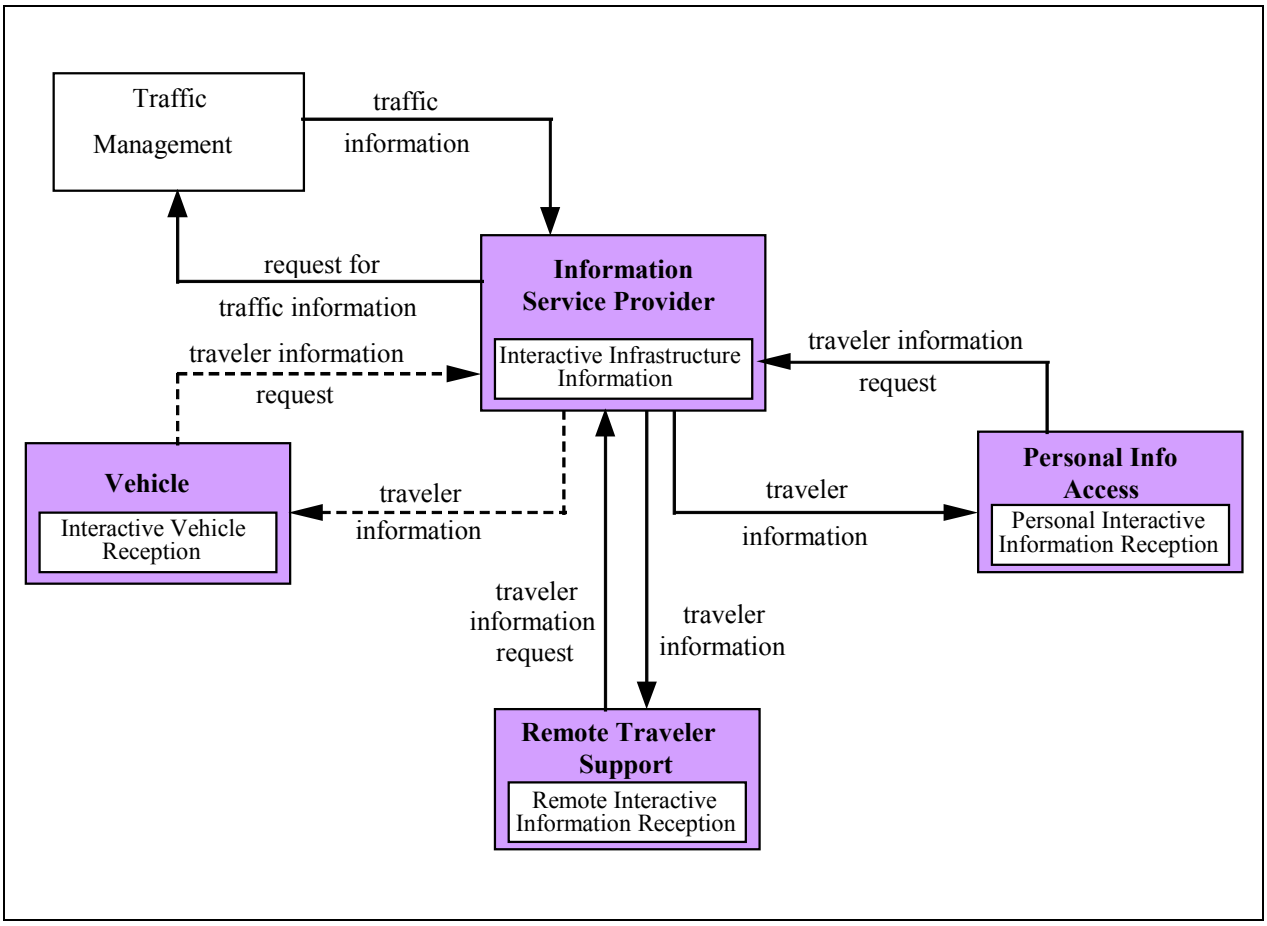


Figure 6. Interactive Traveler Information Market Package

Regional Overview

The Piedmont Region encompasses Rockingham, Stanley, Lee, Chatham, Franklin, Richmond, Granville, Stokes, Vance, Scotland, Person, Davie, Anson, Montgomery, Caswell, Warren, Rowan counties and portions of Hoke, Moore, Randolph, Robeson, Harnett, Bladen, Columbus, Surry, and Yadkin, counties. It has a population of approximately 1,387,000 people, and includes the area surrounding the cities of Asheboro, Salisbury, Pinehurst, Oxford, Henderson and Laurinburg. Other cities in the Piedmont Region include: Reidsville, Eden, Southern Pines, Albemarle, Sanford, Pittsboro, Siler City, Louisburg, Rockingham, Hamlet, Roxboro, Mount Airy, Mocksville, Raeford, Spring Hope, Wadesboro, Pembroke, Yanceyville and Yadkinville. The Piedmont Region includes portions of NCDOT Divisions 5, 6, 7, 8, 9, 10 and 11. The major cities, roadways, and other key features of the Region are shown in **Table 7**.

Table 7. Piedmont Region General Information

County	NCDOT Div.	Population (est. 1999)	CITIES AND TOWNS	Primary State and Federal Highways	Other Notable Features
Anson	10	24,200	Wadesboro*	US 52, US 74	Pee Dee Nat'l. Wildlife Refuge
Blanden	6	30,900	Elizabethtown*	US 701	
Caswell	7	22,400	Yanceyville*	US 158, NC 62, 86	
Chatham	8	46,500	Siler City Pittsboro*	US 64, 15/501, 421, US 1	Jordan Lake State Rec. Area
Columbus	6	53,000	Whiteville*	US 74/76	
Davie	9	32,700	Mocksville*	I-40, US 158, 64, 601	Tanglewood Park (Forsyth Co.)
Franklin	5	45,600	Franklinton Louisburg*	US 1, US 401, NC 56	Sandhills
Granville	5	44,600	Oxford*	I-85, US 15, 158, NC 96	Camp Butner (Fed. and State institutional use)
Harnett	6	72,000	Lillington*	US 401, US 421	Cambell Univeristy
Hoke	8	31,300	Raeford*	US 401	Fort Bragg Military Reservation
Lee	8	49,500	Sanford*	US 1, US 421, 15/501	Lee Co. Recreation Playhouse
Montgomery	8	24,300	Troy*	US 220, NC 109, 134, NC 24/27	Uwharrie Nat'l. Forest, Town Creek State Historic Area
Moore	8	72,900	Southern Pines Pinehurst,Carthage*	US 1, US 15/501, NC 24/27	Pinehurst area golf resorts, Sandhills Comm. College
Person	5	33,900	Roxboro*	US 158, 501, NC 49	Hyco Lake recreation area, Mayo Lake recreation area
Randolph	8	123,400	Asheboro*	US 64, 220, 311, NC 49	NC Zoological Park
Richmond	8	45,700	Rockingham*,Hamlet	US 1, US 74, 220	Rockingham Motor Speedway
Robeson	6	116,597	Lumberon*, Pembroke	I-95, US 301, US 74	UNC Pembroke
Rockingham	7	90,300	Eden, Reidsville Wentworth*	US 29, 158, 220	Chinqua-Penn Plantation State Historic Park
Rowan	9	126,600	Salisbury*, Spencer	I-85, US29/70,601, 52	High Rock Lake recreation area
Scotland	8	35,900	Laurinburg*	US 15/501, 74	Laurinburg Institute
Stanley	10	56,500	Albemarle*	US 52, NC24/27, 73	Badin Lake recreation area, Morrow Mtn. State Park
Stokes	9	43,900	King, Danbury*	US 311, NC 89, 66	Hanging Rock State Park
Surry	11	68,000	Elkin Mt. Airy*	I-77, US 52, 601	Pilot Mtn. State Park, Horne Creek Historical Park, Blue Ridge Mtns.
Vance	5	42,500	Henderson*	I-85, US 1, 158	Kerr L. State Rec. Area
Warren	5	18,900	Warrenton*	I-85, US 1, 158, 401	Lake Gaston Rec. Area
Yadkin	11	35,200	Yadkinville*	I-77, US 421, 601	Gateway to Blue Ridge

* Indicates county seat.

Overview of ITS in the Region

Although relatively new, there are many ITS deployments that are either fully functional, in construction, or in the planning stages throughout the state. As part of the process, an inventory of all of these projects was performed. **Table 8** lists the deployed, planned, and programmed ITS projects in the Piedmont Region

Table 8. Piedmont Region Existing ITS Deployments

LEGEND
Existing
Planned/Under Construction

Incident Management

- 1 Changeable Message Sign on I-85 northbound in Orange County
- 1 Changeable Message Sign on I-85 southbound in Vance County
- 6+ portable Changeable Message Signs

Traffic Signal Cont

Closed Loop Signal Systems
Barnes Street at US29 in Reidsville – 4 signals (R-2560)

Enforcement

- Franklin Co. Sheriff- Computer Dispatching
- Vance Co. Sheriff
- Warren Co. Sheriff
- Granville Co. Sheriff
- Person Co. Sheriff- Computer Dispatching
- Caswell Co. Sheriff

Fire/Rescue

- Caswell Co. Emergency Management
- Vance Co. Fire Department
- Warren Co. Emergency Management
- Person Co. Emergency Service- Computer Dispatching
- Granville Co. Emergency Mgnt./Fire Marshal-
- 1 Computer in vehicle

Regional Traveler Information

- 1 Highway Advisory Radio on I-85 in Orange County
- 1 Highway Advisory Radio on I-85 in Vance County
- 2+ portable Highway Advisory Radios

Regional Strategic Deployment Plan Process

Meetings

Due to the size of the Piedmont Region, a summit was not held for the Region as attendance from a broad base of stakeholders was not likely. Therefore, user needs in the Piedmont Region were derived from several meetings with stakeholders throughout the Region. The meetings provided an overview of the entire project as well as the process for the regional and statewide plans. The meeting included a discussion of project specific issues, including:

- The perception of ITS in the Region
- Comments on the proposed process
- Identification of the stakeholders

The discussion helped to identify some of the key aspects of the project that needed to be carried forward throughout the process. The following formal meetings were held in the Piedmont Region:

- Division 8 - February 7, 2000
- Salisbury Interagency Team - February 16, 2000
- Divisions 5 and 7 - February 22, 2000 in Reidsville
- Salisbury Regional Team - February 23, 2000

Additionally, multiple informal meetings were held both in person and via phone with the Division traffic Engineers in the various Divisions in the Region, as well as other stakeholders throughout the Region.

Identification of Transportation Needs or Issues

Based on information gathered during the meetings, a composite list of user needs was developed. The resulting 54 users needs gathered from groups within the Piedmont Region can be seen in **Table 9**. **Table 9** also includes 19 unique user needs from “other input sources” which represents information gathered from other states and North Carolina statewide needs, for a composite list of 73 user needs for the Region. The identified user needs resulted in the development of four key program areas for the Piedmont Region:

- Safety improvements
- Congestion/mobility/traffic management
- Traveler information
- Provider Information

These 73 user needs shown in the four groupings or subcategories are shown in **Table 9.**

Table 9. Composite of User Needs in Piedmont Region from all Sources

	Reidsville	Salisbury	Other NC Regions	Other Sources
Safety Needs				
Safety on secondary roads at unsignalized intersections	X			
Safety at highway-rail grade crossings	X	X		
Improve commercial vehicle weight operations and law enforcement	X			
Improve commercial weight detection & enforcement and quicker clearance at ports-of entry	X			
Real-time weather information, fog detection, and early warning of reduced visibility				X
Improved safety for construction workers in highway work zones				X
Safety and security at rest areas, welcome centers, and 24-hour information availability				X
Means to detect emergencies in remote areas				X
Weather information, fog detection,			X	
Communication between snow plows and law enforcement			X	
Real-time information from Highway Patrol			X	
Closed loop Signal Systems, other isolated signals			X	
Traffic Hot Spots			X	
Areas prone to truck accidents		X	X	
Pedestrian safety			X	
Emergency services on two-lane roads			X	
Alternate routes for emergency responders			X	
Congestion/ Mobility/ Traffic management Needs				
Congestion on commuter routes	X	X		
Congestion around large developments, major interchanges	X	X		
School bus and bus route location planning, drop-offs, etc.	X		X	
Lack of fixed route/demand responsive regional transit	X			
Signal preemption for emergency vehicles	X			
Poor traffic signal coordination	X			
Information on conditions on alternate routes, managing traffic on local roads and streets		X	X	
Emissions reduction, managing peak hour traffic		X	X	
Bike trail information (e.g., specifically proposed for US 421 corridor)			X	
General congestion (e.g resort and recreation areas, lakes, etc.)			X	
Public transportation, pedestrian needs, park&ride, rideshare		X	X	
Transponders on trucks to by-pass weigh stations (e.g., PrePass)				X
Relief from truck congestion at over-crowded rest areas and welcome centers				X
Region-wide communications infrastructure				X
Real-time, continuously maintained traffic and roadway conditions database				X
Reduce delays and secondary incidents				X
Traveler Information Needs				
Traveler Info Kiosks (@ Rest areas, truck stops, hotels, Super K, CVBs & Chambers of Commerce, malls, Old Salem, Pilot Mtn. SP, Hanging Rock SP., recreation & other areas)	X	X	X	X

Convenience of use of transportation system	X			
Information on park-and-ride, rideshare facilities	X	X		
Regional traveler information on the Net	X	X		
Communications including e-mail to CVO providers, dispatchers, trucks in transit, etc.			X	
Higher frequency for HAR, tourist information on HARs			X	
Permanent Dynamic Message Signs (DMS)			X	
Portable Dynamic Message Signs (DMS)			X	
Smaller DMSs on shoulder mounts			X	
Better directional signing, speed limit, pedestrian warnings			X	
Information on construction, weather, road conditions,			X	X
Construction information to travelers			X	
Ski and tourist information			X	
Information to through-travelers (e.g., on Interstates)			X	
Central phone number for traffic information (511)	X			
NCSMARTLINK Website	X	X		
Link local, regional websites to NCSMARTLINK and MAPQUEST			X	
Link traffic information to local TV, Cable			X	
Transit information, AMTRAK on SMARTLINK			X	
Flashing “Tune to AM XXX” signs for HAR			X	
Balance between HARs and DMSs			X	
24-hour per day, accurate pre trip and en-route traveler information				X
Real-time alternate route guidance				X
Broadcast traffic conditions				X
A statewide TOC or information clearinghouse with current traveler and road conditions				X
Expand the NCSMARTLINK web-based real-time traffic information				X
More efficient integration of transit with other modes				X
Provide access to up-to-date traveler information at public venues				X
Electronic yellow pages at highway stops and en-route				X
Improved bandwidth/increased number of channels on communications infrastructure				X
Provider Information Needs				
Lack of computer dispatch & mobile data terminals for emergency response, fire & police	X			
Regional and multi-state incident management planning, response and information			X	
Communications links to other state DOTs (TN, VA, SC, GA)			X	
Information on major events that affect road closings for construction			X	
Collect and share traffic crash data, conflict analysis results		X	X	
Detour route information to emergency responders			X	
Interagency coordination and communications	X	X	X	
Eliminate traffic delays at cross-jurisdictional boundaries			X	X
Data sharing between agencies for improved traffic management and planning		X		X
New/revised maintenance measures for ITS technologies				X

Many needs that were not specifically identified in the Piedmont Region have been identified in one or more of the other rural regional meetings. In addition, some needs that apply to urban areas also apply to

the rural areas. Some of these needs, as identified in other urban and rural regions, have been identified as “linkages” to statewide or “extra-regional” needs. Some of those needs cross the statelines. The “inter-regional linking” needs that resulted from other regions are identified below:

Congestion/Mobility/Traffic Management

- Real-time, continuously maintained traffic and roadway conditions database
- Reduced delays and secondary incidents

Traveler Information

- 24-hour, accurate pre-trip and en-route traveler information
- Real-time alternate route guidance
- Broadcast traffic conditions
- A statewide TMC or information clearinghouse with current traveler and road conditions
- Expand the SMARTLINK web-based, real-time traffic information
- More efficient integration of transit with other modes
- Access to up-to-date traveler information at public venues

Inter-agency and inter-jurisdictional data exchange (Provider Information)

- Elimination of traffic delays at cross-jurisdictional boundaries
- Data sharing between agencies for improved traffic management and planning
- New/revised maintenance measures for ITS technologies

SOCIO-ECONOMIC FACTORS

The Piedmont Region encompasses 26 different counties in the piedmont area of North Carolina, which is located in the middle of the state. The Piedmont Region stretches through the entire state, bordering Virginia and South Carolina. By considering the Region’s socio-economic factors, the proper ITS deployment packages can be chosen to benefit the area.

The northern part of the Region receives 10” to 12” of snowfall a year. This can cause dangerous driving conditions and result in accidents. Computer aided dispatching (CAD), vehicle location, and vehicle GPSs could be used to accelerate the response times to accidents. An improvement in road weather information system coverage, a real-time website, and kiosks that give weather information at rest stops and stores could help in warning the public about coming storms.

In some parts of the Region, such as Davie and Rockingham County, the vehicle registration has shown a significant increase – approximately 60 percent over a ten-year period. If this trend continues, potential traffic congestion problems could arise. Therefore, these areas should take action with ITS technology to guard against future problems. HOV lanes, signal system upgrades, real-time information via kiosks and websites, en-route access to traffic information, etc. could be employed to lessen the effects of increased vehicles in the area.

The Piedmont Region has a diverse population. Many retirees live in the Sandhills area; Moore County, for example, has approximately 18% of their population over 65. An aging population requires an efficient

transportation infrastructure to permit fast response times to emergency vehicles. Examples include expanding 911 coverage, ensuring coverage of the statewide 800 MHz radio system, and developing a computer aided dispatch system. These systems are all intended to induce faster response times because of the increased chance of health problems for those over age 65.

To develop a regional ITS architecture, this information was grouped into market packages. This process is described in detail in the Appendix.

Regional Strategic Plan

The basic premise for this ITS strategic deployment plan is to identify the transportation problems and needs in North Carolina and to select ITS technologies that can be used to address these needs. The ITS technology selection process begins with identifying appropriate ITS user services. User services represent functions performed by ITS technologies and organizations for the direct benefit of the traveling public.

The national ITS program plan defines the term *users* as: "a wide range of individuals and organizations including drivers, travelers, service providers, and transportation policy makers." The NIA currently defines 31 user services. To better address rural issues, the Advanced Rural Transportation Systems (ARTS) program introduced six additional user services. **Table 10** lists all 37-user services listed in the NIA and also provide a brief definition.

Table 10. ITS User Services (* ARTS User Service)

1	Pre-Trip Travel Information	*Provides info for selecting the best transportation mode, departure time, & route.*
2	En-Route Driver Information	*Provides advisories and in-vehicle signing for convenience and safety.*
3	Route Guidance	*Provides travelers with instructions on how to reach their destinations.*
4	Ride Matching and Reservation	*Makes ride sharing easier and more convenient.*
5	Traveler Services Information	*Provides a business directory, or "yellow pages," of service information.*
6	Traffic Control	*Manages the movement of traffic on streets and highways.*
7	Incident Management	*Helps quickly identify incidents and implement a response.*
8	Demand Management and Operations	*Supports policies to mitigate the environmental/social impacts of traffic.*
9	Emissions Testing and Mitigation	*Provides information for monitoring air quality.*
10	Highway Rail Intersection	*Provides improvements to automated crossing control systems.*
11	Public Transportation Management	*Automates operations, planning, and management of public transit.*
12	En-Route Transit Information	*Provides information on public transportation after the trips begins.*
13	Personalized Public Transit	*Provides flexibly routed transit to offer more convenient service.*
14	Public Travel Security	*Creates a secure environment for transportation patrons and operators.*
15	Electronic Payment Services	*Allows travelers to pay for transportation services electronically.*
16	CVO Electronic Clearance	*Facilitates domestic and international border clearance.*
17	Automated Roadside Safety Inspection	*Facilitates roadside inspections.*
18	On-Board Safety Monitoring	*Senses the safety status of a commercial vehicle, cargo, and driver.*
19	CVO Administrative Processes	*Provides electronic purchasing of credentials, etc.*
20	Hazardous Material Incident Response	*Provides immediate description of hazardous materials.*
21	Commercial Fleet Management	*Provides communication between drivers, dispatchers, and providers.*
22	Emerg Notification and Personal Security	*Provides immediate notification of an incident and immediate request for assistance.*
23	Emergency Vehicle Management	*Reduces incident response time for emergency vehicles.*
24	Longitudinal Collision Avoidance	*Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.*
25	Lateral Collision Avoidance	*Helps prevent collisions when vehicles leave their lane of travel.*
26	Intersection Collision Avoidance	*Helps prevent collisions at intersections.*
27	Vision Enhancement for Crash Avoidance	*Improves the driver's ability to see roadway and objects that are on or along the roadway.*
28	Safety Readiness	*Provides warnings about the condition of the driver, vehicle, and roadway.*
29	Pre-Crash Restraint Deployment	*Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.*
30	Automated Vehicle Operation	*Provides a fully automated hands-off operating environment.*
31	Archived Data User Service	*Provides for automated historic data archiving and sharing.*
32*	Portable Traffic Management	*Traffic surveillance and control that is flexibly and speedily deployable, for highway and traffic conditions that are accidental, sporadic or seasonal.*
33*	Road Maintenance and Management	*The efficient maintenance and rapid repair of roads.*
34*	Seasonal Harvesting	*The coordination of intermodal transportation resources and agricultural production.*
35*	Economic Development (Business Viability)	*The improvement of transportation efficiency, the reduction of adverse transportation impacts.*
36*	Economic Development (Tourism)	*The dissemination of information that promotes compatible enjoyment of parks other tourist sites, and services to tourists.*
37*	ITS Planning and Marketing Data	*The collection & processing of info derived from the operation & valuation of ITS.*

Regional Plan Development Methodology

The objective of this task was to determine, based on stakeholder input, which of the 37 ITS user services were candidate user services to be implemented in the Piedmont Region and how to phase their implementation (i.e., in the short- or long-term timeframes). Since delivering a user service takes more than just one piece of equipment, the ITS architecture groups equipment into market packages.

While user services help us define what is needed, their corresponding market packages describe how to provide those services. Each market package consists of a group of elements (equipment packages) that work together to deliver a particular user service. To identify the specific technology groups that will be needed to provide the selected user services, market packages corresponding to each selected user service were identified in this task.

The activities of this task were divided into three steps aimed at producing a well-defined, integrated user service plan:

- Development of specific user objectives and performance criteria
- Selection of market packages
- Identification and prioritization of applicable user services based on previously identified transportation needs of the rural regions and development of user services deployment timeframes

The following section describes the above steps in more detail. The remainder of this section provides a complete description of each activity associated with these steps.

The first step in this task focused on identifying the user services appropriate for the Piedmont Region based on the previously identified regional needs. First, the user needs gathered through meetings in the Region and other inputs were assembled into a comprehensive list, as shown in **Table 9**. Next, this list of original, user needs was reduced and refined through grouping of similar statements into concise need statements. This step also eliminated those problem statements not directly related to transportation issues that could be related to ITS. These needs were placed them in a separate category of non-ITS needs. Lastly, the concise need statements were matched with appropriate ITS user services.

The Piedmont Region's transportation-related needs, identified in the previous section, were matched, or mapped, with the 37 applicable ITS user services, resulting in a preliminary set of user services to be deployed specifically in the Piedmont Region. These user services were then prioritized based on the relative ranking of each related need. Based on the priority ranking of each user service and, using the common objectives and overlapping functionality of the user services, preliminary short-and long-term deployment timeframes for groups of user services were identified.

In the next step, system objectives were defined for each identified user service. A system objective identifies the improvements in the system that can be expected to occur as a result of a successful implementation of a user service. To judge the degree of success of the implementation of the user services, including the effectiveness of the deployed service or technology in solving the original problem, a set of performance criteria was developed.

Finally, to begin defining the physical ITS architecture for each region and for the state, market packages corresponding to the selected user services were identified. The 63 currently defined ITS market

packages are an important building block of the Statewide ITS architecture definition process and represent specific portions of the architecture that may be required to satisfy the needs identified by North Carolina stakeholders. The transportation needs for the Piedmont Region were then mapped to the user services categories in the NIA. The user service mapping is shown in **Table 11**

Selection of Market Packages

The NIA defines the purpose of market packages as addressing specific services that might be required by traffic managers, transit operators, travelers, and other ITS stakeholders. The market packages are tightly coupled with the architecture definition and represent the building blocks that can be deployed over time to efficiently achieve high-end ITS services. Several different market packages are defined for each major application area, which provides a palette of services at varying cost.

Market packages also are identified to segregate services that are likely to encounter technical or non-technical challenges from lower risk services. For example, driver warning and vehicle control systems are defined as separate market packages due to the increased technical and non-technical risks associated with systems that dilute the driver's direct control of the vehicle. This approach yields market packages that may be deployed early with low risk. Many of the market packages are also increment so that more advanced packages can be efficiently implemented based on earlier deployment of more basic packages. In summary, market packages represent ITS services and implementation options that may be considered by system implementers.

The selection of appropriate market packages is an important step in the ITS strategic planning process. Historically, market packages were introduced in the planning process after user services, which, along with functional requirements, were the last steps in the process before architecture definition. The ITS deployment guidelines have evolved to include additional steps and alternative paths for rural, urban, regional, or statewide ITS strategic plan developments.

The objective of this task was to identify a set of candidate market packages for potential deployment in the Piedmont Region of North Carolina. The NIA provides a matrix connecting the 31 user services and the 31 market packages that are most applicable to rural and small urban areas. This matrix allows market packages and user services to be tracked to identify specific projects and their coverage of elements in the NIA.

Table 12 illustrates the matching of the user services to the market packages for the rural regions. The selected market packages corresponding to the transportation needs identified by the stakeholders are indicated with a "YES". Linkages that exist, but are not applicable to the identified Piedmont Region stakeholder needs are indicated with a "NO".

Twenty-four of the possible 31 market packages were identified as potentially deployable in the rural regions. Several of the identified user services will require portions of numerous market packages. For example, the traffic control user service is matched with five market packages.

TABLE 11. MATCHING USER NEEDS TO USER SERVICES FOR THE PIEDMONT REGION

			User Services																																		
			Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other	
			1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	2.3	2.4	3.1	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2	6.1	6.2	6.3	6.4	6.5	6.6	6.7	7.1	8.1	
ID#	Piedmont Rural Regional Needs	Need Score	Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Emissions Testing And Mitigation	Highway-rail Intersection	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Public Travel Security	Electronic Payment Services	Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-board Safety Monitoring	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Longitudinal Collision Avoidance	Lateral Collision Avoidance	Intersection Collision Avoidance	Vision Enhancement For Crash Avoidance	Safety Readiness	Pre-crash Restraint Deployment	Automated Vehicle Operation	Archived Data Function	Other	DESCRIPTION OF "OTHER" SERVICES
S-1	Real-time weather information, fog detection, and early warning of reduced visibility		X	X										X									X						X	X	X	X	X		Traveler information clearinghouse(s)
S-2	Communication between snow plows and law enforcement								X															X										X	Coordinate efforts between snow plower's and law enforcement
S-3	Real-time information from Highway Patrol		X	X	X				X															X	X										Computer Aided Dispatch
S-4	Closed loop Signal Systems, other isolated signals							X																				X					X		Closed Loop Signal Systems
S-5	Traffic Hot Spots							X				X																X					X		CCTV installations to monitor traffic
S-6	Areas prone to truck accidents								X										X	X			X	X		X	X			X			X		Collision avoidance systems in CVs and in passenger vehicles. Roadside speed displays. Speed enforcement.
S-7	Pedestrian safety																									X		X		X					Active pedestrian crosswalks
S-8	Emergency services on two-lane roads			X					X															X	X										Signal pre-emotion
S-9	Alternate routes for emergency responders				X				X																X								X		AVL linked to GIs for dispatch
S-10	Improve safety for construction workers in highway work zone																																		Portable DMS ahead of freeway construction sites. Inclusion of construction-zone/lane closure information in all modes of traveler information access, with frequent updates, through central information repository and dissemination system.
S-11	Safety and security at rest areas, welcome centers, and 24-hour information availability																																		CCTV cameras for safety and monitoring
S-12	Safety on secondary roads at unsignalized intersections																											X	X	X					Advance Warning Devices
S-13	Means to detect emergencies in remote areas																																		CCTV , detection algorithms
S-14	Safety at highway-rail grade crossings											X																X	X	X					Automated gate closure information
S-15	Improve commercial vehicle weight operations and law enforcement																		X	X	X														Electronic Clearance
S-16	Improve commercial weight detection and enforcement and quicker clearance at ports-of-entry																	X	X	X															Electronic Credentialling
S-17	Weather information, fog detection																								X								X		Traveler information clearinghouse(s)
C-1	School bus and bus route location planning drop-offs, etc							X																						X			X		Advanced active school bus stops sigh
C-2	Information on conditions on alternate routes, managing traffic on local roads and streets		X	X	X			X																									X		Route Guidance through DMS, radio. HAR
C-3	Emissions reduction, managing peak hour traffic										X																						X		Coordinated signals
C-4	Bike trail information (e.g., specifically proposed for US 421 corridor)		X	X																														X	Traveler/bike information on kiosks
C-5	Congestion around large developments, major interchanges		X		X			X																											Signal system
C-6	Public transportation, pedestrian needs, park & ride, rideshare												X	X			X																		In-bus real-time schedule and route displays. Customizable web-based transit information. Transit kiosks with custom query capability.
C-7	Congestion on commuter routes		X	X		X		X	X																										Signal Systems
C-8	Lack of fixed route/demand responsive regional transit												X		X																				AVL on demand responsive vehicles
C-9	Real-time, continuously maintained traffic and roadway conditions database																																		Advanced signal system
C-10	Reduce delays and secondary incidents																																		Active warning signs at high accident sites
C-11	Region-wide communication infrastructure																																		Communications plan
C-12	Transponders on trucks to by-pass weigh stations (e.g., PrePass)																																		AVL on commercial vehicles
C-13	Signal preemption for emergency vehicles																								X										Signal pre-emption
C-14	Poor traffic signal coordination									X																									Advanced signal system
C-15	Relief from truck congestion at over-crowded rest areas and welcome centers																				X		X												Parking management system
T-1	Traveler Information Kiosks (@ Rest areas, truck stops, hotels, Super K, CVBs and Chamber of Commerce, malls, Old Salem, Pilot Mtn. SP, Hanging Rock SP., recreation and other areas)		X		X		X					X																					X		Traveler information kiosks located at high-pedestrian traffic areas (office buildings, banks, stores, hotels, restaurants, visitor centers, chambers of commerce, etc.) Hardware, software, and partnership agreements with media for traveler information delivery.
T-2	Communications including e-mail to CVO providers, dispatchers, trucks in transit, etc.																			X	X		X										X		AVL/dispatch to commercial vehicles
T-3	Higher frequency for HAR, tourist information on HARs			X	X		X	X	X																										AM and FM - based Highway Advisory Radio (HAR) (freeways and arterials), Kiosks in public places, FM radio station for traffic information
T-4	Permanent Dynamic Message Signs (DMS)			X				X	X																										Dynamic Message Signs on freeways and arterials with frequent and accurate message updates.
T-5	Portable Dynamic Message Signs (DMS)			X				X	X																										Portable DMS
T-6	Smaller DMSs on shoulder mounts			X				X	X																										Shoulder mounted DMS
T-7	Better directional signing, speed limit, pedestrian warnings			X	X			X																						X					Active signing
T-8	Information on construction, weather, road conditions		X	X	X			X															X		X				X						Free traffic conditions data access for value-added private partners for digital broadcasts (SmartRoutes, TEAK, etc.)
T-9	Construction information to travelers		X	X	X			X															X												Portable DMS/ web update
T-10	Tourist information		X			X	X						X											X											AM and FM - based Highway Advisory Radio (freeways and arterials), Kiosks in public places, FM radio station traffic information
T-11	Information to through-travelers (e.g., on Interstates)			X	X		X																												In-vehicle navigation
T-12	1-800 Central phone number for traffic information		X																														X		Traveler information region wide
T-13	NCSMARTLINK Website		X				X																										X		Website development
T-14	Link local, regional websites to NCSMARTLINK and MAPQUEST		X				X																										X		Website development

TABLE 11. MATCHING USER NEEDS TO USER SERVICES FOR THE PIEDMONT REGION

ID#	Piedmont Rural Regional Needs	Need Score	Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Emissions Testing And Mitigation	Highway-rail Intersection	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Public Travel Security	Electronic Payment Services	Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-board Safety Monitoring	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Longitudinal Collision Avoidance	Lateral Collision Avoidance	Intersection Collision Avoidance	Vision Enhancement For Crash Avoidance	Safety Readiness	Pre-crash Restraint Deployment	Automated Vehicle Operation	Archived Data Function	Other	DESCRIPTION OF "OTHER" SERVICES
T-15	Link traffic information to local TV, Cable		X																														X		Website development
T-16	Transit information, AMTRAK on SMARTLINK		X				X					X		X																			X		Website development
T-17	Flashing "Tune to AM XXX" signs for HAR			X	X			X	X																										Update HAR sites, install new HAR sites
T-18	Balance between HARs and DMSs			X																													X		HAR/DMS plans
T-19	24-hour per day, accurate pre trip and en-route traveler information																																		Free traffic conditions data access for value-added private partners for digital broadcasts (SmartRoutes, TEAK, etc.)
T-20	Real-time alternate route guidance																																		VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection. FM subcarrier incident location feeds to in-vehicle devices with map and alternate route databases. Centrally located alternate route database system. Commercial radio and HAR broadcasts with alt. route information. Internet based incident/closure location data with date, time, and alt. route suggestions.
T-21	Broadcast traffic conditions																																		VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection. FM subcarrier incident location feeds to in-vehicle devices with map and alternate route databases. Centrally located alternate route database system. Commercial radio and HAR broadcasts with alt. route information. Internet based incident/closure location data with date, time, and alt. route suggestions.
T-22	A statewide TOC or information clearinghouse with current traveler and road conditions																																		Statewide data clearinghouse
T-23	Expand the NCSMARTLINK web-based real-time traffic information																																		Website development
T-24	More efficient integration of transit with other modes																																		Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers. Shared, real-time demand tracking databases. Modern transit dispatching centers. Advanced demand estimation modeling based on archived data.
T-25	Provide access to up-to-date traveler information at public venues																																		Traveler information kiosks located at high-pedestrian traffic areas (office buildings, banks, stores, hotels, restaurants, visitor centers, chambers of commerce, etc.)
T-26	Electronic yellow pages at stops and en-route																																		Kiosk program
T-27	Convenience of use of transportation system		X	X	X		X			X			X	X	X		X																	Traveler information via web / kiosks
T-28	Information on park-and-ride, rideshare facilities																																		Parking management system
T-29	Improved bandwidth/increased number of channels on communications infrastructure		X		X		X	X	X				X	X	X		X	X						X										High-bandwidth fiber optic communications lines between traffic control/traffic management centers.
T-30	Regional traveler information on the Net																																		Traveler information web site
P-1	Regional and multi-state incident management planning, response and information								X																									X	ITS Planning
P-2	Communications links to other state DOTs (TN, VA, SC, GA)		X		X				X																								X		High-bandwidth fiber optic communications lines between traffic control/traffic management centers.
P-3	Information on major events that affect road closings for construction		X	X			X																										X		Website/kiosk development
P-4	Lack of computer dispatch and mobile data terminals for emergency response, fire and police																							X	X										Computer Aided Dispatch
P-5	Detour route information to emergency responders			X					X															X	X								X		Website/kiosk development
P-6	Interagency coordination and communications				X				X															X	X									X	High-bandwidth fiber optic communications lines between traffic control/traffic management centers.
P-7	Collect and share traffic crash data, conflict analysis results		X		X				X															X									X		Archived date warehouse
P-8	Eliminate traffic delays at cross-jurisdictional boundaries		X		X		X		X				X																						Cross jurisdictional coordinated signal system
P-9	Data sharing between agencies for improved traffic management and planning		X		X				X															X											Data clearinghouse
P-10	New/revised maintenance measures for ITS technologies		X		X																			X											Maintenance data warehouse

Table 12. Matching Market Package to Selected User Services

		User Services																														
		Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	2.3	2.4	3.1	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2	6.1	6.2	6.3	6.4	6.5	6.6	6.7	7.1	8.1
RURAL AND SMALL URBAN MARKET PACKAGES		Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Emissions Testing And Mitigation	Highway-rail Intersection	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Public Travel Security	Electronic Payment Services	Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-board Safety Monitoring	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Longitudinal Collision Avoidance	Lateral Collision Avoidance	Intersection Collision Avoidance	Vision Enhancement For Crash Avoidance	Safety Readiness	Pre-crash Restraint Deployment	Automated Vehicle Operation	Archived Data Function	Other
ad4	ITS Planning	YES	YES	YES	NO	YES	YES	YES		NO	NO	NO	YES			YES		NO	NO	YES			YES	NO								YES	YES
apts3	Demand Response Transit Operations											YES	YES			YES																YES	
apts4	Transit Passenger and Fare Management												YES			YES																	
apts5	Transit Security											NO																					
apts6	Transit Maintenance											YES																					
apts7	Multi-modal Coordination						YES					YES										YES		YES									
atis1	Broadcast Traveler Information	YES	YES			YES		YES					YES									YES										YES	
atis2	Interactive Traveler Information	YES	YES	YES	NO	YES							YES			YES																YES	
atis3	Autonomous Route Guidance		YES	YES																												YES	
atis7	Yellow Pages and Reservation	YES	YES		NO	YES							YES			NO																YES	
atis9	In Vehicle Signing		YES				YES				NO																						
atms02	Probe Surveillance						NO																										
atms06	Traffic Information Dissemination						YES				NO																						
atms08	Incident Management System			YES				YES													NO		YES	YES								YES	
atms09	Traffic Forecast and Demand Management						YES																									YES	
atms14	Advanced Railroad Grade Crossing										YES												NO	YES		NO							
atms18	Road Weather Information System	YES	YES					YES					YES									YES	YES		NO			NO	NO	NO	NO	YES	
avss05	Intersection Safety Warning										YES															NO	NO		NO				
avss10	Intersection Collision Avoidance										NO															NO	NO						
cvo01	Fleet Administration			YES																		YES										YES	
cvo02	Freight Administration																				YES											YES	
cvo03	Electronic Clearance																NO			NO												NO	
cvo04	CV Administrative Processes																NO			YES	NO	YES										NO	
cvo06	Weigh-In-Motion																NO	NO				NO											
cvo07	Roadside CVO Safety																	YES				YES			NO	NO							
cvo08	On-board CVO Safety																		NO			NO			NO	NO							
cvo09	CVO Fleet Maintenance																		NO			YES										YES	
cvo10	HAZMAT Management							NO													NO	NO										NO	
em1	Emergency Response		YES																				YES	YES									
em2	Emergency Routing		YES	YES			YES																	YES								YES	
em3	Mayday Support																						YES	YES									

Matching Market Packages to Selected User Services

		User Services																															
		Travel And Traffic Management										Public Transportation				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	2.3	2.4	3.1	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2	6.1	6.2	6.3	6.4	6.5	6.6	6.7	7.1	8.1
RURAL AND SMALL URBAN MARKET PACKAGES		Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Emissions Testing And Mitigation	Highway-rail Intersection	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Public Travel Security	Electronic Payment Services	Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-board Safety Monitoring	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Longitudinal Collision Avoidance	Lateral Collision Avoidance	Intersection Collision Avoidance	Vision Enhancement For Crash Avoidance	Safety Readiness	Pre-crash Restraint Deployment	Automated Vehicle Operation	Archived Data Function	Other
ad4	ITS Planning	X	X	X	X	X	X	X		X	X	X	X			X		X	X	X			X	X								X	
apts3	Demand Response Transit Operations											X	X			X																X	
apts4	Transit Passenger and Fare Management												X			X																	
apts5	Transit Security											X																					
apts6	Transit Maintenance											X																					
apts7	Multi-modal Coordination						X					X										X		X									
atis1	Broadcast Traveler Information	X	X			X		X					X									X										X	
atis2	Interactive Traveler Information	X	X		X	X							X			X																X	
atis3	Autonomous Route Guidance		X	X																												X	
atis7	Yellow Pages and Reservation	X	X		X	X							X			X																X	
atis9	In Vehicle Signing		X				X				X																						
atms02	Probe Surveillance						X																										
atms06	Traffic Information Dissemination						X				X																						
atms08	Incident Management System			X																	X		X	X								X	
atms09	Traffic Forecast and Demand Management						X																									X	
atms14	Advanced Railroad Grade Crossing																						X	X		X							
atms18	Road Weather Information System	X	X					X					X									X	X		X			X	X	X	X	X	
avss05	Intersection Safety Warning										X															X			X				
avss10	Intersection Collision Avoidance										X															X							
cvo01	Fleet Administration			X																		X										X	
cvo02	Freight Administration																				X											X	
cvo03	Electronic Clearance																			X												X	
cvo04	CV Administrative Processes																X				X	X										X	
cvo06	Weigh-In-Motion																X	X				X											
cvo07	Roadside CVO Safety																					X			X	X							
cvo08	On-board CVO Safety																					X			X	X							
cvo09	CVO Fleet Maintenance																		X			X										X	
cvo10	HAZMAT Management							X														X										X	
em1	Emergency Response		X																														
em2	Emergency Routing		X	X			X																	X								X	
em3	Mayday Support																						X	X									

Piedmont Region ITS Architecture

The ITS architecture is a framework that describes the purpose of a system, and how it functions. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components. This chapter describes the process of developing the Piedmont Region architecture.

The national ITS plan originally defined a series of short-, medium-, and long-term deployment timeframes for ITS. A number of years have passed since this timeframe was developed, and the initial goal was to match schedules with the reauthorization of ISTEA. This schedule reflected FHWA's desire to implement, as quickly as possible, visible and effective ITS projects to stimulate public support for addition funding for future deployment programs.

For the purposes of this regional ITS plan, and taking into account that the ISTEA reauthorization occurred when TEA-21 was passed in 1998, the deployment timeframes for a regional implementation of selected user services are based on anticipated funding, need, and lead-time for the typical planning, design, and implementation schedules for transportation projects.

The following deployment timeframes have been identified for the Piedmont Regional ITS plan, consistent with the other regional plans in North Carolina:

Short-Term **through fiscal year 2006**

Long-Term **2006 through fiscal year 2011**

General Description of ITS Architecture

The ITS architecture is comprised of two technical layers: a transportation layer and a communications layer. The transportation layer includes the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and other equipment used by the traveler to access ITS services. The communications layer provides for the transfer of information between the transportation layer elements. The transportation and communication layers together form the *architecture framework* that coordinates overall system operation by defining interfaces between equipment that may be deployed by different procuring and operating sectors.

The transportation layer involves 19 interconnected subsystems, as shown in **Figure 7**. A complete description of each subsystem, along with its architecture diagram, is provided in the national architecture documents.

In general, the Communication layer consists of two components: one wireless and one wireline. The Transportation layer is supported by one of both of these components. The wireline portion of the network may be manifested in many different ways most, of which are implementation dependent.

A simplified view of the communications interface is provided in the Very Top Level Architecture Interconnect Diagram in **Figure 7**.

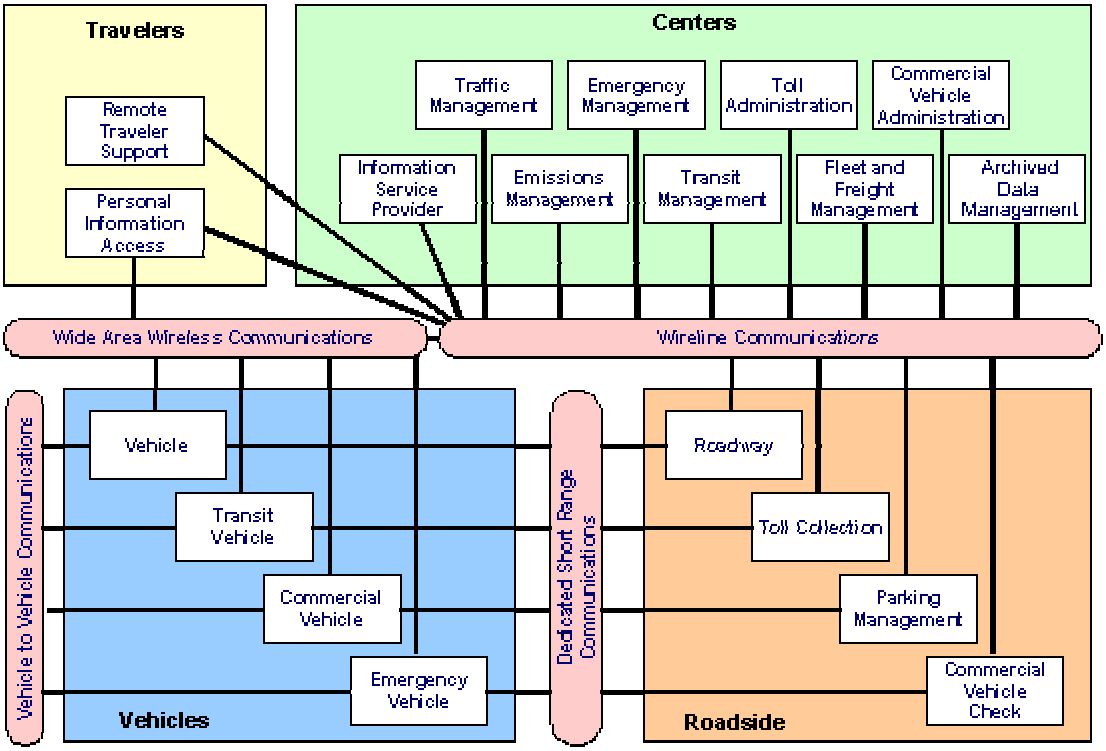


Figure 7. Very Top Level Architecture Interconnect Diagram

Another element of the architecture is the Institutional layer, which documents the policies, funding incentives, working arrangements, and jurisdictional structure that supports the Transportation and Communication layers of the architecture. The Institutional layer describes who is responsible for deploying the specific market packages and individual ITS projects and programs. It also identifies opportunities for public-public and public-private partnerships that will be necessary for successful deployment and/or operations and maintenance.

Recommended ITS Physical Architecture

The ranked user needs facilitated the identification of market package selection. Candidate technologies, projects and concepts to meet the transportation needs were identified. Based on this input, market packages for the selected user services were identified, as was the priority in terms of short-and long-term projects. The resulting market package deployment within each of the applicable user services is summarized in **Table 13.**

S – Short-Term Project/Market Package

L – Long-Term Project/Market Package

Table 13. Market Package Deployment, by Timeframe

		1.1	1.2	1.3	1.5	1.6	1.7	1.10	2.1	2.2	3.1	4.2	4.4	4.5	4.6	5.1	5.2	7.1
RURAL AND SMALL URBAN MARKET PACKAGES		Pre-trip Travel Information	En-route Driver Information	Route Guidance	Traveler Services Information	Traffic Control	Incident Management	Highway-rail Intersection	Public Transportation Management	En-route Transit Information	Electronic Payment Services	Automated Roadside Safety Inspection	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Archived Data Function
ad4	ITS Planning	S	L	S	S	S	S			S	L		S			S		S
apts3	Demand Response Transit Operations								L	L	L							L
apts4	Transit Passenger and Fare Management									L	L							
apts6	Transit Maintenance								L									
apts7	Multi-modal Coordination					L			L						L		S	
atis1	Broadcast Traveler Information	S	L		S		S			S					S			S
atis2	Interactive Traveler Information	L	L	L	L					L	L							L
atis3	Autonomous Route Guidance		L	L														L
atis7	Yellow Pages and Reservation	L	L		L					L								L
atis9	In Vehicle Signing		L			L												
atms06	Traffic Information Dissemination					S												
atms08	Incident Management System			L			L									S	S	S
atms09	Traffic Forecast and Demand Management					L												L
atms14	Advanced Railroad Grade Crossing							L									L	
atms18	Road Weather Information System	S	L				S			S					S	S		S
avss05	Intersection Safety Warning							L										
cvo01	Fleet Administration			L											L			S
cvo02	Freight Administration													L				L
cvo04	CV Administrative Processes												L		L			
cvo07	Roadside CVO Safety											L			L			
cvo09	CVO Fleet Maintenance														L			L
em1	Emergency Response		L													S	S	
em2	Emergency Routing		L	S		S											S	S
em3	Mayday Support															L	L	

Recommended Projects and Technologies

This section summarizes the technology recommendations that support the short- and long-term deployment of ITS in the Piedmont Region. These are the same deployment horizons used elsewhere in this report. The following list summarizes these technologies:

Short-Term (2000 - 2006) Projects

- Traveler information kiosks (via partnerships with Information Service Provider and kiosk vendor)
- Web based mapping and route identification
- Web based data, video, and CCTV
- Portable Dynamic Message Signs (DMS)
- Traffic signal systems
- Road Weather Information Systems (RWIS)
- Computer-aided dispatching
- Traffic Operations Center (TOC) and Information Clearinghouse (Phase I)

Long-Term (2006 - 2011) Projects

- TOC and ATIS (Phase II)
- Database of archived data
- En-Route access to traffic information
- Additional deployments of DMS and CCTV
- Regional system integration
- Voice Remote Access System (VRAS)
- Smart Cards

Technologies Especially Applicable to Rural Areas

Traveler Information Kiosks – Kiosks provide users with free access at welcome centers, rest areas, etc. to a wide range of information available from state transportation agencies, local governments, tourist destinations and organizations, and downloaded information from the Web. Users are also able to check their e-mail, surf the Web, or use a search engine for a small cost. Different types of kiosks have been developed for these applications: sit-down, stand-up, or stand-alone countertop unit. Some of these units are designed to supplement traveler counselors available at many of the state's welcome centers.

World Wide Web – The Web provides access to a great deal of information to the users, some of which (weather, road closures, etc.) can be downloaded from other sites. Applications are for users prior to departure, although en-route information can be provided at kiosks in welcome centers.

In-vehicle Automatic Vehicle Location (AVL) System – Integrated units featuring cellular digital packet data (CDPD) modem, a global positioning satellites (GPS) receiver, processor, keypad, display and sensor interface are available. Some units are designed to interface to vehicle sensors and controls such as road temperature, material spreaders via standard RS-232/RS-485 interface, and are able to detect

plow or sweeper up/down status. Functions include operator log-on, emergency alarms, vehicle position and transmitting, two-way messaging, and sensor data collection and storage.

Vehicle Tracking and Information System Software - These systems are integrated with the in-vehicle device referenced above, and include the mapping, reporting, playback, messaging and vehicle information functions. Reporting occurs through an open database connectivity (ODBC) compliant database, and information includes data such as total operating miles, road temperatures, deadhead miles, material spread (maintenance vehicles), etc.

Lateral warning and guidance system. The magnetic tape that is used helps snow plow operators during difficult winter weather conditions. Magnetic tape is grooved into the pavement, typically along the center lane markings or along the edge line of the roadway. Magnetic media and pliant polymer pavement markings are two technologies that work together in this system. This system is adapted for all-weather, all-light condition performance.

Highway Fog Warning System. A device that has been developed to detect and measure the light scattered in a forward direction by moisture in the air is called a nephelometer. This device is smaller and lighter than previous models as currently developed. Nephelometer are spaced between 200 and 700 feet from each other, which allows them to detect both patchy as well as dense fog. The sensor unit consists of electronics, an optical scanner, and software for communication to a host computer. The sensor is designed to provide accurate fog density measurement and has low maintenance requirements, and selected output format. Communication can be fiber, cable, wireline, cellular, or RF.

Surveillance and Delay Advisory System (SDAS) - The SDAS consists of three data collection technologies: video-based sensing, Weight-In-Motion (WIM) and spot speed measurements. SDAS gathers data from a construction zone (the area around a special venue such as a tourist destination), computes travel times and delays through the zone of interest, and transmits delay messages to motorists traveling through the zone.

Satellite communications system for MayDay applications. Data from the Fatal Accident Reporting System (FARS) show that it takes almost twice as long to respond to rural incidents involving fatalities than to respond to rural and urban fatal incidents. MayDay systems have developed to the point that they can dramatically reduce response time. Satellite communications work at a regional or national level to support MayDay response systems.

Road Weather Information Systems (RWIS). RWIS develops, stores, and disseminates information that is used to augment maintenance decisions associated with weather and pavement conditions. Examples of RWIS applications in overall system operations include bridge spraying, surface monitoring at major corridor intersections, DMS applications, etc. RWIS usually consists of pavement specific weather forecasts, remote sensing equipment, data processing and display software, training and service of the equipment in order to reduce the overall maintenance and operational costs.

Dynamic message signs (DMS). Uses for DMS in rural areas include fog and weather advisories, wind, and various events including duration, size, and severity. The life cycles of storms can be statistically analyzed to understand the need for providing a message to travelers on the signs. These signs should be erected as aids to truckers on mountain grades for safety advisories.

Voice remote access system (VRAS). En-route traveler information was identified as one of the key needs within the Region. One of the more effective methods of en-route traveler information is via a

voice-activated system using standard cellular phones. This system will feature a 511 number and the computer support to enable the entire system to be voice activated without the need for operators.

Description of Strategic Plan Projects

This Piedmont Regional ITS Strategic Plan has identified the needs of the Piedmont Region's transportation stakeholders and has matched them, where possible, to one or more ITS market packages, each representing an ITS solution. Of the 63 market packages currently defined in the NIA, 24 were identified as suitable for deployment in the Region. By identifying the desired implementation horizon for each of the 24 selected market packages, technology deployment phasing was developed. The recommended ITS solutions were once again cross-checked against the identified user needs, resulting in a more complete set of recommendations.

This section lists the technologies that should be deployed to achieve the desired functionality of each selected market package. The project title, description, and estimated cost of each deployment is listed. In addition, the schematic diagram of the existing, planned, and programmed ITS deployments in the Region has been modified to show the proposed short- and long-term proposed deployments. This modified schematic is shown in **Figure 8**.

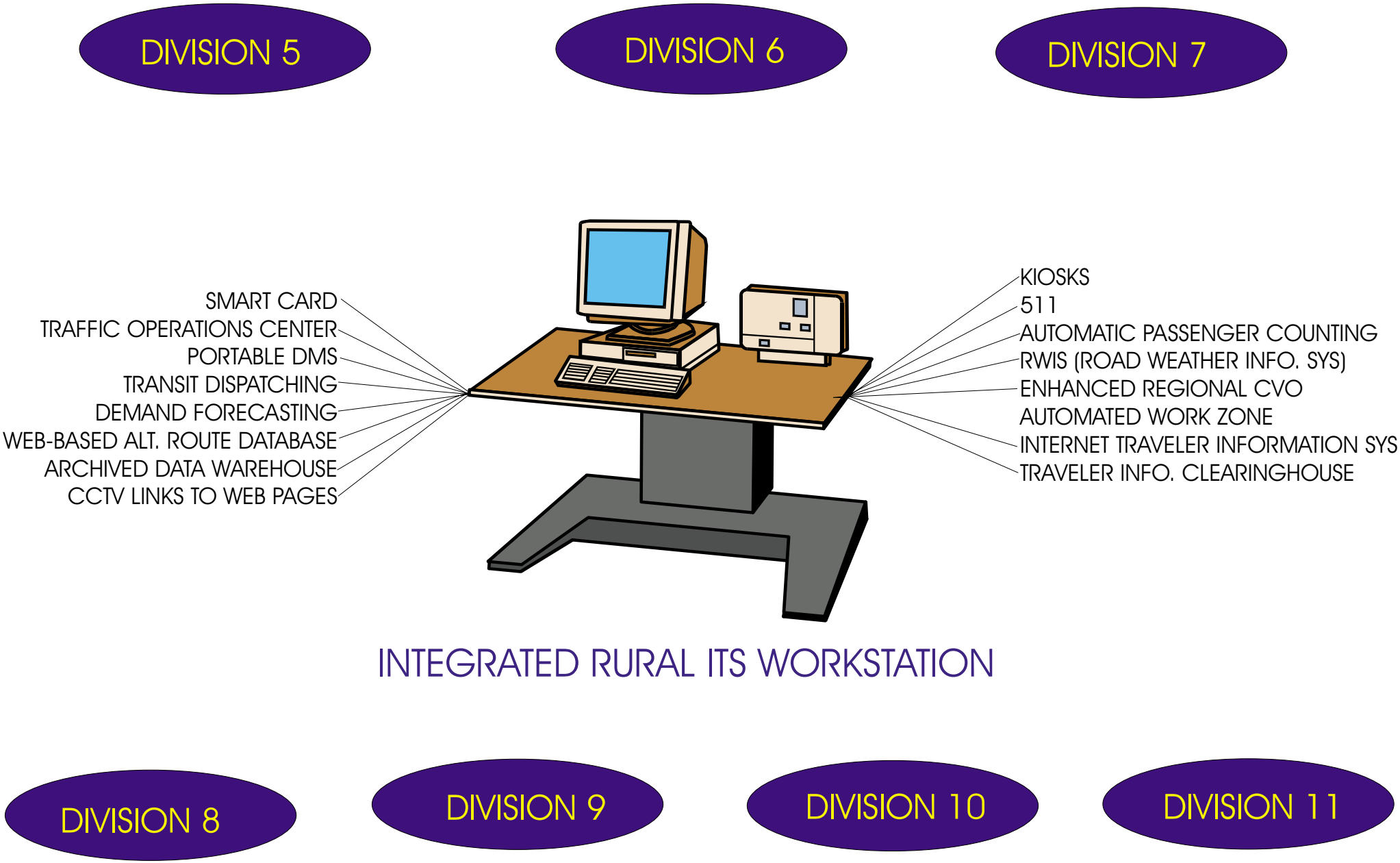


FIGURE 8. SHORT AND LONG TERM ITS DEPLOYMENTS IN THE PIEDMONT REGION

Kimley-Horn and Associates, Inc.

Short-Term Projects

The following projects are recommended for short-term deployment in the Piedmont Region. The projects are grouped according to systems. All costs shown are assuming year 2001 dollars.

Freeway/Incident/Event Management

Integrated rural ITS workstation. The NCDOT will develop an integrated rural ITS workstation to monitor and control the field devices within the Piedmont Region. One workstation will be located in each of the NCDOT Division offices within the Piedmont Region (Divisions 5, 6, 7, 8, 9, 10 and 11). Each district office will be provided with one portable workstation to permit remote operations and maintenance.

The concept of the integrated rural ITS workstation is to provide a low-cost, consistent interface that will permit operators to monitor and control all of the critical ITS devices within the Region. The workstation will consist of a front-end map with a series of icons depicting each device. Those icons will have certain attributes associated with them, such as element status and current message. By clicking on the icon, the operator will have the opportunity to change a message or gain additional information regarding the device.

The current deployment across the Region uses multiple devices by many manufacturers. Consequently, a truly integrated system may not be possible or will be prohibitively expensive. The standard front-end that is developed will access vendor specific software to operate a certain device.

The architecture of this system is described later in this report.

The development of the integrated rural ITS workstation is anticipated to cost $400,000. (Note that this development cost assumes that only one of the rural regions develops the integrated workstation. If all three rural regions develop similar workstations through the same system integrator, the development costs can be significantly reduced.) Each workstation, including software licenses, hardware and printer is anticipated to cost $25,000. Four workstations are required for the divisional offices, and an additional four are required for the major urban centers (Triad, Metrolina, Triangle and Statewide). The portable workstations are anticipated to cost $12,500 each for the necessary software and hardware. A total of 20 portable workstations will be purchased.

The total anticipated cost for the integrated rural ITS workstations in the Piedmont Region is $850,000.

Traffic Operations Center. The current freeway management system in the Piedmont Region includes dynamic message signs, CCTV cameras, and detection. This system will be expanded to include an additional ten signs. Additional detection, using non-intrusive detection methods, will also be installed to expand the existing system and obtain better accuracy within the existing system. The anticipated cost for these improvements is $3,000,000.

Portable Dynamic Message Signs (DMS). Portable DMS, both solar-powered and generator-powered, for work zones are needed to warn and direct traffic of upcoming road and lane closures. NCDOT will

purchase ten (10) additional signs for deployment during preplanned events, long-term incidents and in work zones. The anticipated cost for these ten additional signs is $250,000.

Road Weather Information Systems (RWIS). This project will install RWIS sites along Interstate and other divided highway routes at strategic location. Also included in the project will be the integration of the RWIS sites to the corridor communications network and the Regional TOC. Road and bridge ice sensors are to be included as appropriate. A total of 20 new sites will be added in this Region. It is recommended that the RWIS system consist of road ice sensors, fog sensors, a weather station, controller subsystem, and a communications subsystem.

Each RWIS collects and processes micro-climate weather and local road condition information. When ice, rain, or fog is detected, the RWIS Controller Subsystem formats a message and sends it to the Regional TOC. Operators send advisories to appropriate DMS and DMS/HAR sites. The system should be designed to automatically pass the advisories on to ATIS devices, like kiosks and the web page.

It is estimated the total cost will be $3,750,000. Unit costs for RWIS are $187,500 complete per unit.

Transit

Transit Dispatching, Demand Forecasting, and Automatic Passenger Counting. A computer aided dispatching system will be developed and deployed for all of the transit systems in the Region. This system will include automatic passenger counting system that work in concert with the AVL system to obtain boarding/alighting data for future route planning purposes. This system is anticipated to cost $250,000.

Traveler Information

Kiosks at Major Public Venues. NCDOT and several cities and other locations in the Piedmont Region will develop and install ten (10) kiosks that use web-based technologies to link to the web sites in the area that display local traffic and event information. The kiosks will consist of an interactive computer, using an HTML-based touch-screen interface. The kiosk will be designed to feature (when available) real-time traffic and accident information (such as the location of accident sites at a particular time and place). Currently-available information (Phase I deployment) will include general safety information, current weather with radar and area forecasts, and tourist information for the area. Another feature may be an interactive kiosk at one or more key truck stops to provide information on truck safety, truck escape ramps on mountain grades, signage and enforcement on grades, and overall safety awareness. The kiosks would be updated using digital telephony services (ISDN).

In addition, these kiosks will display information if interest for tourists, including destinations, lodging, restaurants, and information centers. Potential locations include: rest areas, truck stops, hotels, chambers of commerce, malls, recreation areas, and other locations.

Kiosks provide NCDOT the opportunity to enter into ventures with private entities in two ways. The first is by leasing kiosks in both public buildings and locations that are not public facilities. This may include large employers, malls, or hotels. In addition, if additional kiosks are requested at locations, they may be sold or leased as well. The second opportunity is to permit the generation of kiosk operating revenue by

either selling advertising or licensing the kiosks. This would permit NCDOT to recover some of the costs of providing the data and hosting web sites.

The cost of installing 10 kiosks throughout the Piedmont Region is approximately $775,000. There would be additional costs associated with the long-term operations of kiosks, especially as more are added, for updating information and adding bandwidth. These costs are approximated at $25,000 per year.

Web-based Alternative Route Database. The web-based alternative route database will allow users to lookup route alternatives when the shortest time route is unavailable. This system will work in conjunction with the NCDOT road closure reporting system. Parts of this project are already being developed by NCDOT, including the development of real-time mapping and a dial-up information hotline. This project is anticipated to cost $81,500.

Internet Traveler Information System. NCDOT will develop a web site or set of pages at an existing web site to provide static travel information. This information may include transit schedules, fares and routes, published road closures, traffic policies, major generator and special event information, rideshare matching information, and links to other city and NCDOT websites. This project is anticipated to cost $95,000.

CCTV Links to Web Pages. NCDOT will develop a similar web site for the Piedmont Region as has previously been developed for the Triangle Region that displays static images of the CCTV cameras. This project is anticipated to cost $37,500.

Traveler Information Clearinghouse. A clearinghouse will be established to store real-time data for traveler information. This system will include data from system loops, intersections, detector station, posted incident reports, IMAP incident reports, and real time bus schedule information. This information will all be accessible from a central location, whether it is stored locally or remotely. The development of this clearinghouse will be used in the kiosks and web sites, with the development geared for long-term projects, such as a voice activated system. The anticipated marginal cost of this system to include a database for the Piedmont Region is $200,000.

Long-Term Projects

The following projects are recommended for short-term deployment in the Piedmont Region. The projects are grouped according to systems.

Transit

Smart Card Payment System. There are a number of regional bus systems that either exist or are planned within the Region. Once these exist, a regional electronic payment system will be implemented that permits the same method of payment for all transit systems within the Region. In addition to permitting travelers to use multiple bus systems without a complicated payment system, Smart Cards allow the various transit and planning agencies to better track ridership, transfers, and other information that can be used in the planning for future transit enhancements. The anticipated project cost is $1,150,000.

Traveler Information

Voice Remote Access System (VRAS). En-route traveler information was identified as one of the key needs within the Region. One of the more effective methods of en-route traveler information is via a voice-activated system using standard cellular phones. This system will include a 511 number and the computer support to allow the entire system to be voice activated without the need for operators. This system will be developed statewide so there will not be any development costs particular to the Piedmont Region. However, the Region will have to pay for the local information added to the statewide expansion and promoting costs that could be billboards, commercials, etc. It is anticipated that these responsibilities will cost $1,500,000.

Internet Traveler Information System (Phase II). The internet system, both existing and that being developed in the short-term projects, will be expanded from a static system to a dynamic system with constant updates from the various detection stations in the Region. In addition, as more bandwidth becomes available, more options for the CCTV video feeds will be available for streaming video to the internet from the various CCTV cameras in use. This expansion is anticipated to cost $250,000.

Regional Archived Data Warehouse. ITS data collection components provide a significant amount of information that can be used in the long-term planning process, as well as for various optimization routines and strategies. The data collected through the ITS elements will be collected/warehoused in a database for future use in these processes. All of the data from the Region will be available at one central location for future use and reference. The anticipated cost of this system $750,000.

Commercial Vehicle Operations

CVISN. CVISN is the use of ITS information system elements, which support commercial vehicle operations (CVO). This includes a network of information systems owned and operated by governments, carriers and other stakeholders. The goal of the CVISN process is to use information technologies and networks to transfer credentials concerning commercial vehicles to reduce the time and energy costs typically associated with this process. NCDOT has been very actively working to implement CVISN statewide. This includes enforcement and electronic credentials. Some of the projects that are currently underway within the CVISN and ITS/CVO programs include:

Web Credentials. NCDOT is in the process of preparing electronic credentials on the web for commercial vehicle operators. A portion of the site is already operational, however the electronic credentials is still under development. This project is being done internally to NCDOT so there are no development costs.

Truck Presence Detection. NCDOT is presently implementing an automated system in the Charlotte area to identify trucks on alternate routes that are using those alternate routes to bypass weigh and inspection stations.

Mobile Inspection. NCDOT and the Department of Revenue are deploying a fleet of vehicles that can check credentials and perform truck inspections remotely throughout the Charlotte area. This fleet, called Wolf Packs, will be used to identify non-compliant trucks and trucks that are using alternate routes to avoid weigh and inspection stations.

Weigh in Motion (WIM) Sites. NCDOT will implement WIM sites throughout the Region to verify truck weights. This will begin with a demonstration project to determine the effectiveness of these sites with respect to catching cheaters. This demonstration project will cost approximately $200,000.

Safety

Automated Work Zones. NCDOT is in the process of purchasing equipment that provides worker safety in work zones. This equipment consists of standard off-the-shelf packages that include portable speed and classification detection, speed warning signs, communication (via cellular telephone or radio) to alert police of speeders in a work zone, and, possibly, automatic enforcement measures.

Project Summary

A summary of the aforementioned projects and their estimated cost are shown in **Table 14**. All costs shown are assuming year 2001 dollars.

Table 14. Summary of ITS Projects and Estimated Costs (based on year 2001 dollars).

Short-Term Projects			Long-Term Projects		
Description		**Cost ($000)**	**Description**		**Cost ($000)**
ATMS					
S-1	Integrated Rural ITS Workstation	$850			
S-2	Traffic Operations Center	$3,000			
S-3	Portable Changeable Message Signs	$250			
S-4	Road Weather Information System	$3,750			
Subtotal		$7,850			
APTS			**APTS**		
S-5	Dispatching, Demand Forecasting, & Automated Passenger Counting	$250	L-1	Smart Card Payment System	$1,150
Subtotal		$250	**Subtotal**		$1,150
ATIS			**ATIS**		
S-6	Kiosks at major public venues	$775	L-2	Voice Remote Access System (VRAS)	$1,500
S-7	Web-based Alternative Route Database	$81.5	L-3	Internet Traveler Information System (Phase II)	$250
S-8	Internet Traveler Information System	$95	L-4	Regional Archived Data Warehouse	$750
S-9	CCTV Links to Web pages	$37.5			
S-10	Traveler Information Clearinghouse	$200			
Subtotal		$1,189	**Subtotal**		$2,500
			CVO		
			L-5	Web Credentials	***
			L-6	Truck Presence Detection	***
			L-7	Mobile Inspection	***
			L-8	Weigh In Motion Sites	$200
			Subtotal		$200
			Safety		
			L-9	Automated Work Zones	***
			Subtotal		$0
Total Short-Term		$9,289	**Total Long-Term**		$3,850
Anticipated Annual O&M Costs (8% of Total Short-Term)		$743	**Anticipated Annual O&M Costs** (8% of Total Long-Term)		$308
Total 20-year Estimated Costs			**$13,139,000**		
*** Costs are borne internally by NCDOT					

Operational Concepts

A primary objective of the ITS deployments is to provide operational coordination across jurisdictional lines. Unlike the Triad, Triangle, and Metrolina regions — where there are large regional operations centers either existing or planned, and there are multiple local jurisdiction — the Piedmont Region consists of smaller counties and small to mid-sized towns. The operational plan for the Piedmont Region is envisioned as NCDOT with traffic management responsibilities distributed amongst the rural workstations. The regional backup to this center will come from the Triad or Metrolina. In all likelihood, there will be no 24-hour staffing requirement in the rural regions for day-to-day operations, beyond the operational responsibilities of NCDOT maintenance field forces, personnel at the welcome centers, and municipal personnel responsible for individual municipal systems.

However, there should be a regional incident management plan with set responses for incidents throughout the Region, procedures on working with various emergency personnel, and directions on how to work with the many different traffic management and signal systems in the Region. This plan needs to be tied into the statewide plan to provide for the backup for both the system and personnel on a statewide level.

The agencies in the Piedmont Region, and their primary responsibilities are:

NCDOT – Piedmont Region

- IMAP patrol on I-40 and I-85
- Regional traveler information – website development
- Highway advisory radio (HAR)
- Major event/incident coordination

Department of Travel and Tourism

- Traveler information kiosks in welcome centers

NCDOT – Statewide

- Statewide coordination
- Statewide traveler information – website, etc.

Benefits of ITS Systems

The benefits of ITS deployment are difficult to measure by simple quantitative analysis. An integrated ITS deployment program can include safety improvements, delay reduction, cost savings, capacity improvements, customer satisfaction, energy consumption reduction, and positive environment impacts. Municipalities throughout the United States are already seeing benefits from existing deployments.

This is especially true in rural areas. Eighty percent of all U.S. road miles are located in rural areas and 40 percent of vehicle miles traveled occur in these areas. North Carolina's Piedmont Region is a rural region and will benefit from deploying ITS technologies, however the analysis of these benefits is not as straight forward as in urban regions. Unlike in the urban regions, traffic congestion is not a major concern in rural regions. The Region's focus on ITS technologies will benefit in the following critical program areas:

- Traveler safety and security
- Tourism and traveler information services
- Public traveler/mobility services
- Emergency services
- Fleet operations and management
- Commercial vehicle operations
- Infrastructure operations and maintenance

These areas offer the private and public sectors benefits such as improved safety conditions, reduced travel times, improved emergency response times, tourist convenience, and traveler information. The previously mentioned critical program areas are used to assess the needs of the rural regions and develop a deployment plan.

Due to the unique demographics and land uses of the rural regions, the areas are less densely populated and emergency management personal is further spaced than in urban regions. Incident response times are twice as long as those in urban regions. ITS has proven to significantly reduce these response times in rural regions throughout the United States.

Traveler safety and infrastructure operations and maintenance also are affected in the rural region due to more severe weather conditions that create dangerous driving conditions. ITS technologies such as, DMS, HAR, AVL, etc., may assist travelers by warning them of severe weather conditions and road closures. **Figure 9** shows an example of a website used to inform travelers of weather conditions. Drivers could then heed the warnings and take proper precautions.

Rural regions typically have a higher percentage of elderly population than urban regions. This older population, in addition to those who are unable to drive for various other reasons, could benefit from ITS technologies and transit services in their area —such as better scheduling, improved dispatching, Smart Card readers and payment services, and computerized ride-sharing systems. These technologies improve the efficiency of transit services and their accessibility to rural residents. ITS technologies are scarce in rural regions, but offer many benefits, if implemented, to CVO operators. Electronic clearance

offers drivers convenience and save time, which saves money. Travelers benefit from the improved monitoring and enforcing of commercial vehicles. AVL is another technology that will benefit commercial vehicle operators. AVL allows the commercial vehicles to be tracked more accurately by their companies and customers.

Another commercial vehicle concern is unique to truck safety. Because mountainous rural regions tend to have different terrain from most urban regions, truckers are more at risk on steep grades and during inclement weather. ITS technologies could be used in these areas to warn the truckers so that they could take proper precautions. Sensors could be used to warn truckers of other vehicles or obstacles during low visibility times. These technologies are being implemented in urban regions to reduce congestion; however, the same packages could be implemented to address rural concerns.

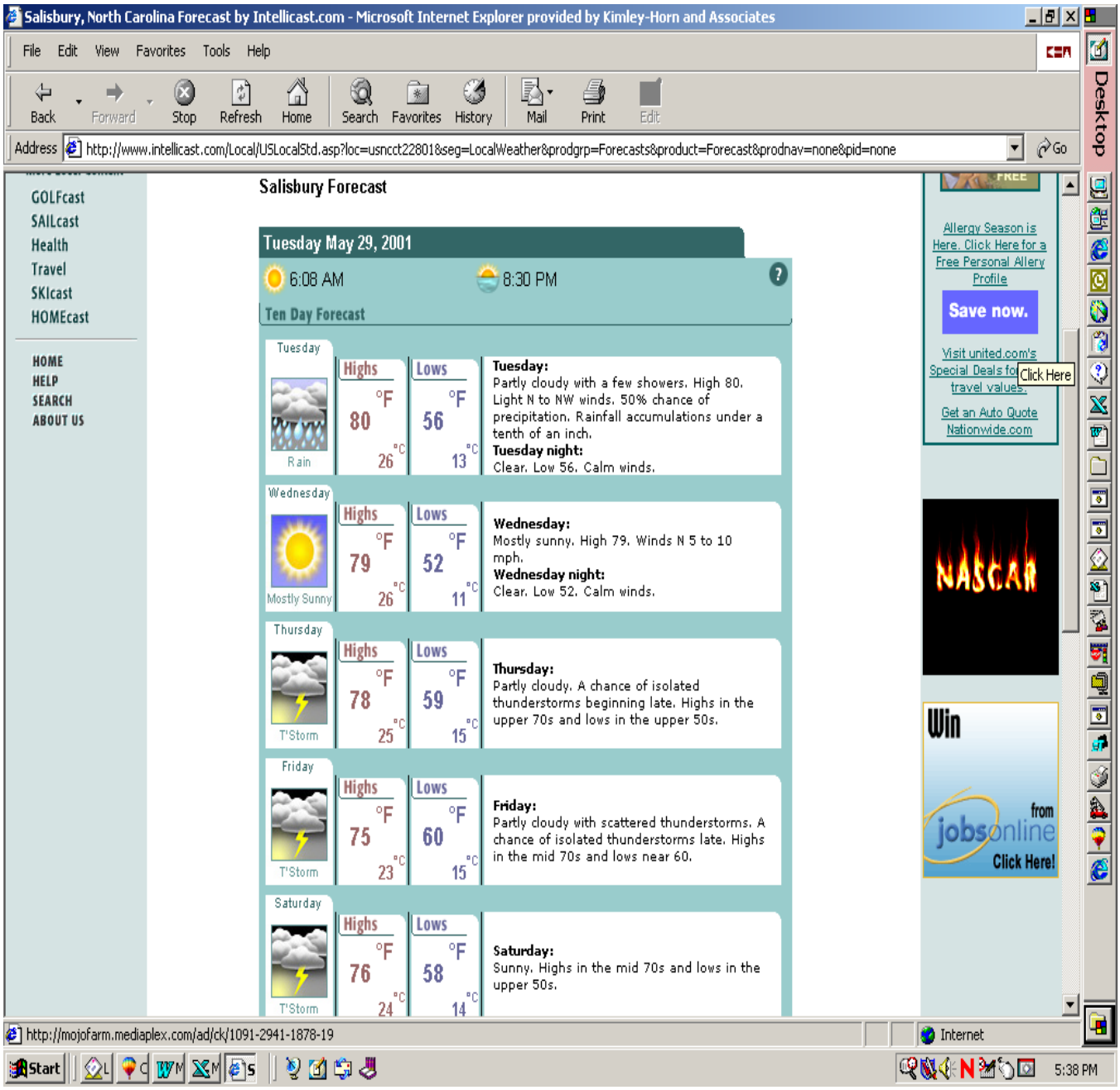
The rural regions are often a place for tourism. Rural ITS technologies could be implemented to aid in the travelers' experience by providing local information, directions, weather forecasts, etc. Kiosks, radio, websites, in-vehicle signing, etc. could be used to accomplish these tasks, thereby encouraging more tourist travel.

This benefit analysis reviews the existing deployments for various short and long term projects recommended for the Piedmont Region and provides real-world examples of benefits being realized by other municipalities. Quantifiable benefits for air quality monitoring can be obtained by following the Federal Highway Administration August 1999 report *Off-Model Air Quality Analysis – A Compendium of Practice*, which is included in the Appendix. The following examples illustrate true potential application of the Piedmont Region ITS deployment plan.

Freeway/Incident/Event Management

There are three major ITS functions that make up Freeway Management Systems (FMS). These include monitoring and controlling freeway operations and providing current traffic information to motorist. The most common ITS devices used for monitoring and control include camera surveillance and ramp metering. Where variable message signs, updated web sites and highway advisory radio are commonly used to provide traffic information to the motorist. A traffic management center (TMC), the control center for the various ITS deployments, is responsible for monitoring freeway conditions and dispersing the information to motorist. Although FMS are most effective when used in conjunction with incident management and transit management systems, when used by themselves, they can make a substantial difference in increasing average speeds, reducing travel time, minimizing stop delays and reducing accident rates.

Figure 9. Website Informing Travelers of Weather Conditions[4]



[4] Image from: http://www.intellicast.com/Local/USLocalStd.asp?loc=usncct22801&seg=LocalWeather&prodgrp=Forecasts&product=Forecast&prodnav=none&pid=none at approximately 5:42 pm on May 29, 2001.

Transit

Smart Card Technology

Smart Card Technology is a form of electronic payment that permits the same method of payment for all public transit systems. Through a computerized system, the smart card has the ability to track the fare accounts and demands of its riders as well as their respective travel patterns. Information obtained from the smart card system such as route, time or type of fare can be used to modify and/or expand transit routes based on user habits. In addition, this system improves the accuracy and reduces the costs for data collection when research is needed. The use of the Smart Card promotes traveler convenience that also encourages increased use of the public transit systems. Smart Card technology is most effective when used in conjunction with AVL devices and bus arrival systems.

Refer to the *Off-Model Air Quality Analysis: A Compendium of Practice* provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Transit Management System (AVL, etc.)

The implementation of a complete Transit Management System has shown to increase ridership and reduce costs for transit operators. For example, Winston-Salem, North Carolina evaluated a computer aided dispatch and scheduling system on a 17 bus fleet. Within six months the ridership grew from 1,000 to 2,000 users and vehicle miles per passenger-trip grew 5%. Moreover, operator expenses dropped 2% per passenger trip and there was a decrease in passenger wait time by 50%.[5]

Transit management systems also provide more efficiency for transit operations and may enable transit operators to streamline operations. Kansas City, Missouri was able to reduce 10% of the equipment required for some bus routes by using AVL/CAD while maintaining customer service. In addition, the use of an AVL system allowed Kansas City to eliminate seven buses out of a 200 bus fleet, thus allowing Kansas City to recover its investment in the AVL system within two years.[6]

Refer to the *Off-Model Air Quality Analysis: A Compendium of Practice* provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Traveler Information

Web/Roadway Traveler Information System

Providing traveler information over several modes of travel can be beneficial to both traveler and service providers. Several transit agencies as well as some Traffic Management Centers have started using kiosks, local cable television and web sites to disperse information about current traffic conditions and transit schedules. This enables travelers to make more informed decisions for trip departures, routes and modes of travel. They have been shown to increase transit usage, and may help reduce congestion when travelers select alternate routes or postpone trips.

[5] Stone, J., "Winston-Salem Mobility Management: An Example of APTS Benefits, "NC State University, 1995.
[6] Giugno, M., Milwaukee County Transit System, July 1995 Status Report.

An example of how effective the traveler information system can be is illustrated by the surveys performed in the Seattle, Washington and the Boston, Massachusetts areas. These surveys indicated that when provided with traveler information, 30%-40% of travelers adjusted their travel. Of those that changed their travel, 45% of travelers changed their route of travel and 45% changed their time of travel, while the remaining 10% changed their mode of travel.

Traveling information systems are believed to greatly impact vehicle emissions as well. In 1999, it was projected that 96,000 callers would use the SmarTraveler system in Boston on a daily basis . To estimate the impact the SmarTraveler system would have on emissions, the MOBILE5a model was used but included only 30% of the projected 96,000 daily callers. The results from the model concluded that on a daily basis there would be an average reduction by 25% of volatile organic compounds, as well as 1.5% of NO_x and 33% of CO as compared to daily vehicle emissions not influenced by the SmarTraveler system[7].

Refer to the *Off-Model Air Quality Analysis: A Compendium of Practice* provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Other ITS Benefits

Arterial Management Systems

Arterial Management systems are used to manage the traffic and control of arterial roadways through signal coordination, surveillance, sign control, and motorist informational systems. Traffic management centers also play an important role in these systems by monitoring and controlling traffic conditions and dispersing information to motorist about the arterial roadways. There have been numerous evaluations on the arterial management systems operating in cities around the world that have determined that these systems produce substantial environmental benefits by reducing vehicle stops, which then creates a reduction in fuel consumption and vehicle emissions. Additionally, arterial management systems have improved methods for reducing incident delays, increasing average speeds, as well as lowering accident rates. Arterial management systems are most effective when used in conjunction with incident management and transit management systems. Moreover, when multiple operational components are implemented such as surveillance, motorist informational systems as well signal coordination, a traffic management center has greater adaptive capabilities and control to improve changing traffic conditions.

A good example of how arterial management systems can substantially improve traffic conditions is demonstrated by a 1994 evaluation of a computerized signal control in the City of Los Angeles. This system had been in operation since 1984 and as of 1994 it was comprised of 1,170 intersections and 4509 detectors for signal timing optimization. The results of this evaluation reported a 13% decrease in vehicle stops, 18% reduction in travel time, 16% in average speed, 13% decrease in fuel consumption and 14% decrease in emissions.[8]

[7] Tech Environmental, Inc., Air Quality Benefit Study of the SmarTraveler Advanced Traveler Information Service, July 1993.
[8] City of Los Angeles Department of Transportation, "Automated Traffic Surveillance and Control (ATSAC) Evaluation Study," June 1994.

There are many different types of ITS devices that produce successful arterial management systems. In Fairfax City, Virginia a program was started that used automated cameras to record violations and ticket violators in an effort to reduce intersection accidents. It was reported that after the program was implemented there was a 35% reduction of accidents at intersections with traffic lights. Arterial management systems can increase overall capacity of existing roadways, increase road safety for motorist and improve the environment at a justifiable cost.

Refer to the *Off-Model Air Quality Analysis: A Compendium of Practice* provided in the appendix of this report for methodologies of calculating the effects of signal improvements on air pollution.

National Architecture Compliance

The development of the short- and long-term projects is the final step before the development of the regional architecture. The regional architecture that is used is a derivative of the national architecture as previously discussed. However, the regional architecture includes multiple figures and tables that document the relationships between various components, control centers, and agencies. The regional architecture documentation and all associated figures are provided as a supplement to this report.

The intent of the regional architecture is to document the flows of data between various elements that are currently and will ultimately be deployed throughout the Piedmont Region. Based on the regional architecture, as individual projects are developed, they can be incorporated to ensure that information is shared throughout the Region.

The architecture database that has been prepared for this report is not intended to sit on a self. Rather, it is intended to be a living database that is updated as projects are deployed or new projects are planned.

Standards

In additional to complying with the National Architecture, USDOT has been working with the industry to develop standards for use within the ITS community. The most common standard that has been deployed to date is the National Transportation Communications for ITS Protocol (NTCIP) for traffic signals. As of 1999, NTCIP was the only widely adopted standard. However, there are many more that are being developed and approved nationally for use in ITS. The standards that have been identified are:

Relevant Standards Activities)

Organization	Standard Name	Standard Number
AASHTO	NTCIP - Application Profile for File Transfer Protocol (FTP)	2303
AASHTO	NTCIP - Application Profile for Trivial File Transfer Protocol	2302
AASHTO	NTCIP - Applications Profile for Data Exchange ASN.1 (DATEX)	2304
AASHTO	NTCIP - Base Standard: Octet Encoding Rules (OER)	1102
AASHTO	NTCIP - Subnetwork Profile for Ethernet	2104
AASHTO	NTCIP - Subnetwork Profile for Point-to-Point Protocol using RS 232	2103

AASHTO	NTCIP Guide	9001
AASHTO	NTCIP - Object Definitions for Video Switches	1208
AASHTO	NTCIP - Simple Transportation Management Protocol (STMP)	1103
AASHTO	NTCIP - Profiles - Framework and Classification of Profiles	8003
AASHTO	NTCIP - Ramp Meter Controller Objects	1207
AASHTO	NTCIP - Data Dictionary for Closed Circuit Television (CCTV)	1205
AASHTO	NTCIP - Object Definitions for Environmental Sensor Stations & Roadside Weather Information System	1204
AASHTO	NTCIP - Applications Profile for Common Object Request Broker Architecture (CORBA)	2305
ASTM	Standard Specification for DSRC - Physical Layer 902-928 MHz	PS 111-98
ASTM	Standard Specification for DSRC - Data Link Layer	Draft Z7633Z
EIA/CEA	Data Radio Channel (DARC) System	EIA-794
EIA/CEA	Subcarrier Traffic Information Channel (STIC) System	EIA-795
ANSI	Commercial Vehicle Safety Reports	TS284
ANSI	Commercial Vehicle Safety and Credentials Information Exchange	TS285
ANSI	Commercial Vehicle Credentials	TS286
IEEE	Standard for Common Incident Management Message Sets (IMMS) for use by EMSs	P1512
ITE	Advanced Traffic Controller (ATC) Application Program Interface (API)	9603-1
ITE	ATC Cabinet	9603-2
ITE	Advanced Transportation Controller (ATC)	9603-3
ITE	Message Set for External TMC Communication (MS/ETMCC)	TM 2.01
ITE	Standard for Functional Level Traffic Management Data Dictionary (TMDD)	TM 1.03
IEEE	Survey of Communications Technologies	ITSPP#5
IEEE	ITS Data Dictionaries Guidelines	ITSPP#6A
AASHTO	NTCIP - Simple Transportation Management Framework (STMF)	1101
AASHTO	NTCIP - Class B Profile	2001
AASHTO	NTCIP - Global Object Definitions	1201
AASHTO	NTCIP - Object Definitions for Actuated Traffic Signal Controller Units	1202
AASHTO	NTCIP - Object Definitions for DMS	1203
AASHTO	NTCIP - Point to Multi-Point Protocol Using RS-232 Subnetwork Profile	2101
IEEE	Guide for Microwave Communications System Development	1404
IEEE	Recommended Practice for the Selection and Installation of Fiber Optic Cable	P1454
IEEE	Message Sets for DSRC ETTM & CVO	1455
IEEE	Standard for Message Set Template for ITS	P1488
IEEE	Standard for Data Dictionaries for ITS	1489
AASHTO	NTCIP - Transportation System Sensor Objects	1209
AASHTO	NTCIP - Data Collection & Monitoring Devices	1206
AASHTO	NTCIP - Application Profile for Simple Transportation Management Framework (STMF)	2301
AASHTO	NTCIP - Internet (TCP/IP and UDP/IP) Transport Profile	2202
SAE	Truth-in-Labeling Standard for Navigation Map Databases	J1663
SAE	Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications	J1708
SAE	Information Report on ITS Terms and Definitions	J1761
SAE	A Conceptual ITS Architecture: An ATIS Perspective	J1763

SAE	ISP-Vehicle Location Referencing Message Profiles	J1746
SAE	In-Vehicle Navigation System Communication Device Message Set Information Report	J2256
SAE	On-Board Land Vehicle Mayday Reporting Interface	J2313
SAE	Mayday Industry Survey Information Report	J2352
SAE	Information System (ATIS) Data Dictionary	J2353
SAE	Advanced Traveler Information System (ATIS) Message Set	J2354
SAE	ITS Data Bus Architecture Reference Model Information Report	J2355
SAE	Standard for Navigation and Route Guidance Function Accessibility While Driving	J2364
SAE	ITS Data Bus Protocol - Link Layer Recommended Practice	J2366-2
SAE	ITS Data Bus Gateway Recommended Practice	J2367
SAE	ITS Data Bus Conformance Test Procedure	J2368
SAE	Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media	J2369
SAE	Field Test Analysis Information Report	J2372
SAE	Stakeholders Workshop Information Report	J2373
SAE	National Location Referencing Information Report	J2374
SAE	ITS In-Vehicle Message Priority	J2395
SAE	Measurement of Driver Visual Behavior Using Video Based Methods (Def. & Meas.)	J2396
SAE	Adaptive Cruise Control: Operating Characteristics and User Interface	J2399
SAE	Forward Collision Warning: Operating Characteristics and User Interface	J2400
SAE	ITS Data Bus Data Security Services Recommended Practice	J1760
SAE	ITS Data Bus Protocol - Physical Layer Recommended Practice	J2366-1
SAE	ITS Data Bus Protocol - Thin Transport Layer Recommended Practice	J2366-4
SAE	ITS Data Bus Protocol - Application Layer Recommended Practice	J2366-7
ITE	TCIP - Control Center (CC) Business Area Standard	1407
ITE	TCIP - Common Public Transportation (CPT) Business Area Standard	1401
ITE	TCIP - Fare Collection (FC) Business Area Standard	1408
ITE	TCIP - Framework Document	1400
ITE	TCIP - Incident Management (IM) Business Area Standard	1402
ITE	TCIP - Onboard (OB) Business Area Standard	1406
ITE	TCIP - Passenger Information (PI) Business Area Standard	1403
ITE	TCIP - Scheduling/Runcutting (SCH) Business Area Standard	1404
ITE	TCIP - Spatial Representation (SP) Business Area Standard	1405
ITE	TCIP - Traffic Management (TM) Business Area Standard	TS 3.TM

The first priority with the continued deployment in the Piedmont Region is to comply with national standards. However, a number of choices were made in the development and deployment of ITS technologies in North Carolina over the past few years that will impact the standards that are chosen. An example is emergency vehicle preemption. To date, all of the deployments for emergency vehicle preemption have used 3M Opticom® equipment. This system uses a proprietary interface that is not standard. To change this to an open standard driven system would require that all of the existing 3M

Opticom® equipment be either replaced or upgraded (if possible). This is not feasible. In instances such as this, the existing system will be maintained.

Regional Communication Architecture

Based on the short- and long-term projects, the key component of the Piedmont Region ITS Deployment plan is to develop a central database of traveler information to be disseminated to motorists throughout the Region. This regional system, with the various inputs and outputs is shown in **Figure 10.**

The concept of the architecture for the Piedmont Region is that the NCDOT controls a majority of the traffic operations equipment through the Region, and, therefore, has easy access to a majority of the traffic information generated by these elements. External inputs, such as from the welcome centers, the IMAP program, and the NCDOT statewide program office needs to be accessed, but not generated or stored locally.

The concept of the architecture is that the NCDOT and the local municipalities share information both regionally and, to some extent, statewide to provide information that can be easily accessed from one concise front end. There are two options to operate a regional traveler information system: central and virtual. These two concepts are shown in **Figure 11**.

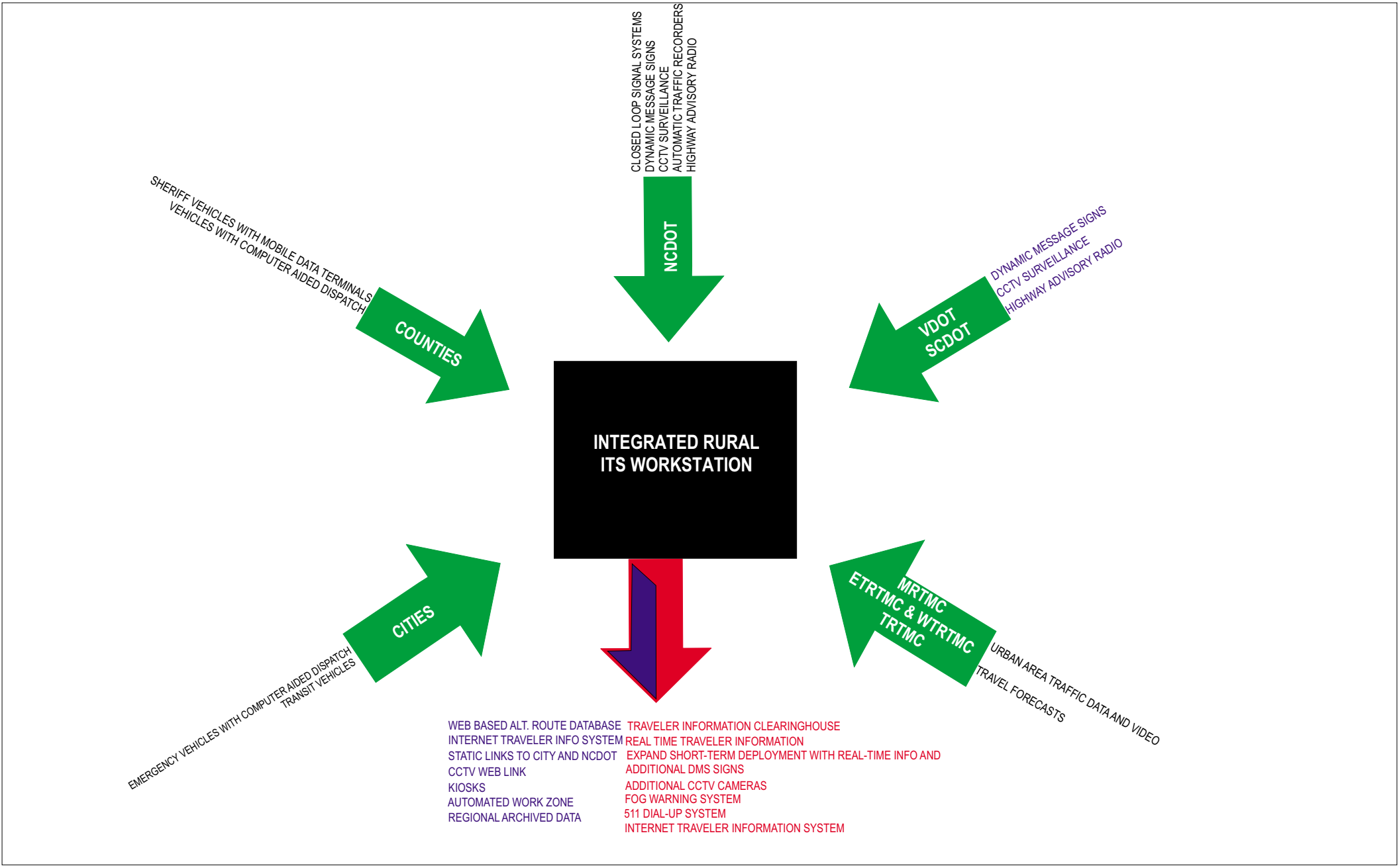


Figure 10. Generic Regional Architecture

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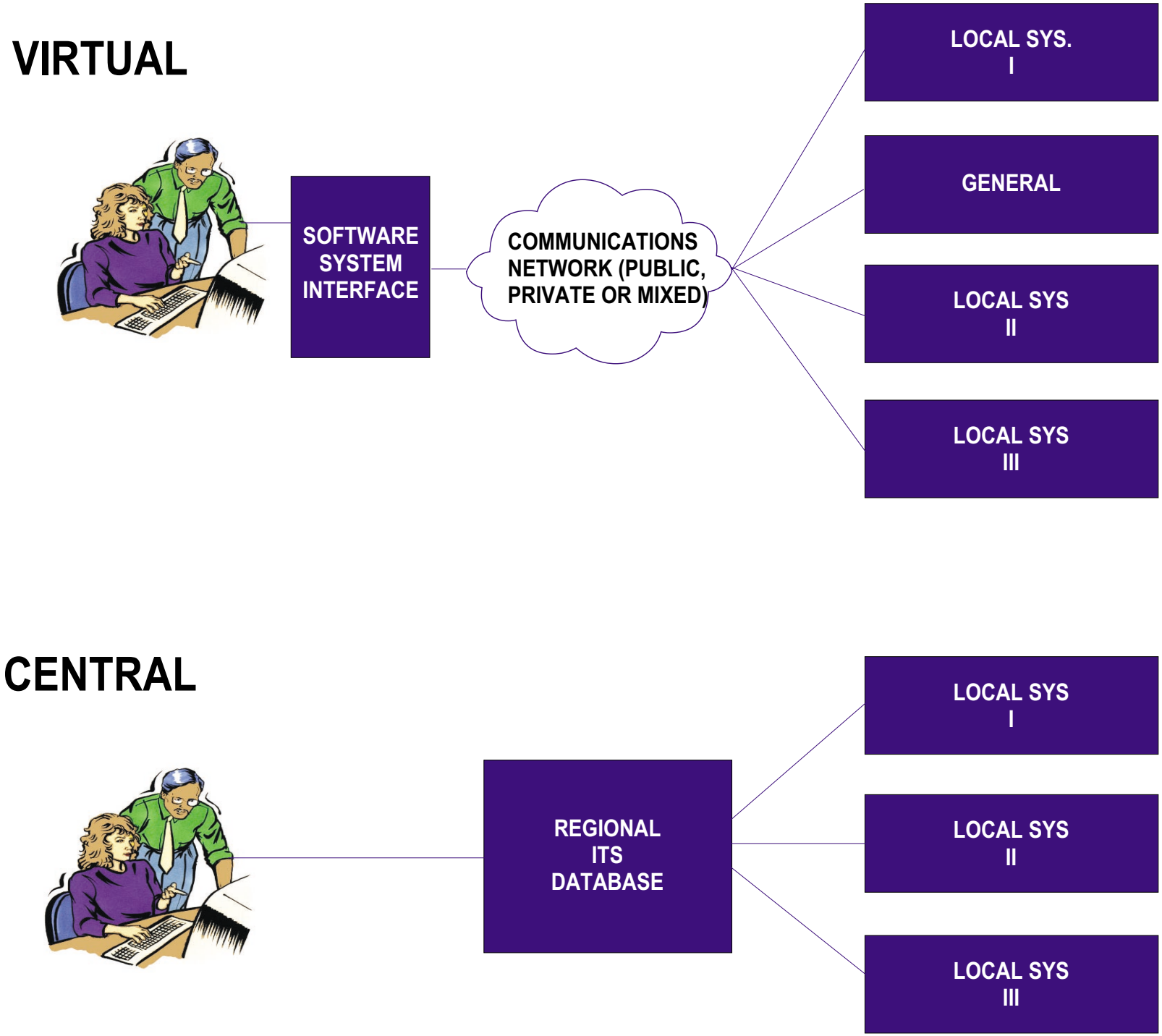

Figure 11 Central vs. Virtual Information System

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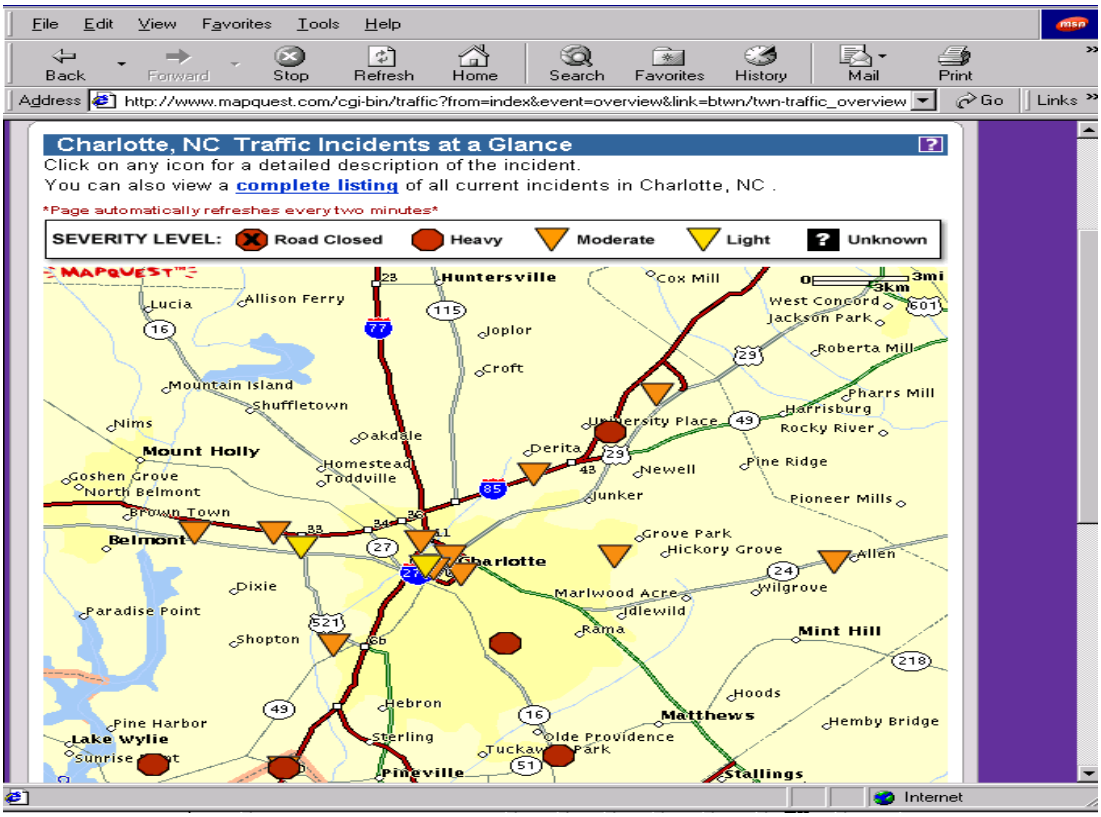
Central Information System

A central system is the more expensive of the two to design, build, operate, and maintain. A central system requires that all the data, video, and other information be brought to one central location for dissemination. For instance, the MRTMC could house the information system for the Piedmont Region. This system would store all of the information, both data and video, and disseminate it as needed. A type of central system is provided by MapQuest at www.mapquest.com. MapQuest's traveler information pages get data from the DOT and provide it on the MapQuest. A sample image from MapQuest is provided for the Charlotte areas in **Figure 12**.

MapQuest is a sample of a third party using available information to document and present traffic conditions in real time. Other web sites with similar information include www.smartroutes.com, www.strategy.com (in development), and others.

Figure 12. Sample MapQuest Image [9]



[9] MapQuest is just one of many private sector companies repackaging ITS information for profit. Others include Yahoo! (traffic.yahoo.com),SmartRoutes (www.smartroutes.com) and TrafficStation (www.trafficstation.com). Image from www.mapquest.com at approximately 6:15 p.m on May 9, 2000

The advantage of a central system is that is provides consistency to the end user in both the look and feel, and also in the data and video provided. A central system provides greater control over the information in that one agency, organization, or even person has the ultimate responsibility for all of the system's components.

The key disadvantage is the cost needed to design, construct, operate, and maintain such a system. Where a virtual system requires that the end user have an adequate connection to the regional and local sites, the central system requires that there be a permanent connection from the central system to each of the local sites. In essence, the responsibility of data and video dissemination falls on whoever is operating the central system.

Virtual Information System

A virtual information system requires less front-end expense than the central system, but also has issues with compatibility and consistency. A virtual system provides a front-end for the user from which he or she can select the information desired. When selected, however, the user connects directly to the local system from which information is requested. The only information stored at the central location is the front-end and generic regional information. All of the specific data and video can be accessed from each of the local sites.

The advantage of a virtual system is that it provides the same information as a central system but at a lower front cost. The requirement for the virtual system is a link from the central system to each of the local systems. The bandwidth for the local systems to transmit this information to the end user is the responsibility of the local agencies. A virtual system is very similar to the World Wide Web. A site like www.yahoo.com provides traffic and traveler information through links to the various sites. This is similar to a virtual system.

The key disadvantage of the virtual system is the consistency amongst the sites, both in terms of look and feel, as well as status. Different internet sites have different methods of presenting information. Unlike a central system where one person or group has control of the look of a site, a virtual system has different groups of people responsible for each of the local sites, which can confuse a user. Standardizing the front ends of the various systems can eliminate this problem.

It is important that the status of the varying sites be consistent. Where the central system has all of the data and information stored and processed locally, the virtual system relies on other sites to be operational, up-to-date, and consistent. If it is not, users will stop visiting the site for traffic and traveler information

Regional Architecture Recommendation

The Piedmont Regional plan focuses on improving the existing ITS deployments and enhancing traveler information. This deployment has promoted the deployment of a centralized communication system. Although there will be a number of virtual elements, specifically regarding information from the NCDOT both regionally and statewide, the vast majority of input into the system is currently centralized, and should remain that way.

Communication System

The regional communication is limited because both the existing and planned deployments are so dispersed. The system will encompass the existing communications in the Piedmont Region and existing ITS elements, with new deployments providing or improving communication, as necessary.

Additional infrastructure desired for this project will be developed as part of the short- and long-term projects. Each project that requires communications should be deployed with the intent of expansion of communications, since the addition of fiber for the regional system adds an insignificant cost (The vast majority of installing fiber optic cable is in the trench, conduit and labor to install the cable. Installing additional strands do not add a significant amount per linear foot of cable).

Communications Assessment

The only regional communication that is required for the short- and long-term ITS deployment in the Piedmont Region is the communication necessary to connect the Piedmont Region into the NCDOT statewide system. A full-time connection is recommended between the NCDOT Division offices in the Region and the WRTMC and the MRTMC to share video and data. The statewide standard that is being recommended from each region is a 3 Mbps (2 T-1 lines) connection. This will permit, as described below, multiple low frame rate video channels to be transmitted across the network until a statewide network is fully developed. The communications plan is shown in **Figure 13**.

The statewide link is necessary for a number of reasons, most notably to view traffic in the Triangle, Triad and Metrolina regions, and for those regions to view traffic in the Piedmont Region. Additionally, traffic in Piedmont can significantly impact the I-40 and I-85 corridors as well as the opposite. Traffic monitoring and control is a local issue, with regional and statewide impacts. For that reason, transmitting basic data and video images to a statewide network does not require the same quality as for local information. Video images from Piedmont Region to NCDOT are recommended to be limited to 384 Kbs. Additional connections should be made to TNDOT and VDOT to share common information.

The statewide link is recommended to be a leased network at this time. There are many states in the process of developing statewide fiber optic deployments from border to border along the major freeways with assistance from private partners. In lieu of this occurring in North Carolina, a statewide leased network is sufficient to provide basic data and video transmission. It is recommended that a total of 2 T-1 connections be provided from the Piedmont Region to NCDOT headquarters in Raleigh. The cost to lease the bandwidth required to connect these two centers would be approximately $58,000 per year, in addition to a one-time setup and installation cost of approximately $20,000.

Video images can be broadcast or transmitted at different data rates, depending on the quality desired by the viewer. The higher the data rate, the better the quality. As data rates decrease, images tend to become either smaller or jumpy. It is recommended that for center to center video, a data rate of between 3 and 6 Mbs (Megabits per second) be used. This rate will allow full frame, full motion video with little or no “jumping.”

Video between Piedmont Region and the rest of the state can vary depending on the bandwidth available, and expand as the communication infrastructure increases. For the purposes of traffic control video, a low data rate of 1.5 Mbs is reasonable, since it can be transmitted over one leased T-1 line. The video transceivers and multiplexers available today allow the data rate to be changed, so as different

communication options become available, the only changes necessary in the end equipment is in the software to convert the data rate, and in the network interface to change connection types.

Data transmission of traffic information is significantly reduced from the needs of video transmission. Typical data from a traffic signal system is constant, but not at a high data rate (most controllers are limited to data rates as low as 14.4 or 28.8 Kbs. Data from other sources, such as traffic data count stations, DMS and HAR does not require continuous communications, rather the data (or voice for HAR) is sent in a burst. The more bandwidth available, the shorter the burst. These communication can be handled by standard plain old telephone system (POTS).

Communications between the local cities in the Piedmont Region is recommended to continue using standard telephone service. Although the information collected by the various elements encompassing the ITS deployment in the Piedmont Region can impact these other municipalities, a majority of the impacts and response will be handled by the local municipalities. The bandwidth necessary to transmit basic data between Piedmont Region and these surrounding communities will be very limited. The local municipalities or the police departments will coordinate a majority of the incident responses that require multiple jurisdictions. Communications during these events will occur via either radio or telephone. A standard telephone line connecting these facilities will permit the exchange of basic data and still frame video images.

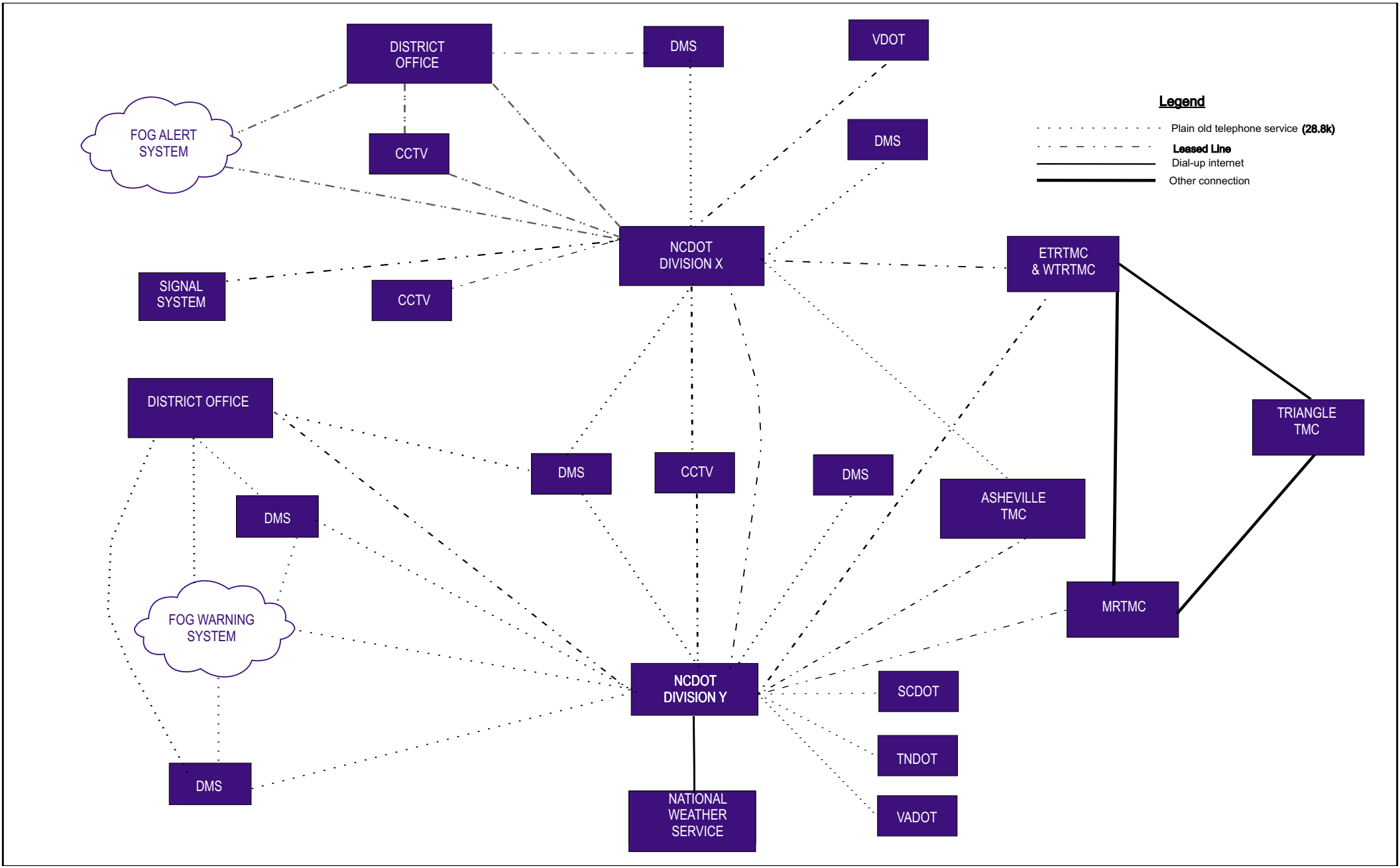


Figure 13 Piedmont Region Communications Plan

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APPENDIX

Meetings

Summits

NIA Compliance

FHWA: Off-Model Air Quality Analysis – A Compendium of Practice – August 1999