Metrolina Regional Report

SMART link
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.
ETRTMC	*Eastern Triad Regional Transportation Management Center*
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*
WTRTMC	*Western Triad Regional Transportation Management Center*

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 Metrolina 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 Metrolina region includes the five county areas surrounding the city of Charlotte, NC. Cities in the Metrolina region include: Charlotte, Gastonia, Concord, Kannapolis, Monroe, Matthews, Mint Hill, Mount Holly, Stanley, Cherryville, Bessemer City, Lowell, Belmont, Weddington, Wingate and Mooresville. Although ITS is relatively new, there are many ITS deployments that are either fully functional, in construction, or in the planning stages throughout the Metrolina Region.

From the stakeholder input process, the ITS Strategic Deployment Plan process identified 32 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 traffic control, public transportation management, archived data function, and pre-trip travel information were the most urgent issues. Short- and long-term project plans were then determined from the needs. The key component of the Metrolina 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 Metrolina Regional architecture is that NCDOT Traffic Management Center controls most of the traffic operations equipment through the region, and, therefore, has easy access to most of the generated traffic information. External inputs, such as from the City of Charlotte signal system, 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.

The regional communications architecture is complex because of the deployments (both existing and planned) and the amount of ITS already present in the region. The system will encompass the existing communications between NCDOT; the cities of Charlotte, Gastonia, and other municipalities in the area; and the existing ITS elements, with new deployments providing or improving communication, as necessary.

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 Metrolina-- 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.

The Metrolina 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 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).

The program 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.

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 Metrolina Region. A more detailed description of the process, and the elements that make up the process used in the plan development, is provided in the Appendix.

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 Metrolina Region.

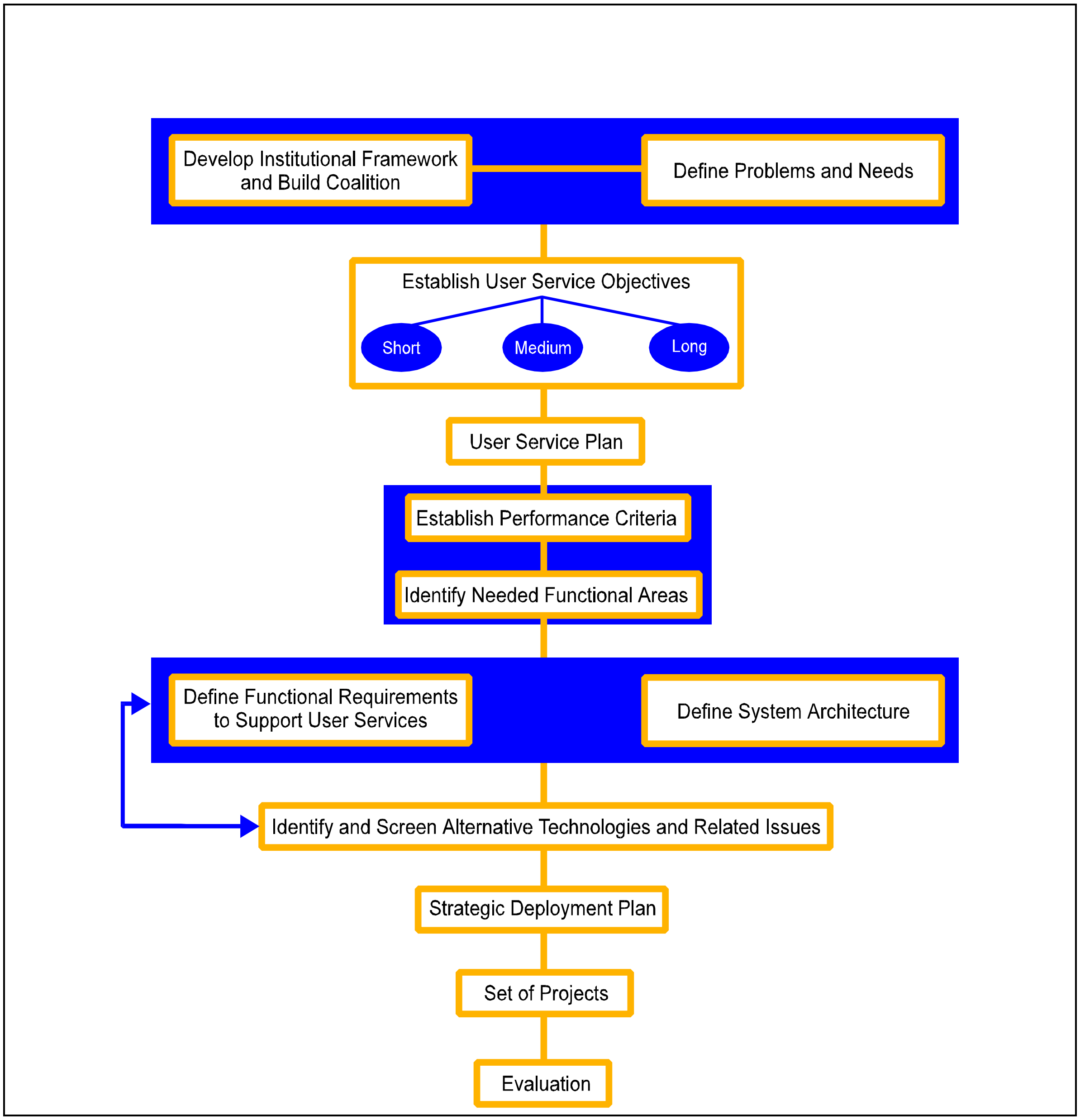


Figure 1. ITS Planning Process

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.

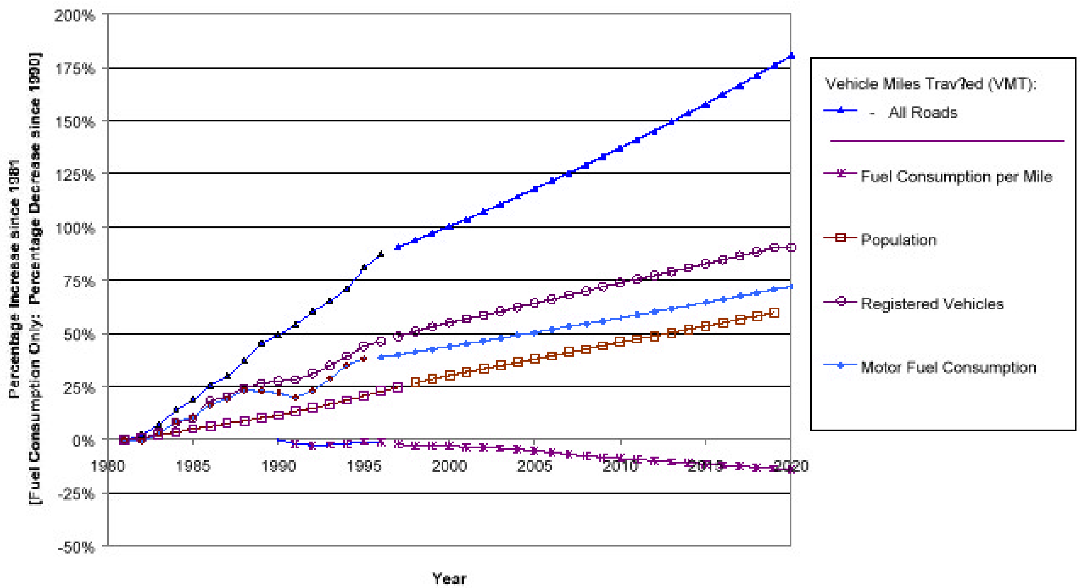


Figure 2. Projection of Key Transportation Indicators for North Carolina.

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 ht Statewide Report in the interstate system). These regions are grouped according to the ITS needs within each region. For instance, the needs in the Asheville region focus on tourism and weather, 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 composed of multiple stakeholders and jurisdictions. These stakeholders include cities, counties, several field divisions within NCDOT, and metropolitan planning organizations (MPOs) for the 17 urban regions in the state. Other interested organizations in urban regions include the police, fire departments, county emergency management agencies, and urban 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 Metrolina 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

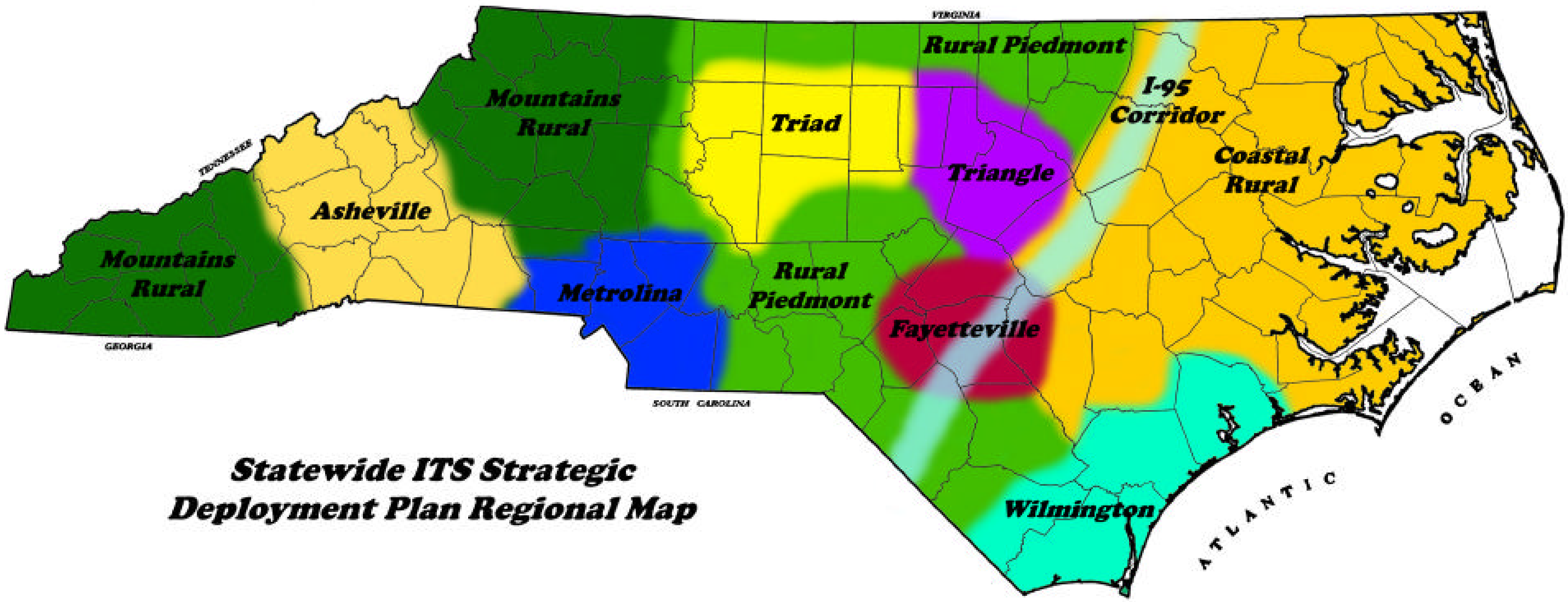


Figure 3. North Carolina ITS Strategic Deployment Plan Regions

- 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

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:

[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

- 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 ITS goals are identified in this document: short-term and long-term.

Short-term

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

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.

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. A detailed description of the NIA process, goals and objectives is included in the Appendix.

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. One to four regional summits were held in each 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.

Regional Team Meetings. Regional team meetings involved a group of key transportation stakeholders and decision-makers in the region. These meetings were used to establish the existing ITS deployments, prioritize regional needs identified in the summit meetings, and develop short- and long-term packages for deployment.

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**.

The overall system architecture can be developed by selecting the appropriate user services and market packages. Grouping these 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 packages are more specific types of projects.

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 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 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 lists potential ITS market packages to go with these critical program areas. There currently are 63 market packages in the NIA. **Table 1** lists specific market packages that are applicable to most urban regions and may be applicable in the Metrolina Region.

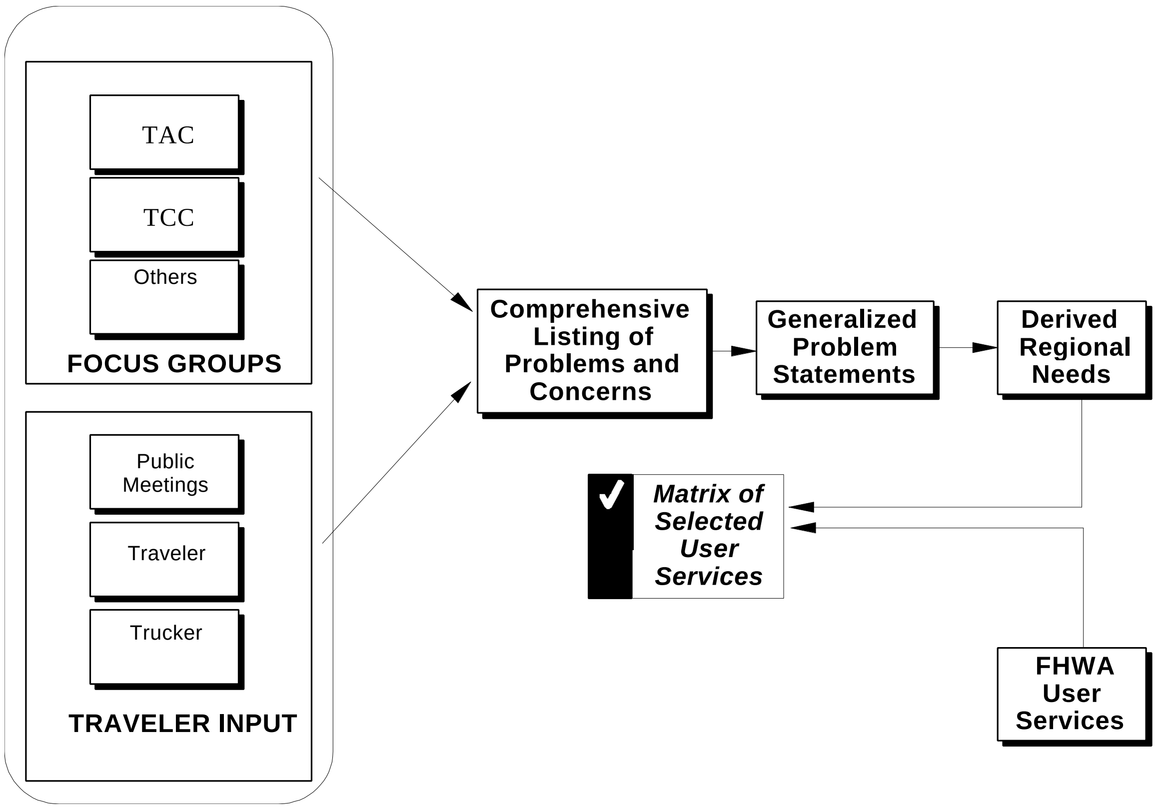


Figure 4. Identification of Needs and User Services

The following example illustrates the benefit of this categorization of market packages. The Regional ITS Summit in the Metrolina 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. Affected ITS critical program areas would include 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

Traffic information dissemination is another market package that is listed in the NIA as belonging in the infrastructure operations and maintenance area, and this market package also is applicable.

By identifying these five as the primary market packages to meet the needs of metro 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**.

Table 1. Probable ITS Market Packages Based on Typical Needs in Urban Areas

Critical Program Areas	Specific 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 interactive traveler information market package exemplifies the market packages that are applicable to urban 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.

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).

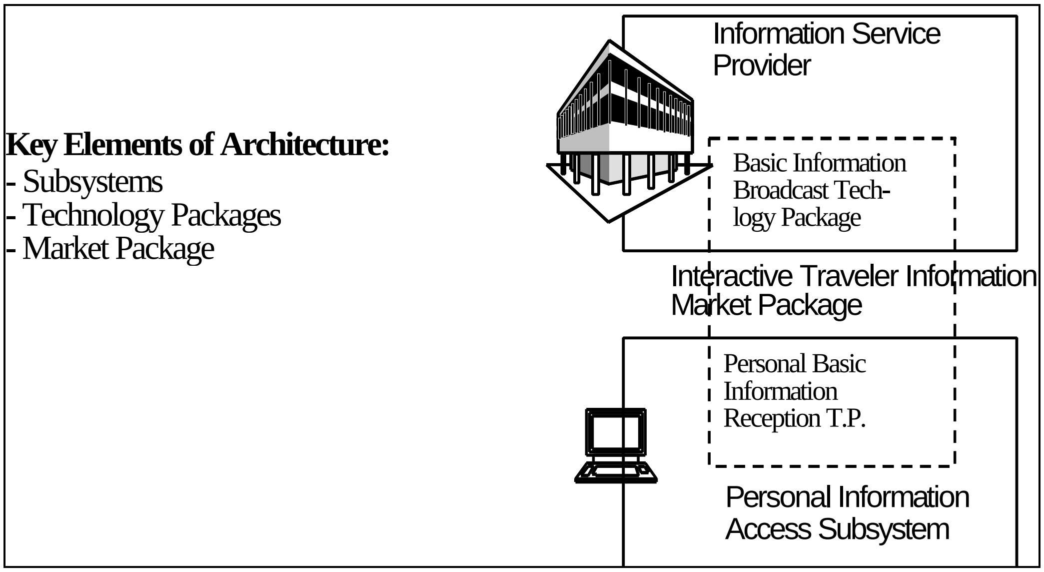


Figure 5. Relationship of Market Packages, Technology Packages, and Subsystems.

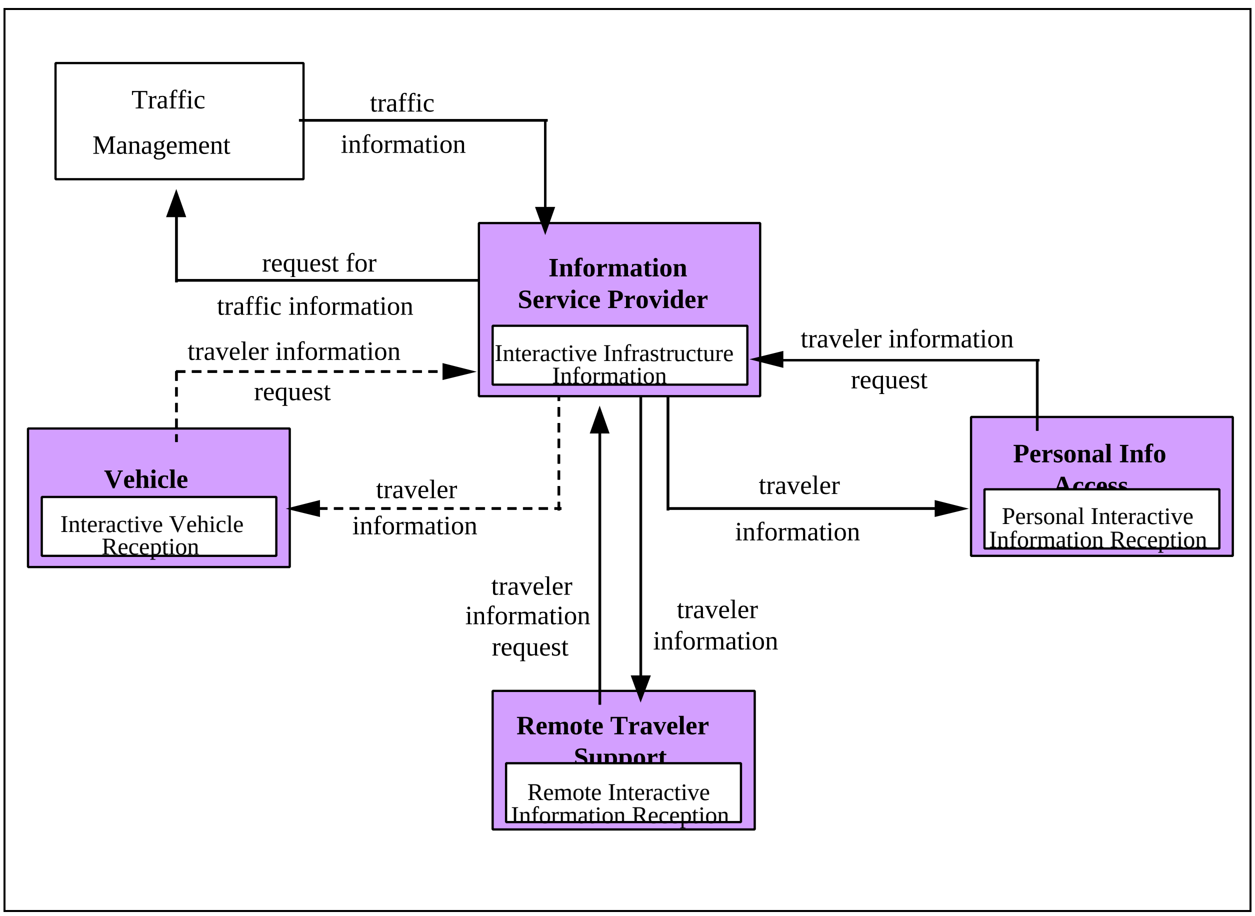


Figure 6. Interactive Traveler Information Market Package

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 concentrate on those pieces of the architecture necessary to support the selected deployment.

Regional Overview

The Metrolina Region encompasses Mecklenburg, Cabarrus, Gaston, Union Counties, and a portion of Rowan and Iredell County. It has a population of approximately 1,121,000 people and are shown in **Table 2**. The Metrolina Region includes portions of NCDOT Divisions 9, 10, and 12. Interstate 85 runs west/northeast through the Metrolina, connecting the region with Gastonia to the west and Concord to the northeast. Highway 29 and 74 run west/southeast through the Metrolina, connecting the region with Gastonia to the west and Monroe to the southeast.

The counties that make up the Metrolina region, as well as the population, major cities, roads, and any universities and military institutions are shown in **Table 2**. There are many improvements to the overall transportation network that are either proposed or under construction. A list of these is provided in the Appendix.

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 Region. As part of the process, an inventory of all of these projects was performed. **Table 3** lists the deployed, planned and programmed ITS projects in the Metrolina Region. At the heart of the existing deployments in the Metrolina Region is the Metrolina Regional Transportation Management Center (MRTMC). This center currently manages the system of cameras and message boards on I-77 and I-85 and in the future will be the central hub for the entire Metrolina Region ITS Architecture.

The deployed, planned, and programmed elements are shown schematically in **Figure 7** This figure shows the relationships between the elements and the various management centers, as well as the current connections between the centers.

TIP/STIP Project Listing

NCDOT Divisions 9, 10 and 12 have a very aggressive plan for ITS deployment over the next few years, including numerous projects that are on the Transportation Improvement Plan (TIP) as well as some that projects are planned but not funded. These projects are all listed and described in this section. Some of the projects included in **Table 4** are included as recommended short- and long-term deployments listed later in this document.

	NCDOT				
County	Division	Population	Major Cities	Major Roads	Military/Universities
Mecklenburg	10	648,000	Charlotte	I-77, I-85	UNC - Charlotte
			Matthews	US 21, US 29, US 74, US 521	Johnson C. Smith
			Mint Hill	NC 16, NC 24, NC 27, NC 49	Davidson College
					Queens College
Gaston	12	185,000	Gastonia	I-85	Belmont Abbey College
			Mount Holly	US 29, US 74, US 321	
			Stanley	NC 27, NC 150, NC 273	
			Cherryville	NC 274, NC 275, NC 279	
			Bessemer City		
			Lowell		
			Belmont		
Cabarrus	10	124,000	Concord	I-85	Barber-Scotia College
			Kannapolis	US 29, US 601	
				NC 24, NC 49, NC 200	
Union	10	114,000	Monroe		Wingate University
			Weddington	US 74, US 601	
			Wingate	NC 84, NC 200, NC 218, NC 522	
Rowan	9	32,000		I-85	
(~25%)				US 29	
				NC 150, NC 152	
Iredell	12	18,000	Mooresville	I-77	
(~15%)				US 21	
				NC 136, NC 150, NC 152	

Table 2. Metrolina Region General Information.

Division 9 Projects

The projects listed below are planned in Division 9. These projects — all of which are part of the recommended deployment in the Metrolina Region over the next 10 years — are divided into funded and unfunded projects. Some of these projects have been included in the project (**Table 4**). The costs provided by NCDOT are a preliminary construction estimate.

Funded

I-85 (I-3802). Install 28 Closed Circuit Television (CCTV) cameras, five DMS, and fiber optic cable and conduit along I-85 from NC 73 in Cabarrus County to US 29-601 Connector in Rowan County. This project is estimated to cost $7,214,400.

Division 10 Projects

The projects listed below are planned in Division 10. These projects — all of which are part of the recommended deployment in the Metrolina Region over the next 10 years — are divided into funded and unfunded projects. Some of these projects have been included in the project (**Table 4**). The costs provided by NCDOT are a preliminary construction estimate.

Table 3. Metrolina Region Existing ITS Deployments

LEGEND

Existing
Planned/Under Construction

Freeway Management

- Metrolina Regional Transportation Management Center (MRTMC) in Charlotte
  27 traffic sensors, 26 CCTV cameras, 11 DMS, 4 HAR on I-77
- Reversible HOV Lane on US 74 (Independence Blvd) - currently operated as express busway
- *FY2005 expand to 4 MI with 11 CCTV, 3 DMS*
- *Expansion of Metrolina TMC on I-77 from I-85 to Charlotte Outer Loop North (I-3311) with possible HOV*
- *Expansion of Metrolina TMC on I-85 from US 29-49 Connector to NC 73 (I-3803)*

Incident Management

- Mecklenburg County – Patrol 15 miles of I-77 & I-85 and respond to an additional 45 miles
- Gaston County – Patrol 20 miles of I-85
- Cabarrus County – Respond to I-85 incidents dependent on severity
- Gaston County – DMV special enforcement in work zones
- Rowan County – patrol I-85 (Division 9)
- South Carolina – SHEP patrols on I-77
- Tyvola Road Reversible Lane System for Charlotte Coliseum – 5 MI with 5 CCTV, 1 DMS
- Reversible lanes on 7th street in Charlotte from NC27 to Laurel Avenue
- *US29 Reversible Lane System for Lowe's Motor Speedway*

Traffic Signal Control

Closed Loop Signal Systems

- US74 in Matthews (4 signals)
- US521 in Pineville (15 signals)
- US74 in Monroe (13 signals)
- US74 in Marshville (4 signals)
- US29-74 in Charlotte (9 signals)
- US29-74 in Gastonia (42 signals)
- US29 in Concord from 73 to Mount Olive (10 signals)
- *US74 from SR3169 to Union County Line (C-3103)*
- *University Research Park area in Charlotte: Harris Boulevard, Mallard Creek Road, US-29 (C-3602)*

City Signal Systems

- Charlotte - 139 signals in CBD, 280 in 33 closed loops, 7CCTV in CBD

Transit Management

- Charlotte – 58 demand-responsive paratransit vehicles with mobile data terminals and automated vehicle locators operated under a computer-aided dispatch/scheduling system.
- Charlotte – bus priority at 17 intersections on Central Avenue and Albemarle Road
- Charlotte
  – 173 Buses w/ GPS receivers tied to automated voice anunciators (annouces upcoming stops to passengers)
  – Automated bilingual telephone system to be upgraded to include customer service module tied to Stop #
  – *Buses will be upgraded to AVL with real-time schedule/route adherence within the year*
  - *Autopass Counters and scheduling software*
  - *Website for traveler information and transit schedules*

Table 3. Metrolina Region Existing ITS Deployments (cont.)

Electronic Fare Payment

- Charlotte - 173 City Buses equipped for Electronic Fare Collection
- Gastonia – 8 buses with electronic fare payment

Emergency Management

Enforcement

- Charlotte - 426 Charlotte vehicles under computer-aided dispatch with automated vehicle identification and traffic signal system communications
- Rock Hill - 80 vehicles under computer-aided dispatch
- Tega Cay - 4 vehicles under computer-aided dispatch
- York County - 120 vehicles under computer-aided dispatch
- Highway Patrol – all vehicles equiped with Mobile Data Terminals
- Gaston County – CAD, AVL, MDT
- Gastonia – CAD, AVL, MDT

Fire/Rescue

- Charlotte- 62 Fire vehicles under Computer-aided dispatch
- York County- 12 rescue vehicles under computer-aided dispatch
- Piedmont- 7 emergency vehicles under computer-aided dispatch
- York County - 116 Fire vehicles under computer-aided dispatch
- Concord – fire preemption on 4 signals (testing)
- Charlotte – fire preemption on 30-50 signals, all new truck equiped with opticom emitters
- Gaston Emergency Medical Services – CAD, AVL, MDT

Highway-Rail Intersections

- Charlotte – 8 Signals with preemption capability
- Salisbury – video enforcement (testing)
- Gastonia – 2 signals with preemption capability

Regional Traveler Information

- Metrolina TMC Web Page with link status map and camera images available
  Working on agreements with media to share video
- Charlotte Transit - Automated bilingual telephone system to be upgraded to include customer service module tied to Stop #
- Charlotte network television station linked to 7 CCTV in the Charlotte CBD

Other Deployments

ITS Integration Earmark

- *Metrolina - $1.6M for Systems Integration*
  Needs to be allocated by end of Fed. FY00 (9/00) and under contract by 9/02.

Other

- Charlotte – stop red light running program at 30 locations
- Charlotte – using machine vision cameras for local detection to view for remote incident/ congestion monitoring
- CVS/ Samaritania free/ private incident management patrol on I-77 from the state line to I-85

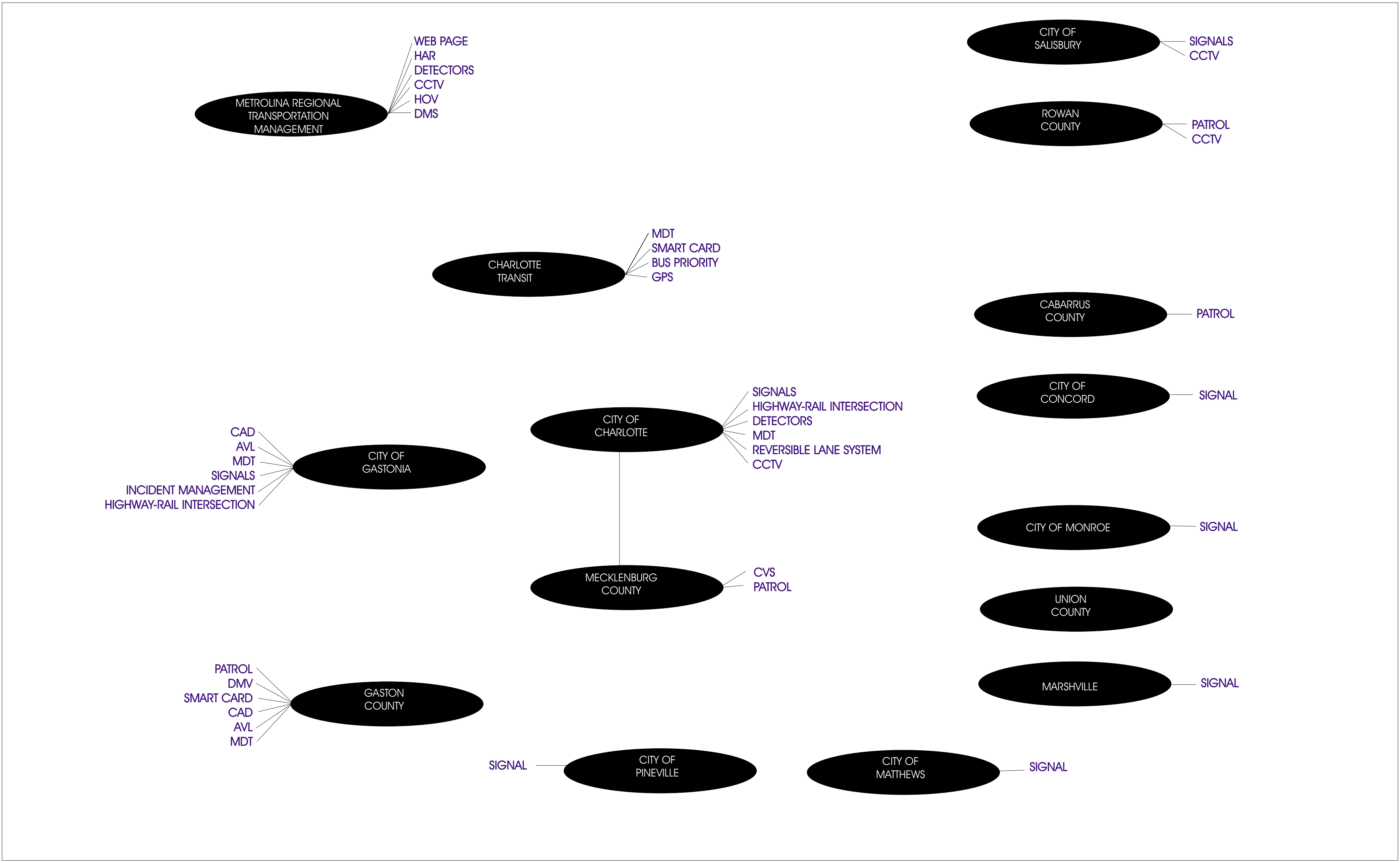


FIGURE 7. SCHEMATIC REPRESENTATION OF METROLINA REGION ITS ELEMENTS

Kimley-Horn and Associates, Inc.

Table 4. Funded and Unfunded Projects in Divisions 9, 10 and 12

Division 10			Division 9		
Funded			**Unfunded**		
Project Name	**Number**	**Cost**	**Project Name**	**Number**	**Cost**
US 74 HOV (Independence Blvd)	U-0209F	$3,959,697	I-85	I-3802	* $7,214,400
US 29 Reversible Lanes	U-3115	$ 1,649,376			
Earmark #1	____	$ 1,572,842			
Earmark #2	____	$ 1,000,000			
I-485 (Charlotte Outer Loop)	R-2248BB	$ 1,523,300			
I-485 (Charlotte Outer Loop)	R-2248C	$ 2,088,900			
I-485 (Charlotte Outer Loop)	R-2248D	$ 2,238,900			
I-77	I-3311A	$ 3,935,450			
I-85	I-3803A	$ 3,209,900			
I-485 (Charlotte Outer Loop)	R-2248E	$ 3,556,000			
I-77	I-3311B	$ 2,645,850			
Future US 74 (Monroe Bypass)	R-3329A	$ 3,447,400			
I-85	I-3803B	$ 925,450			
I-85	I-3802	$ 7,214,400	**Division 12**		
Unfunded			**Unfunded**		
Project Name	**Number**	**Cost**	**Project Name**	**Number**	**Cost**
I-85 (I-77 to US 29-NC49)	Unfunded	$ 3,230,650	I-85 (Gaston County)	Unfunded	$ 17,023,900
I-85 (I-77 to Gaston County line)	Unfunded	$ 4,865,850			
I-277 (Belk/Brookshire Freeway)	Unfunded	$ 4,274,850			
I-485 (Charlotte Outer Loop)	Unfunded	$27,668,450			
US 74 (Monroe Bypass)	Unfunded	$ 4,943,000			
Off Freeway Surveillance for Alternate Routes	Unfunded	$ 2,547,400			

* Project in both Division 9 and 10 cost included in Division 10 projects

Funded

US 74 HOV (Independence Blvd.) (U-0209F). Install nine CCTV camera, three DMS, and fiber optic cable and conduit along US 74. This project is estimated to cost $3,959,697.

US 29 Reversible Lanes (U-3115). US 29, SR 2771 (I-85 Connector) in Mecklenburg County to Rocky River in Cabarrus County. Widen to provide additional through lanes. SR 1300, Mallard Creek to US 29 in Cabarrus County. Widen to Multi-lanes This project is estimated to cost $1,649,376.

Earmark #1 (U-0209F). Provide communication links between MRTMC and Charlotte Signal System Operations Center for US 74 HOV lanes. This project is estimated to cost $1,572,842.

Earmark #2 (U-0209F). Instrumentation of I-277 and integration of CDOT TOC and MRTMC video for US 74 HOV lanes. This project is estimated to cost $1,000,000.

I-485 (Charlotte Outer Loop) (R-2248BB). Install two CCTV cameras, one DMS, and fiber optic cable and conduit along I-485 from north of I-85 to NC 27. This project is estimated to cost $1,523,300.

I-485 (Charlotte Outer Loop) (R-2248C). Install one CCTV camera and fiber optic cable and conduit along I-485 from north of NC 27 (Mount Holly Road) to northeast of SR 2042 (Oakdale Road). This project is estimated to cost $2,088,900.

I-485 (Charlotte Outer Loop) (R-2248D). Install one CCTV cameras, one DMS, and fiber optic cable and conduit along I-485 from east of SR 2042 to US 21. This project is estimated to cost $2,238,900.

I-77 (I-3311A). Install six CCTV cameras, two DMS, and fiber optic cable and conduit along I-77 from I-85 to Charlotte Outer Loop North. This project is estimated to cost $3,935,450.

I-85 (I-3803A). Install five CCTV cameras, two DMS, and fiber optic cable and conduit along I-85 from US 29-NC 49 Connector to SR 2467. This project is estimated to cost $3,209,900.

I-485 (Charlotte Outer Loop) (R-2248E). Install one CCTV camera, one DMS, and fiber optic cable and conduit along I-485 from US 21 to I-85 North. This project is estimated to cost $3,556,000.

I-77 (I-3311B). Install four CCTV cameras, one DMS, and fiber optic cable and conduit along I-77 from Charlotte Outer Loop North to NC 73 (Sam Furr Road). This project is estimated to cost $2,645,850.

Future US 74 (Monroe Bypass Connector) (R-3329A). Install five CCTV cameras, two DMS, and fiber optic cable and conduit along US 74-Monroe Bypass Connector from I-85/US 74 to SR 1520. This project is estimated to cost $3,447,400.

I-85 (I-3803B). Install two CCTV cameras and fiber optic cable and conduit along I-85 from US 29-NC 49 Connector to SR 2467. This project is estimated to cost $925,450.

I-85 (I-3802). Install 28 CCTV cameras, five DMS, and fiber optic cable and conduit along I-85 from NC 73 in Cabarrus County to US 29-601 Connector in Rowan County. This project is estimated to cost $7,214,400.

Unfunded

I-85. Install three CCTV cameras, one DMS, and fiber optic cable and conduit along I-85 from I-77 to US 29-NC 49. This project is estimated to cost $3,230,650.

I-85. Install eight CCTV cameras, two DMS, and fiber optic cable and conduit along I-85 from I-77 to the Mecklenburg/Gaston County line. This project is estimated to cost $4,865,850.

I-277 (Belk/Brookshire Freeway). Install nine CCTV cameras, 10 DMS, and fiber optic cable and conduit for communications, Surveillance/detection, travel information and integration along I-277. This project is estimated to cost $4,274,850.

I-485 (Charlotte Outer Loop). Install 30 CCTV cameras, 11 DMS, and fiber optic cable and conduit for I-485/Charlotte Outer Loop expansion. This project is estimated to cost $27,668,450.

US 74 (Monroe Bypass). Install seven CCTV cameras, two DMS, and fiber optic cable and conduit along the US 74/MonroeBypass from west of US 601 to west of SR 1758. This project is estimated to cost $4,943,000.

Off Freeway Surveillance for Alternate Routes. Install 60 CCTV cameras and fiber optic cable and conduit for off-freeway surveillance including communications. This project is estimated to cost $2,547,400.

Division 12 Projects

The projects listed below are planned in Division 12. These projects — all of which are part of the recommended deployment in the Metrolina Region over the next 10 years — are divided into funded and unfunded projects. Some of these projects have been included in the project (**Table 4**). The costs provided by NCDOT are a preliminary construction estimate.

Unfunded

I-85 Expansion. Install two DMS and fiber optic cable and conduit for I-85 expansion in Gaston County. This project is estimated to cost $17,023,900.

Regional Strategic Deployment Plan Process

Meetings

Regional Kick-off/Consensus Building

A consensus building meeting was held in the region on June 9, 1999. The purpose of the consensus building meeting was to introduce the plan to transportation officials in the region, and to gather input into the process of the plan. The meeting included representatives from the local cities, county, state and Metropolitan Planning Organization in the region. This meeting was not only the first meeting in the region, but also the first meeting for the project overall. The group agreed that the project approach should be modified to help gather more public support. The group suggested that we meet separately with each region's Traffic Coordinating Committee and Transportation Advisory Committee to tell them about the project and upcoming summit, and to encourage their participation in the process. This strategy was employed for the region and the entire project.

Planning Meetings

In preparation for the Metrolina Regional Summit, six consensus-building and planning meetings were held. The minutes for these two meetings are included in the Appendix.

The consensus-building meeting provided an overview of the entire project as well as the process for the regional and statewide plans. It involved 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 planning meeting involved a more limited group of individuals than the consensus-building meeting. This group met to identify specific ITS projects in the region as well as numerous future needs that were carried over to the regional summit meetings and provided the basis for the reminder of the strategic plan.

Summits

Following the initial consensus-building meetings, a regional summit meeting was held on November 17, 1999.

The summit gave people from many backgrounds, with transportation-related professions, the opportunity to learn more about ITS and to provide input on the specific needs that can be met using ITS products and technologies. Attendees included mayors and city and state traffic engineers, representatives from law enforcement agencies, State Senators and transit operators. Members of the news media were invited. The minutes from this summit are provided in the Appendix.

Based on the summit 32 needs were identified for which ITS could be a viable solution. These needs, which are identified and discussed in the next section, are summarized below:

- User-friendly, real-time traffic information
- Coordinated transit service and easier fare mechanism;

- Increased incident management
- Management tools for commercial vehicles

This information was grouped into packages to develop a regional ITS architecture. This process is described in detail later in this report.

Regional Team Meetings

The regional team meetings involved the same transportation professionals as the planning meeting. This team met two times during the course of the project. The first meeting was held on February 11, 2000. At the meeting, the needs identified during the break-out sessions were reviewed and ranked based on their level of importance within the region. From this ranking of needs, a list of short and long term deployments could be developed. Potential projects to help address these needs were discussed, and specific areas of need were addressed. Additionally, information was gathered on the existing and planned ITS projects in the region. The second (March 10, 2000) was to discuss the short and long-term deployment packages that were synthesized from the ranking of regional needs in the first regional team meeting. Potential projects were discussed, and refined based on inputs from the stakeholders. Final information was also confirmed and gathered on the existing and planned deployments in the region.

Identification of Transportation Needs or Issues

As a result of the meetings, summits, and breakout groups focused on three key areas for the Metrolina area were identified:

- Automobiles
- Transit
- Commercial vehicles.

The key transportation issues were identified based on the discussions of the various groups and input from the regional team. There were 32 specific issues in total identified in the transportation summits. Of the 32 needs, seven groupings or subcategories were identified as follows:

Traveler Information

- Too few operational dynamic message signs with current traveler information
- Poor traffic control at major trip generators and highway access points
- Lack of real-time transit information, including travel times, pre-trip and at bus stops
- Poor advance warning of and traffic control in work zones
- Lack of user-friendly, customized traffic information
- Lack of access to traveler information through kiosks and television
- Poor availability and content of digital traveler information broadcasts to portable communication devices (personal digital assistants, pagers, email, etc.)
- Lack of information on park-and-ride facilities
- Lack of remote, interactive voice access to location-specific traveler information
- Lack of remote voice access to traveler information

Inter-jurisdictional Coordination

- Lack of high-speed communications between traffic management centers for real-time information
- Poor integration of transit with other modes (commuter)
- Lack of coordination of transit vehicles across jurisdictional boundaries
- Lack of electronic information sharing with frequent updates between law enforcement and commercial vehicle operators

Traffic Signal Coordination

- Poor signal progression
- Poor traffic control at major trip generators and highway access points
- Lack of signal preemption for emergency vehicles
- Lack of signal priority for transit vehicles

Freeway Management

- Peak hour freeway congestion needs to be addressed
- Lengthy traffic delays and accidents caused by drivers paying attention to incident removal
- Poor traffic control at major trip generators and highway access points

CVO

- Insufficient commercial vehicle monitoring for safety or equipment violations
- Lack of automated commercial vehicle compliance enforcement, including non-point of entry locations, with weigh-in-motion and CCTV surveillance

- Lack of real-time commercial vehicle location for size and weight enforcement and for fleet management
- Inefficient commercial vehicle clearance at points of entry

Transit
- Lack of incentives to use public transit
- Lack of real-time transit information, including travel times, pre-trip and at bus stops
- Poor bus schedule adherence and travel times
- Lack of real-time transit vehicle location for schedule adherence and routing
- Poor integration of transit with other modes (commuter)
- Insufficient fixed-route transit operations, small service area and lengthy travel times
- Lack of widespread electronic transit fare payment systems, including multiple transit fare structure
- Lack of dynamic transit scheduling (adaptive demand responsive scheduling and routing)
- Lack of information on park-and-ride facilities
- Low level of personal safety for transit users
- Difficulties in serving para-transit efficiently
- Lack of signal priority for transit vehicles

Other
- Lack of collision avoidance devices on passenger vehicles

Some of these needs fit in multiple categories and are shown as such.

Several needs that were not identified in the Metrolina Regional summit were identified in one or more of the urban regional meetings. Some of these needs, and some identified in the urban summits, have been identified as linkages to statewide or “extra-regional” needs.

This information was grouped into market packages to develop a regional ITS architecture. This process is described in detail later in this report.

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 for urban areas. **Table 5** lists all 31 user services listed in the NIA and provides a brief definition.

Table 5. ITS User Services.

1	Pre-Trip Travel Information	*Provides information for selecting the best transportation mode, departure time, and 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	Emergency 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 the 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.*

Regional Plan Development Methodology

The objective of this task was to determine, based on stakeholder input, which of the 31 ITS user services need to be implemented in the Metrolina Region and how to phase their implementation (i.e., in the short-term 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 develop 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 key steps aimed at producing a well-defined, integrated user service plan, as follow:

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

The following describes the above steps in more detail. The remainder of this section of the Report 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 North Carolina based on previously identified regional needs. First, the original statements of problems and concerns gathered through stakeholder meetings in each of the summits were assembled into a comprehensive list. Next, this list of original, raw statements 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. Lastly, these needs were placed in a separate category of non-ITS related needs. Lastly these concise need statements were matched with appropriate ITS user services.

The Metrolina Region's transportation-related needs, identified in the previous section, were matched, or mapped, with the 31 applicable ITS user services, resulting in a preliminary set of user services to be deployed specifically in the Metrolina Region. Several overlapping needs that were identified in the other urban regions (Triangle and Triad) were carried over to the Metrolina Region.

These user services were prioritized based on the relative ranking of each related need. The regional team provided the needs ranking, in terms of importance, during regional team meetings. 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 the 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. Market packages and their definitions from the NIA are identified in Table A-2 in the Appendix.

Input Mapping to User Services

The transportation needs for the Metrolina Region, as discussed in the previous section, were mapped to the user services categories in the NIA. The user services mapping is shown in **Table 6**.

Ranking of Identified Needs

The prioritization of user services was based on the relative ranking of each of the 32 needs identified by the stakeholders. The Metrolina Region's transportation stakeholders, ranked the needs during the first regional team meeting.

The assignment of the need rankings (shown in **Table 7**) to the matched user services was accomplished by summing the point scores of all the needs corresponding to each matched user service as shown in **Table 6**. **Table 7** shows the ranking of these needs by the stakeholders involved in the ITS project from the Metrolina Region.

The score for each user service was expressed as a percentage of the total score (equal to the sum of scores for all user services), and plotted on a bar chart. **Figure 8** shows the resulting ranking of the user services receiving points. (The details of this methodology are provided in the Appendix).

The user services shown in **Figure 8** were identified as most likely to achieve strategic planning success in the Metrolina Region. Other possible service packages that ranked low on the relative score system are as follows: Longitudinal Collision Avoidance (0.24%), Lateral Collision Avoidance (0.24%), Public Travel Security (0.64%), Commercial Vehicle Administrative Processes (0.80%), Emergency Vehicle Management (0.88%), Personalized Public Transit (0.96%), En-route Transit Information (1.36%), Automated Roadside Safety Inspection (1.36%). This selection was not intended to exclude these and other user services as needed in specific areas. The list of user services does, however, represent recommendations of regional services on which the remainder of this strategic plan was based.

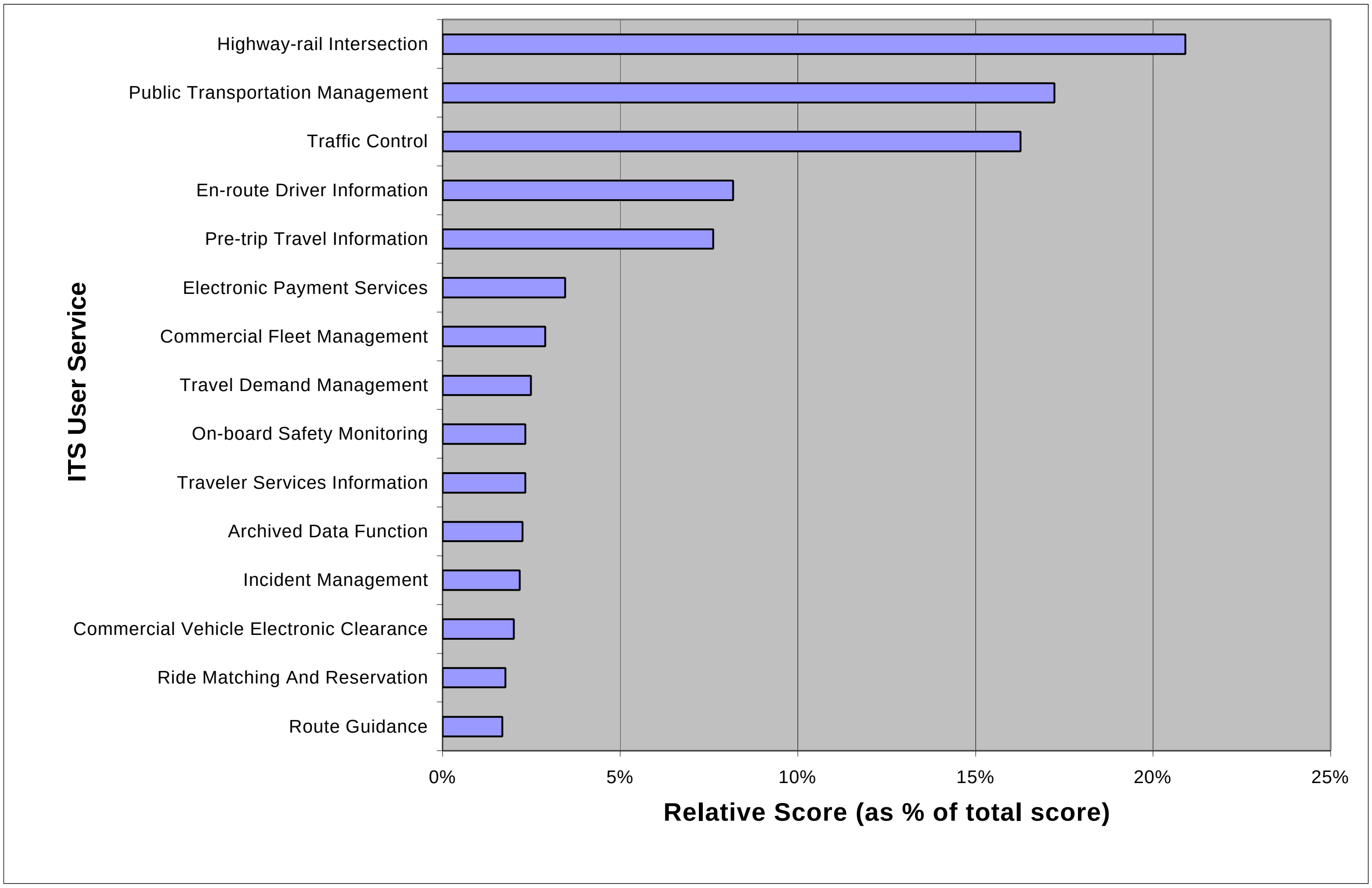
Table 6. Matching User Needs to ITS User Services

		User Services																																
		Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other	
ID#	METROLINA AREA NEEDS	1.1 Pre-trip Travel Information	1.2 En-route Driver Information	1.3 Route Guidance	1.4 Ride Matching And Reservation	1.5 Traveler Services Information	1.6 Traffic Control	1.7 Incident Management	1.8 Travel Demand Management	1.9 Emissions Testing And Mitigation	1.10 Highway-rail Intersection	2.1 Public Transportation Management	2.2 En-route Transit Information	2.3 Personalized Public Transit	2.4 Public Travel Security	3.1 Electronic Payment Services	4.1 Commercial Vehicle Electronic Clearance	4.2 Automated Roadside Safety Inspection	4.3 On-board Safety Monitoring	4.4 Commercial Vehicle Administrative Processes	4.5 Hazardous Material Incident Response	4.6 Commercial Fleet Management	5.1 Emergency Notification And Personal Security	5.2 Emergency Vehicle Management	6.1 Longitudinal Collision Avoidance	6.2 Lateral Collision Avoidance	6.3 Intersection Collision Avoidance	6.4 Vision Enhancement For Crash Avoidance	6.5 Safety Readiness	6.6 Pre-crash Restraint Deployment	6.7 Automated Vehicle Operation	7.1 Archived Data Function	8.1 Other	POTENTIAL PROJECTS
1	Lack of user-friendly, customized traffic information		X			X	X																											AM and FM - based Highway Advisory Radio (freeways and arterials), Kiosks in public places, FM radio station traffic information
2	Poor availability and content of digital traveler information broadcasts to portable communication devices (personal digital assistant, pagers, email, etc.)	X	X																															Free traffic conditions data access for value-added private partners for digital broadcasts (SmartRoutes, ETAK, etc.)
3	Poor signal progression						X																									X		synchronization.
4	Lack of real-time transit information, including travel times, pre-trip and at bus stops	X										X																						Transit kiosks. Web-based transit information access. Bus stop transit schedule displays.
5	Peak hour freeway congestion						X																											Regional traffic control system (freeway management system with system detection, video monitoring, incident detection, ramp metering). Synchronization of ramp meter signals with adjacent traffic signals.
6	Lack of information on park-and-ride facilities	X	X			X							X																					Transit kiosks. Web-based park-and-ride information. Voice remote access system park-and-
7	Poor bus schedule adherence and travel times											X																						State of the art transit dispatching center. Bus priority system (signals). AVL for buses.
8	Lack of coordination of transit services across jurisdictional boundaries											X																						Transit-center-to-transit-center real-time electronic data sharing for bus routing and schedule coordination.
9	Difficulties in serving paratransit efficiently											X																						Various ITS technologies for smaller transit collector services (private and public). Real-time communications between transit and paratransit centers for demand-responsive route and schedule coordination.
10	Lack of remote voice access to traveler information	X	X			X							X									X												VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection.
11	Lack of real-time commercial vehicle location for size and weight enforcement and for fleet management																	X				X												Automatic Vehicle Location system for CVs
12	Inefficient commercial vehicle clearance at points of entry																X																	Automated CV clearance at highway speeds at POEs using PrePass-like technologies.
13	Insufficient commercial vehicle monitoring for safety or equipment violations																		X															In-vehicle driver monitoring systems with wireless communications to dispatching center.
14	Lack of widespread electronic transit fare payment systems, including multiple transit fare structure											X				X																		Smart Card transit fare payment with single payment for multiple transfers and transit mode changes.
15	Too few dynamic message signs with current traveler information		X				X																											Variable Message Signs on freeways and arterials with frequent and accurate message updates.
16	Poor integration of transit with other modes (commuter)				X							X																						Demand responsive transit scheduling systems.
17	Poor advance warning of and better traffic control for work zones	X	X	X			X															X												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.
18	Lengthy traffic delays and accidents caused by rubber-necking during incident removal.							X																										Expand IMAP provider. Incident saftey.
19	Poor traffic control at major trip generators and highway access points						X																											Localized traffic signal coordination and video surveillance near major trip generators. Ramp metering. Synchronization of ramp meter signals with adjacent traffic signals.
20	Lack of signal preemption for emergency vehicles						X																	X										Signal pre-emption for emergency vehicles.
21	Lack of high speed communications between traffic management centers for real-time information sharing						X		X																									High-bandwidth fiber optic communications lines between traffic control/traffic management centers.
22	Insufficient fixed-route transit operations, provide wider service area and minimize travel time											X																						State of the art transit dispatching center. Bus priority system (signals). AVL for buses.
23	Lack of dynamic transit scheduling (adaptive, demand-responsive scheduling and routing)											X		X																				State of the art transit dispatching center. Bus priority system (signals). AVL for buses.
24	Lack of real-time transit vehicle location for schedule adherence and routing											X																						Automatic Vehicle Location system for buses.
25	Lack of signal priority for transit vehicles						X					X																						Signal system software and hardware upgrades to accommodate bus priority processing.
26	Lack of remote, interactive voice access to location-specific traveler information	X	X										X																					VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection.
27	Lack of incentives to use public transit											X				X																		Any transit related improvement will qualify here.
28	Low level of personal safety of transit users														X																			Audio and video monitoring at bus stops. Emergency phones at bus stops.
29	Lack of access to traveler information through kiosks and television	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.
30	Lack of automated commercial vehicle compliance enforcement, including non-point of entry locations, with weigh in motion and CCTV surveillance																X	X	X															Strategically located, concealed WIM stations with associated CCTV surveillance cameras with wireless alerts to law enforcement. AVL for CV with random or permissive tracking by law enforcement.
31	Lack of collision avoidance devices on passenger vehicles																								X	X								Promote use of longitudinal and lateral collision avoidance devices in private vehicles.
32	Lack of electronic information sharing with frequent updates between law enforcement and commercial vehicle operators																X			X		X												Protocols, agreements, communications hardware and software for real-time information exchange between CVO and law enforcement.

Table 7. Coalition Ranking of Identified Needs (by Score).

ID #	Identified Issue	Priority
5	Peak hour freeway congestion	1
21	Lack of high speed communications between traffic management centers for real-time information sharing	2
15	Too few operational dynamic message signs with current traveler information	3
27	Lack of incentives to use public transit	4
3	Poor signal progression	5
18	Lengthy traffic delays and accidents caused by rubber-necking during incident removal	6
19	Poor traffic control at major trip generators and highway access points	7
4	Lack of real-time transit information, including travel times, pre-trip and at bus stops	8
7	Poor bus schedule adherence and travel times	9
24	Lack of real-time transit vehicle location for schedule adherence and routing	10
16	Poor integration of transit with other modes (commuter)	11
17	Poor advance warning of and traffic control in work zones	12
22	Insufficient fixed-route transit operations, small service area and lengthy travel time	13
1	Lack of user-friendly, customized traffic information	14
8	Lack of coordination of transit services across jurisdictional boundaries	15
29	Lack of access to traveler information through kiosks and television	16
13	Insufficient commercial vehicle monitoring for safety or equipment violations	17
2	Poor availability and content of digital traveler information broadcasts to portable communication devices (personal digital assistant, pagers, email, etc.)	18
14	Lack of widespread electronic transit fare payment systems, including multiple transit fare structure	19
30	Lack of automated commercial vehicle compliance enforcement, including non-point of entry locations, with weigh in motion and CCTV surveillance	20
23	Lack of dynamic transit scheduling (adaptive, demand-responsive scheduling and routing)	21
20	Lack of signal preemption for emergency vehicles	22
32	Lack of electronic information sharing with frequent updates between law enforcement and commercial vehicle operators	23
6	Lack of information on park-and-ride facilities	24
28	Low level of personal safety for transit users	25
26	Lack of remote, interactive voice access to location-specific traveler information	26
9	Difficulties in serving paratransit efficiently	27
25	Lack of signal priority for transit vehicles	28
11	Lack of real-time commercial vehicle location for size and weight enforcement and for fleet management	29
31	Lack of collision avoidance devices on passenger vehicles	30
12	Inefficient commercial vehicle clearance at points of entry	31
10	Lack of remote voice access to traveler information	32

Figure 8. User Services Ranking (based on relative importance of associated needs)



Selection of Market Packages

Market packages are also identified to segregate services that are likely to encounter technical and 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 incremental so that more advanced packages can be efficiently implemented based on earlier deployment of more basic packages. In short, 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, that, 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 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 Metrolina Region of North Carolina. The NIA provides a matrix connecting the 31 user services and the 63 market packages. This matrix allows market packages and user service to be tracked to identify specific projects and their coverage of elements in the NIA.

Table 8 illustrates the matching of the user services previously identified to the market packages. 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 Metrolina Region stakeholder needs are indicated with a "NO".

Note that 32 of the possible 63 market packages were identified as potentially deployable in the Metrolina region. This is due to the fact that deployment of several identified user services will require portions of numerous market packages. For example, traffic control user service is matched with 11 market packages; similarly, the economic development user services are related to more than 28 market packages. While this selection may at first sight appear too broad and indiscriminate, one must keep in mind that these market packages represent sets of specific technology applications, called equipment packages, that need not all be implemented to deploy a given user service.

Metrolina Region ITS Architecture

The ITS architecture 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. This chapter describes the process of developing the Metrolina Region architecture.

The national ITS plan originally defined a series of short, medium-and long-term deployment timeframes for ITS. Several 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 that would stimulate public support for additional 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 Metrolina Regional ITS Plan, consistent with the other regional plans in North Carolina:

The following deployment timeframes were identified:

Short-Term: Prior to 2006
Long-Term: 2006 - 2010

General Description of ITS Architecture

The ITS architecture is comprised of two technical layers: a transportation layer and a communications layer. The transportation layer involves 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 9**. 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 or both of these components. The wireline portion of the network can be manifested in many different ways, and most of them are implementation dependent.

A simplified view of the communications interface is provided in the Very Top Level Architecture Interconnect Diagram in **Figure 9**.

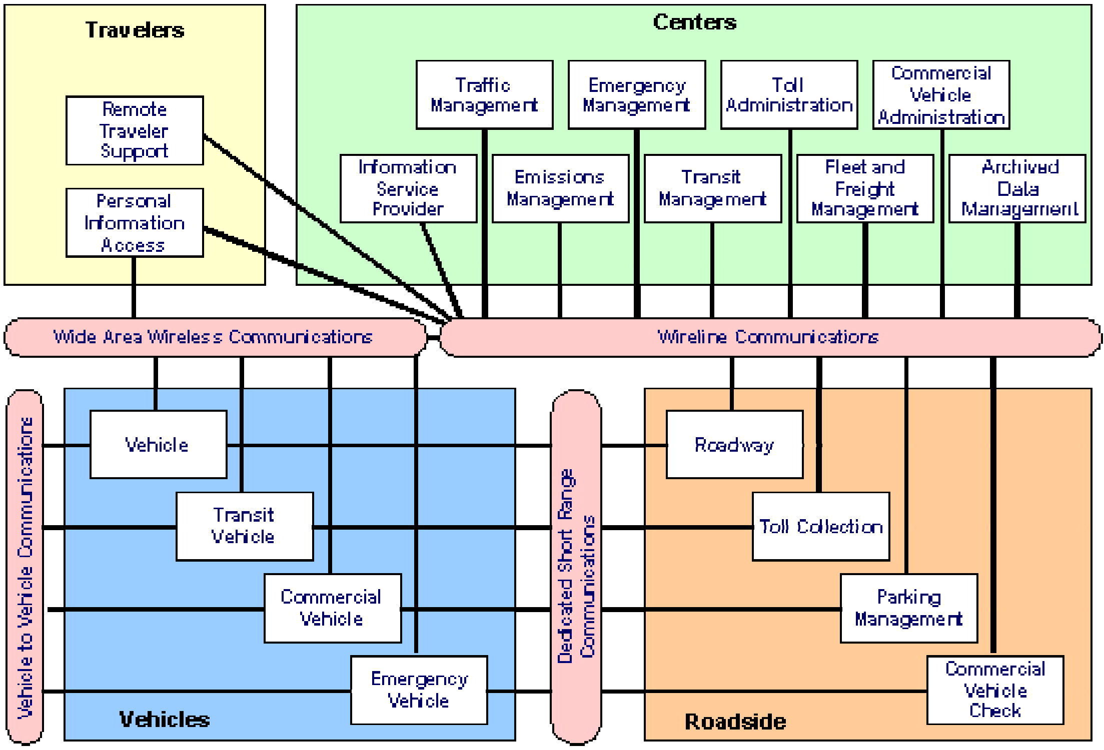


Figure 9. Very Top Level, Simplified Architecture Interconnect Diagram

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 has responsibility for deploying of the specific market packages and individual ITS projects and programs. It also identifies opportunities for public-public and public-private partnerships that would be necessary for successful deployment and/or operations and maintenance.

Recommended ITS Architecture

The regional team facilitated market package selection. Each member of the regional team was given the opportunity to identify candidate technologies, projects and concepts to meet the identified transportation needs. Based on this input, the regional team identified market packages for the selected user services, as well as 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 9.**

S – Short-Term Project/Market Package

L – Long-Term Project/Market Package

Market Packages		1.1 Pre-trip Travel Information	1.2 En-route Driver Information	1.3 Route Guidance	1.5 Traveler Services Information	1.6 Traffic Control	1.7 Incident Management	1.8 Travel Demand Management	2.1 Public Transportation Management	2.2 En-route Transit Information	2.3 Personalized Public Transit	2.4 Public Travel Security	3.1 Electronic Payment Services	4.1 Commercial Vehicle Electronic Clearance	4.2 Automated Roadside Safety Inspection	4.4 Commercial Vehicle Administrative Processes	4.6 Commercial Fleet Management	7.1 Archived Data Function
ad3	ITS Virtual Data Warehouse																	L
apts1	Transit Vehicle Tracking								S	S	S	S						
apts2	Transit Fixed-Route Operations								S	S								
apts3	Demand Response Transit Operations								L	L	L							
apts4	Transit Passenger and Fare Management									L			L					
apts5	Transit Security								L			L						
apts6	Transit Maintenance								S									
apts7	Multi-modal Coordination					S		S	S									
apts8	Transit Traveler Information								S	S								
atis1	Broadcast Traveler Information	S	S							S								
atis2	Interactive Traveler Information	L	L		L					L	L		L					
atis3	Autonomous Route Guidance		L	L														
atis4	Dynamic Route Guidance		L	L	L					L								
atis5	ISP Based Route Guidance	S	S	S									L					
atis6	Integrated Transportation Management/Route Guidance		L	S									L					
atis7	Yellow Pages and Reservation	L	L		L					L			L					
atis8	Dynamic Ridesharing	L	L	L				L		L	L		L					
atis9	In Vehicle Signing		L			L												
atms01	Network Surveillance					S												
atms02	Probe Surveillance					S												
atms03	Surface Street Control					S	S											
atms04	Freeway Control					S	S	S										
atms05	HOV Lane Management					S		S										
atms06	Traffic Information Dissemination					S												
atms07	Regional Traffic Control					S												
atms08	Incident Management System						S											
atms09	Traffic Forecast and Demand Management					S		S										
atms17	Reversible Lane Management																	
atms18	Road Weather Information System		S			S												
avss01	Vehicle Safety Monitoring																	
cvo01	Fleet Administration			L													S	
cvo03	Electronic Clearance													S		S		
cvo04	CV Administrative Processes													S		S		
cvo06	Weigh-In-Motion													S				
cvo07	Roadside CVO Safety														S			
cvo08	On-board CVO Safety																	
cvo09	CVO Fleet Maintenance																S	
em2	Emergency Routing					L												

User Services

Table 9. Market Package Deployment, by Timeframe.

Recommended Projects and Technologies

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

Short-Term (2001-2006) Technologies

1. Web-based mapping and route identification
2. Broadcast video and data (via partnerships with local television stations)
3. Web-based data and video
4. Traveler information kiosks (via partnerships with information service providers)
5. Portable DMS
6. Traffic signal systems
7. Transit AVL
8. Computer-aided dispatching

Long-Term (2006-2011) Technologies

1. Database of archived data
2. Advanced traveler information
3. En-Route access to traffic information
4. Additional deployments of DMS and CCTV
5. Regional system integration
6. Freeway lane control signals
7. Smart Card

Technologies Especially Applicable to Urban Areas

Traveler Information Kiosks – Kiosks provide users with free access at rest areas, welcome centers, etc. to a wide range of information available from state transportation agencies, tourist destinations and organizations, local governments, and downloaded information from the Web. In addition, users can check their e-mail, surf the Web, or use a search engine for a charge. Three 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 most state welcome centers (Source: Arizona DOT).

World Wide Web – The Web provides access to a universe of information, 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 a global positioning satellites (GPS) receiver, cellular digital packet data (CDPD) modem, 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 can detect plow or sweeper up/down status. Functions include operator log-on, vehicle position and transmitting, emergency alarms, two-way messaging, and sensor data collection and storage. (Source: Orbital Sciences Corp., Germantown, Maryland.)

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

Traffic Sensing System – Magneto-inductive sensors are installed in the pavement and transduce small magnetic charges into inductive charges. These charges permit data collection for monitoring traffic. These systems consist of sensors, sensing electronics, cabling, and installation components. They support traffic data collection and storage to monitor speed, number of vehicles by classification, lane occupancy, and vehicle length. (Source: 3M Safety and Security Systems Division.)

Surveillance and Delay Advisory System (SDAS) **-** The SDAS consists of three data collection technologies: WIM, video-based sensing, and spot speed measurements. The system 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. (Source: Office of Safety Research and Development, FHWA, McLean, Virginia.)

DMS - Special attention for use of DMS in urban areas include traffic congestion advisories, tourist information, and various events - such as duration, size, and severity.

Description of Strategic Plan Projects

This Metrolina Regional ITS Strategic Plan has identified the needs of the Metrolina 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, 38 were identified as suitable for deployment in the region. By identifying the desired implementation horizon for each of the 38 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. Probable project costs were derived from recent ITS construction bid documents both locally and nationally. These costs reflect the costs associated with device purchase and deployment. Other associated costs, such as design, mobilization, traffic control and construction observation and testing are not included. These costs can range from as small as 20% of the cost of the devices and construction to as much as 50% or more. In addition, the schematic diagram of the existing planned and programmed ITS deployments in the region (**Figure 7)**, has been modified to show the proposed short and long-term proposed deployments. This modified schematic architecture is shown in **Figure 10.**

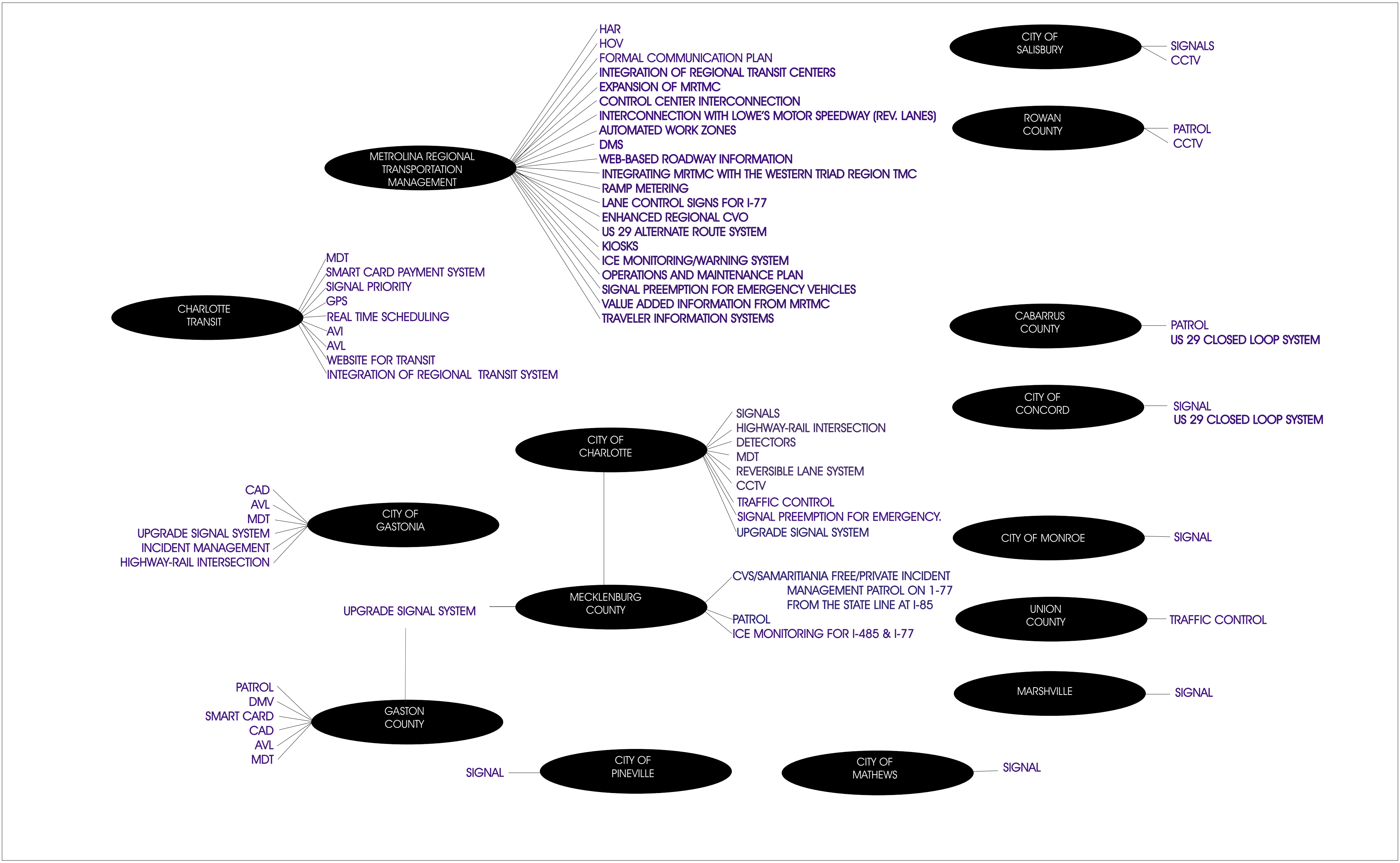


FIGURE 10. SHORT AND LONG TERM ITS DEPLOYMENTS

Kimley-Horn and Associates, Inc.

Short-Term Projects

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

Freeway/Incident/Event Management

Expansion of the MRTMC. The initial MRTMC deployment covered I-77 through central Charlotte from approximately I-85 to the North Carolina state line to the south. This system is to be expanded by adding additional detection, surveillance and traveler information. Ice sensors will also be installed on bridges and overpasses that have historically iced over. The short-term expansion will include I-77 from I-85 to the outer loop to the north, I-85 from NC73 to US29 connector, portions of I-485 as it is constructed and portions of I-277. Portions of this expansion are already being developed by NCDOT. This project will enhance the existing freeway management system by expanding coverage and increasing the number of drivers to whom information can be provided. The cost of this first phase of expansion is estimated to be $63,000,000. This cost estimate includes placing devices along the entire Outer Loop.

Interconnection of MRTMC with US29 Reversible Lane System. There are a number of ITS elements being deployed near Lowe's Motor Speedway. The majority of these elements are designed to provide support for the reversible lanes serving Lowe's Motor Speedway. Tying these devices into the overall regional system will provide consistency and permit NCDOT to use the reversible lanes in the event of a major incident. In addition, more accurate prediction of traffic volumes and arrival times can be made immediately to permit the operators in the MTC to prepare for and respond effectively to incoming traffic from the speedway. These systems will be interconnected with a fiber optic system. The bandwidth necessary is listed in a later section of this report. The cost of this connection is estimated to be $2,500,000.

Control Center Interconnection. One of the key components to a regional transportation management system is integrating the various pieces of the system, both existing and proposed. This also includes tying MRTMC to the surrounding TMC's operated by other agencies. Integration covers both the physical side of connecting these centers (fiber, etc.) as well as the software side. Federal funds and directives have recently been directing DOT's to focus on the latter, attempting to provide interoperability amongst various partners within a region as opposed to installing new infrastructure.

There are multiple control centers in the Metrolina area. These include the City of Charlotte Signal System, numerous Emergency Management Centers, Highway Patrol and Dispatch, the Statewide TMC, Transit Centers, and the South Carolina Freeway Management Systems (FMS) on I-77. A Federal Earmark was identified for regional integration in the Charlotte area. These funds will permit an initial integration effort, however additional monies will be required to permit unlimited information and video sharing throughout the region. The initial integration effort has been budgeted at $2,500,000. The initial integration effort is intended to tie the Charlotte Signal System to the MRTMC. This tie-in will include implementing the infrastructure at the Charlotte Area Transit System to the MRTMC network. The total cost of regional integration is anticipated to be $8,000,000.

Additional Dynamic Message Signs. There are 10 sites identified to receive new permanent DMS structures and signs. These include four signs on the existing MRTMC limits along I-77, three in Gaston and three in Mecklenberg. These signs are not part of the proposed expansion of the MRTMC identified above. The total cost to install these ten signs is approximately $2,000,000.

High Occupancy Vehicle (HOV) Lanes on US 74. Independence Blvd. (US 74) is a major spur into and out of downtown Charlotte from the southeast. Travel on US 74 is highly directional. There is currently a bus only lane in the median that reverses direction based on time of day. NCDOT is planning to make this a general purpose reversible HOV lane. To do this, there are many safety measures that must be implemented to prevent traffic from accidentally entering the lanes while traveling the wrong direction. Some measures may be alerting motorists of the proper direction of flow in advance of the HOV lanes, and visually (as well as automatically) verifying the direction of traffic flow. The total cost to instrument the HOV facility is similar to the costs of extending the MRTMC; that is to say that the cost is dependent on the specifics of the desired devices and their location. The estimated cost for this level of deployment is approximately $6,000,000. This cost, however, can rise significantly based on additional desires and needs, as well as communications along the corridor.

Ice Monitoring/Warning System. The I-485 flyover ramp at I-77 and the interchange of I-77 and the Brookshire Freeway are prone to icing during winter storms. An ice monitoring and warning system will be deployed to determine when icy conditions exist (or are anticipated to exist shortly). The warning system will tie into the existing system and use existing communications. The cost to purchase and install the ice monitoring equipment, provide communications equipment and central control and monitoring equipment for two sites is estimated to cost $50,000. Integrating this into the MRTMC software is estimated to cost $75,000, however once the integration of the weather sensors is implemented, additional locations can be added with very little additional cost at the MRTMC.

Formal Communications Plan. A formal communication plan is needed in the Metrolina region to assist in tying the communications throughout the region together. This Deployment Plan provides a brief overview of the communications network that is necessary for the region. A more formal study, however, is necessary for a number of reasons. A communications plan will determine the exact bandwidth necessary between centers and from individual devices to hubs or concentration points. It will fully document the fiber availability along corridors and will make recommendations as to how best to use this fiber, including technology choices. The communication plan will provide an overall, consistent design standard that all of the agencies throughout the region can use as the system expands. Additionally, documenting specifically what each agency needs to actively participate will allow each agency to budget the resources necessary, both in terms of dollars and people. Finally, by settling on a standard communication framework and device throughout the region, it should be possible to leverage the buying power through the region to get lower prices on end equipment, and a regional maintenance contract, as opposed to expensive training of personnel at each agency.

The development of this plan is anticipated to cost $500,000.

Operations and Maintenance Plan

Traffic Control

US74 from SH 3169 to Union County Line. This project is currently undergoing a feasibility study in conjunction with the expansion of the HOV facility on US74 from Albemarle to Idlewild Road.

Signal Preemption for Emergency Vehicles. One of the issues identified through the stakeholders' involvement process is the need to improve the response time for emergency vehicles to both reach the scene of an incident as well as to return to a hospital or emergency room. The local agencies have already installed 3M Opticom® equipment in the area, and all new emergency vehicle preemption equipment will be the same. A four-way installation of an Opticom® system costs approximately $7,000. These will be installed on an as-needed basis throughout the region.

US29 Closed Loop System in Kannapolis/Concord. As a part of the Lowe's Motor Speedway, US29 will have a number of lanes changed to accommodate flow in both directions. To assist with traffic along this corridor during events at the Speedway, a closed loop system is recommended. This system will permit operators to quickly change timing plans based on traffic volumes and patterns to correlate directly to traffic conditions surrounding the Speedway. Additionally, a closed loop system will reduce motorist delay in general along the corridor by providing an approximately 10% decrease in travel times. The closed loop signal system should extend along US29 into Rowan. The estimated cost for the deployment of the closed loop system along this corridor is $600,000.

Transit

Website. One of the most effective solutions to increasing transit ridership is also amongst the least costly. This solution is to provide transit information on a website. A website has been developed to provide transit schedules, fares, routes and other static information via the web. This website will be modified for expansion along with the transit system to permit future AVL data as well as requests for demand responsive transit. The cost to develop and maintain the basic web site is approximately $50,000.

Bus AVL System. There are over 225 transit vehicles currently in Charlotte. The transit vehicles in Charlotte will be outfitted with AVL systems to permit tracking and enhanced data collection. This system will be developed to permit real-time scheduling and route adherence in future projects. In addition, the buses with this system will be used as probes to determine travel times for various links throughout the system. A demonstration system will be implemented using GPS receivers and cell phones or radios. This demonstration system will not cover all of the vehicles in the fleet, rather only the approximately 60 demand responsive vehicles. This system will cost approximately $50,000. For the fully automated system for all 225 buses in Charlotte, the in-bus components and the central equipment are anticipated to cost approximately $1,200,000.

Real-time scheduling is not completely effective unless the data is provided to the transit riders and potential transit riders. Kiosks and the web are two technologies that will be used to provide this information to riders. However, one of the key means to increase ridership is to provide transit vehicle arrival information at stations. A system will be implemented at major stations and stops to provide this information either visually or audibly. It is estimated that this will cost approximately $15,000 per station. These will be installed on an as-needed basis throughout the region.

Signal Priority for Transit. Once the bus priority lanes along US74 are converted to general use HOV lanes, the need to provide time savings for transit passengers will become a priority. A bus priority system will be implemented along Monroe Road, 7th Street, and Central Avenue. This system will cost approximately $55,000.

Integration of Regional Transit Systems. There are currently multiple transit agencies and service providers in the Metrolina region. Integrating the operations of these transit agencies can reduce some of the inefficiencies in the system. This is a two-phase project. The first phase is the development of an integration plan. This plan will cost approximately $75,000 to develop. The second phase is to integrate the systems. This will require standardizing the communication equipment, scheduling software, and other elements across all of the systems. The actual integration costs will be specifically identified as the integration plan is developed.

Traveler Information

Web-Based Roadway Information. NCDOT is in the process of developing a web-based real-time regional roadway information system to inform motorists of short-term and long-term road closures. This project will all be done internally to NCDOT, so all of the costs are internal to NCDOT.

Value Added Information from MRTMC. There are many private companies that are beginning to repackage ITS data to provide to customers. MapQuest, as described later in this report, is currently providing this information on their website. NCDOT will investigate opportunities to sell or provide this information to these companies. This will require little effort from the DOT aside from identifying potential partners and preparing legal documents relating to the partnership. Data messaging and other efforts required to convert information into a format compatible with the needs of the private partner will be the responsibility of the partner. All of the costs associated with this project are internal to NCDOT.

Traveler Information System. A clearinghouse will be established to store real-time data for traveler information. This system will include data from system detectors, intersections, detector stations, posted incident reports, IMAP incident reports, and real time bus schedule information. This information will also be accessible from a central location, whether it is stored locally or remotely. The development of this clearinghouse will be used in kiosks and websites, with the development geared for long-term projects, such as a voice activated telephone system. The anticipated cost to develop this clearinghouse is $250,000.

NCDOT currently provides road conditions and traveler information over the www.ncsmartlink.org web site. However, the site currently only shows conditions in the Triangle and Salisbury area. Using information from the MRTMC, real-time roadway information will be uploaded to the website to permit users to change travel times and routes based on traffic conditions. A link to the MRTMC web page will be provided upon completion of system acceptance testing in late spring 2001.

Additional Highway Advisory Radio (HAR) Sites. NCDOT will expand the existing HAR system by adding two additional HAR sites. These sites will permit a focused response to traffic incidents and issues by alerting motorists to their existence and detailing the appropriate response. The two additional HAR's are estimated to cost a total of $24,000.

CVO

CVISN. CVISN is the use of ITS information system elements, which support CVO, 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 preparing electronic credentials on the web for commercial vehicle operators. Part 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.

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 in catching cheaters. This demonstration project will cost approximately $200,000.

Safety

Automated Work Zones. NCDOT is 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.

Long-Term Projects

Freeway/Incident/Event Management

Expansion of the MRTMC. The MRTMC will require continued expansion to meet the continued anticipated needs of the Metrolina Region. In addition to expanding along I-485 as various sections are completed, the following freeway segments have been identified for future expansion. They include I-77 from the Outer Loop to Iredell Co. line, I-85 from NC73 to the Rowan County line and I-85 from I-77 south through Gastonia. In addition, MRTMC will be expanded to include US321 in Gaston and the Brookshire Freeway (NC16). The estimated total cost for these improvements is $45,000,000.

Integrating MRTMC with the Western Triad Region TMC. A key component of the development of both a statewide and a regional system is integrating the various TMC's throughout the state. The Western Triad Region TMC in Winston-Salem currently covers I-85 north of Charlotte. By integrating the Western Triad Region system with the MRTMC, the two regions will be better permitted to share information. This is especially important if incidents occur near the TMC "boundaries" or when there is a major traffic issue that concerns both regions. The expansion of MRTMC and the Western Triad TMC will provide the physical infrastructure between the two centers, however active communication elements will be required to connect them. The estimated cost of these active communication elements and the overall integration effort is $4,000,000.

Ramp Metering. NCDOT will provide ramp metering along I-77 and I-85 through Charlotte. These ramp meters will be tied into the Charlotte Signal System (see below) to provide an integrated freeway and arterial management system and to ensure that the queues formed by the ramp meters do not negatively impact traffic flow on the surface streets. Ramp metering along these two freeway segments can reduce recurrent traffic congestion along both I-77 and I-85, and reduce travel times by up to 10%. The cost of providing ramp metering is estimated to be $500,000.

I-77 Lane Control Signs. NCDOT will install lane control signs along I-77 through Charlotte. These lane control signs will be used to inform motorists of lanes that are blocked or restricted in advance. The field equipment will consist of panels with an 'X' indicating that the lane is closed and green and yellow '↓' indicating that the lane is open and/or blocked downstream. These signs will be placed on existing structures and use existing communications infrastructure. The estimated cost to install and integrate the entire land control system along I-77 is $2,000,000.

Traffic Control

Upgrade Charlotte Signal System. The City of Charlotte will upgrade their existing signal system and replace it with a state of the art system. This system will facilitate daily operations, including up and downloading data and timing plans, as well as traffic adaptive abilities. This upgrade will include upgrading the communication network and selected controllers and cabinets. In addition, ATMS elements, such as lane control signals, DMS and CCTV will be included. This system will also be designed and acquired with the intent of full compatibility with the MRTMC. This upgrade is anticipated to cost approximately $20,000,000.

Mecklenburg and Gaston County Signal Upgrades. The existing closed loop signal system along US29/US74 in Mecklenburg and Gaston counties will be upgraded and expanded to encompass the entire corridor. The system will also be upgraded to improve operations, such as ease of use in uploading and downloading information. The overall communication system along the corridor will be upgraded as well, and the system will be integrated into the regional MRTMC. CCTV surveillance cameras will be installed along parallel routes. These upgrades are estimated to cost $300,000.

US29 Alternate Route System. US29 is the primary alternate route for I-85. US29 will be instrumented with ITS elements to alert motorists of the correct route and to permit operators to control devices along the corridor in the event of an incident. This system is anticipated to cost approximately $500,000.

Upgrade the Gastonia Signal System. The signal system in Gastonia will be upgraded to reduce delay and travel time. The Town of Gastonia will upgrade their existing communications as needed. The new system will permit easier uploading and downloading of information. The upgrade is anticipated to cost approximately $2,000,000.

Transit

Smart Card Payment System. There are a number of regional bus systems that either exist or are planned within the region in addition to light rail. Once these exist, and the transfer points are established through the integration plan, 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 System

Kiosks at Major Public Venues. NCDOT and the cities in the Metrolina Region will develop and install twenty (20) kiosks that use web-based technologies to link to the websites in the area that display local traffic and event information. In addition, these kiosks will display information of interest for tourists, including destinations, lodging, restaurants, and information centers. Potential locations include regional malls, rest areas, visitors' bureaus, chambers of commerce, arenas and coliseums, hotels, racetracks, convention centers and others.

Kiosks provide NCDOT the opportunity to enter into ventures with private entities in two ways. The first is by selling or leasing kiosks at locations that are not public facilities, including large employers, malls, or hotels. In addition, if additional kiosks are requested at locations, they also may be sold or leased. 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 websites.

The cost of installing 20 kiosks throughout the Metrolina region is approximately $1,200,000. There are additional costs associated with the long-term operations of kiosks, including maintenance and upkeep of the kiosks themselves and the cost associated with keeping the information on the kiosks up to date. There is also a recurring cost of providing the data link between the kiosk and the central server.

The development costs of the kiosk content needs to be shared amongst the many interested parties. Traffic and transit data is only a small portion of the information that is available, and is typically the least used. The most used information is concerning local interests and directions to destinations. Therefore, the development costs of the content needs to be borne by those who will benefit the most: tourist destinations, restaurants, and hotels.

Expand the Traveler Information System. The traveler information system identified as a short-term project limits the user input to selecting bus routes and identifying "hot spots" along major routes. As a long-term project, NCDOT will expand the system to provide additional real-time information, such as transit arrival and estimated travel times. The expansion of this system, with regard to integration and web site development (including hardware) is estimated to cost $1,500,000.

Project Summary

A summary of these projects and their estimated cost are shown in **Table 10**.

Table 10. Summary of ITS Projects and Estimated Costs (cost based on year 2001 dollars)

Short-Term Projects			Long-Term Projects		
Description		**Cost ($000)**	**Description**		**Cost ($000)**
ATMS			**ATMS**		
S-1	Expansion of the MRTMC	$63,000	L-1	Expansion of the MRTMC	$45,000
S-2	Interconnection of MRTMC with US29	$2,500	L-2	Integrating MRTMC w/ Western Triad Region TMC	$4,000
S-3	Control Center Interconnection	$8,000	L-3	Ramp Metering	$500
S-4	Additional Dynamic Message Signs	$2,000	L-4	I-77 Lane Control Signs	$2,000
S-5	HOV Lanes on US 74	$6,000	L-5	Upgrade Charlotte Signal System	$20,000
S-6	Ice Monitoring/Warning System	$125	L-6	Mecklenburg and Gaston County Signal Upgrades	$300
S-7	US 74 from SR 3169 to Union County Line	*	L-7	US29 Alternate Route System	$500
S-8	Signal Preemption for Emergency Vehicles**	$70	L-8	Upgrade the Gastonia Signal System	$2,000
S-9	US29 Closed Loop System in Kannapolis/Concord	$600			
S-10	Communications Plan	$500			
S-11	Operations & Maintenance Plan	$200			
Subtotal		$82,995	**Subtotal**		$74,300
APTS			**APTS**		
S-11	Transit Website	$50	L-9	SmartCard Payment System	$1,150
S-12	Real-Time Scheduling	$1,250	L-10	Integration of Regional Transit Systems (integration plan)	*
S-13	Bus Priority	*			
S-14	Integration of Regional Transit Systems (integration plan)	$75			
Subtotal		$1,390	**Subtotal**		$1,150
ATIS			**ATIS**		
S-15	Web-Based Roadway Information	***	L-11	Traveler Information Kiosks (20)	1,200
S-16	Value Added Information from MRTMC	***	L-12	Expand the Traveler Information System	1,500
S-17	Traveler Information System	$250			
S-18	Additional HAR Sites	$24			
Subtotal		$274	**Subtotal**		$2,700
CVO					
S-19	Web Credentials	***			
S-20	Truck Presence Detection	***			
S-21	Mobile Inspection	***			
S-22	Weigh in Motion Sites	$200			
Subtotal		$200			
Safety					
S-23	Automated Work Zones	***			
Subtotal		***			
Total Short-Term		$84,859	**Total Long-Term**		$78,150
Anticipated Annual O&M Costs (8% of Total Short-Term)		$6,789	**Anticipated Annual O&M Costs** (8% of Total Long-Term)		$6,252
Total 20-year Estimated Costs			**$163,009**		
*Costs not available at this time					
**With assumed 10 Stations					
***Costs are borne internally by NCDOT					

Operational Concepts

A primary objective with ITS deployments is to provide operational coordination across jurisdictional lines. The proposed Metrolina regional plan will do this by actively sharing data and video and permitting all of the individual deployments to work in concert with one another in the event of a major regional incident. During normal conditions, however, each agency in the region needs to take operational responsibility for their own system.

During major incidents or special events, however, the impacts extend beyond individual jurisdictions and into the entire region. During these major events, regional control and traffic management is a primary concern. The operators within the MRTMC will be trained to respond to incidents and operate the systems around the region.

Following the development of this deployment plan, a regional operations plan that ties in operating procedures for systems throughout the region needs to be developed. This plan will include an 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. The agencies in the Metrolina Region, and their primary responsibilities are as follows:

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

State Highway Patrol
- Emergency management
- Enforcement
- Incident management

Division of Motor Vehicles
- Weigh station
- Incident management

NCDOT Division 9 – Metrolina Region
- IMAP, CCTV, reversible lanes, etc.
- Regional Traveler Information – website development, kiosk traffic information, etc.
- HAR
- Major event/incident coordination

NCDOT Division 10 – Metrolina Region
- IMAP, CCTV, reversible lanes, etc.
- Regional traveler information – website development, kiosk traffic information, etc.
- HAR
- Major event/incident coordination

NCDOT Division 12 – Metrolina Region
- Operate MRTMC
- IMAP, CCTV, reversible lanes, etc.
- Regional traveler information – website development, kiosk traffic information, etc.
- HAR
- Major event/incident coordination

City of Charlotte
- City of Charlotte traffic signal control/systems
- City of Charlotte proposed coordination with statewide center
- City of Charlotte traveler information – local issues and attractions, local traffic information, etc.
- City of Charlotte transit system

- Reversible Lanes

City of Charlotte Police Department (PD)
- City of Charlotte emergency management
- City of Charlotte enforcement
- City of Charlotte incident management

Mecklenburg County Sheriff
- Mecklenburg County enforcement
- Mecklenburg County emergency management
- Mecklenburg County incident management

Mecklenburg County Emergency Medical Service (EMS)
- Mecklenburg County emergency management
- Mecklenburg County enforcement
- Mecklenburg County incident management

City of Gastonia
- City of Gastonia traffic signal control/systems
- City of Gastonia transit system

City of Gastonia PD
- City of Gastonia emergency management
- City of Gastonia enforcement
- City of Gastonia incident management

Gaston County
- Gaston County enforcement
- Gaston County incident management

Gaston County Sheriff
- Gaston County enforcement
- Gaston County safety management

Gaston County EMS
- Gaston County emergency management
- Gaston County enforcement
- Gaston County incident management

City of Concord
- City of Concord traffic signal control/systems

City of Concord PD
- City of Concord emergency management
- City of Concord enforcement
- City of Concord incident management

Rowan County
- Enforcement
- Incident Management

York County Sheriff
- York County incident management
- York County emergency management
- York County enforcement

York County EMS
- York County emergency management
- York County incident management

City of Tega Cay
- Emergency Management

City of Rock Hill
- Emergency Management

South Carolina Department of Transportation
- Incident Management

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 benefit analysis reviews the existing deployments for various short and long term projects recommended for the Metrolina 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 Metrolina Region ITS deployment plan.

Freeway/Incident/Event Management

There are three major ITS functions that make up 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.

IMAP

The Incident Management Assistance Patrol are emergency traffic patrol vehicles equipped to aid minor breakdowns, push or tow vehicles, and reposition and move trailers. The purpose of this program is to respond as quickly as possible to debilitated vehicles to minimize the impact on traffic flow. When additional equipment is added such as computer aided dispatch systems, global positioning systems and mobile changeable message signs, patrols can get the job done faster. Programs like these also benefit the environment by restoring traffic flow and minimizing idling vehicle emissions. Additionally, this program provides an added measure of safety and security to the public.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice included in the appendix of this report for analyzing air pollution reduction with incident management.

Ramp Metering

Ramp meters, an integral ITS deployment used in freeway management systems, have proven to be a valuable tool in controlling traffic while improving flow rates, reducing travel times, emissions and fuel consumption. They also improve the safety of merging traffic while reducing accidents.

A good example of benefits obtained from ramp metering is demonstrated by the collection of data obtained from TMCs around the country for various ramp metering deployments. Survey results demonstrated that ramp meters have increased average speeds between 16% and 62% while reducing travel time by an average of 48%. Also, the data shows TMC's increased throughput between 8% to 22% while demand increased by 17% to 25%. With the increase in demand, the ramp meters have successfully reduced accidents by 15% and 50%[3]. Below are specific examples of ITS benefits from successful nationwide FMS deployments.

- Portland, Oregon: 58 ramp meters, 43% accident reduction, 39% travel time reduction, 25% demand increase, 60% increase in speed.
- Minneapolis/St. Paul, MN: 6 ramp meters, 5 miles of instrumented freeway, 24% accident reduction, 38% accident rate reduction, 16% increase in speed.
- Seattle. WA: 22 ramp meters, 52% decrease in travel time, 39% decrease in accident rate, 86% increase in demand.
- Denver, CO: 5 ramp meters, 50% accident reduction, 18.5% demand increase.
- Detroit, MI: 28 ramp meters, 50% accident reduction, 8% increase in speed, 12.5% increase in demand.
- Austin, TX: 3 ramp meters, 2.6 miles of instrumented freeway, 60% increase in speed, 7.9% increase in demand.
- Long Island, NY: 70 ramp meters, 128 miles of instrumented freeway, 15% accident reduction, 9% increase in speed.

Ramp metering alone has shown to produce a favorable benefit cost ratio. In Minneapolis, an evaluation of the ramp metering deployments showed that benefits of $40 million compared to total costs to implement ramp metering at $2.6 million, yielded a benefit cost ratio of 15:1[4].

Implementing a FMS has also proven to be more cost effective in improving freeway operations than widening the freeway. As an approximate comparison, freeway widening costs $2 million per lane-mile while a complete implementation FMS of an urban corridor costs $500,000 per freeway mile plus the cost of a freeway management center[5]. This amounts to approximately 2:1 benefit cost ratio not including costs for the TMS. Moreover, if the existing freeway is four lanes, implementing a FMS could add about half the capacity of an additional lane at about 1/8 the cost of adding a lane.

For more information on emissions analysis for ramp metering refer to the Off-Model Air Quality Analysis: A Compendium of Practice, Federal Highway Administration Region Four, September 1997 included in the appendix of this report.

Traffic Control

Traffic signals that are interconnected and include traffic adaptive and responsive capabilities have proven to improve traffic progression and reduce delays. Additionally, the interconnection of signals working together has high environmental benefits in the reduction of fuel consumption and emissions. These benefits are illustrated by the examples below:

A Texas state program called the Traffic Light Synchronization (TLS) involved the installation of a system which tied each signal within the system together using communication interconnect with a modem link

[3] Robinson, J. and Piotrowicz., "Ramp Metering Status in North America, 1995 Update," Federal Highway Administration, June 1995
[4] SRF Consulting Group, Inc., N.K. Friedrichs Consulting, Inc. "Twin Cities Ramp Meter Evaluation," Minnesota Department of Transportation, February 2001.
[5]"Comparison of Conceptual System Design and Costs: ITS Surveillance and Communication Applications: Rural vs Urban Freeway Corridors," prepared by Edwards and Kelsy for the I-95 Corridor Coalition, September 1995.

back to a shop computer. The system has resulted in benefits shown below with an estimated benefit/cost ratio of 62:1.[6]

TLS Summary:

Travel Time	13.8%	decrease
Travel Speed	22.2%	increase
Delay	37.1%	decrease
Fuel Consumption	5.5%	decrease
CO Emissions	12.6%	decrease
HC Emissions	9.8%	decrease

Another example that demonstrates the effectiveness of interconnected signals, is the city of Toronto's evaluation of the SCOOT signal control system. This system is comprised of 75 signals and is installed on two corridors and the central business district. The evaluation showed a decrease in both travel time and vehicle stops by 8% and 22%, respectively, and a reduction in delay by 17%. Moreover, due to the improved traffic flow, fuel consumption was reduced by 6%, carbon monoxide (CO) emissions by 5% and hydrocarbon (HC) emissions by 4%.[7]

For methodologies on analyzing emissions reduction, refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report.

Emergency Vehicle Preemption

Emergency vehicle preemption works with traffic signal systems by alerting the signals of their oncoming presence up to a half-mile away. Traffic signals can then adjust their timing and allow emergency vehicles to proceed through an intersection with little delay. This system greatly reduces the chances of a collision at an intersection that in return saves costs in both emergency vehicle replacements and the legal liability when a motorist is injured. In addition, emergency vehicle preemption allows emergency vehicles to reach their destination faster which can make a difference between life and death in many emergency situations. This system works in concert with a well timed signal system to provide priority for emergency services while having minimal impact on other traffic.

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

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[6] Benefits of the Texas Traffic Light Synchronization Grant Program I, TxDOT/TTI Report #0258-1, Texas DOT, Austin,

[7] Glassco, R., "Potential Benefits of Advanced Traffic Management Systems," The MITRE Corporation, ITS-L-141, November, 1995.

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%.[8]

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.[9]

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.

Rideshare Matching Software and Web Access

A ridesharing program through access on the Web would provide travelers an easy way to find carpool candidates. The encouragement of ridesharing could impact traffic congestion and air pollution if single occupancy trips were reduced.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for the Dade County Florida Vanpool methodology.

Transit Priority

The transit priority allows for special treatment to transit vehicles at signalized intersections on roads with significant transit use. Three types of priority strategies exist. The first type of priority is the passive priority strategy that incorporates the timing of coordinated signals at the average bus speed instead of the average vehicle speed. The second type of priority is the active priority strategy that involves signals detecting the presence of a transit vehicle and thereby granting an early green signal or holding a green signal that is already displayed. The third priority strategy involves a short stretch of bus lane at the intersection called the queue jump lane. This enables buses to by-pass waiting queues of traffic and to cut out in front by receiving an early "bus only" green signal. By including at least one or all of the priority strategies, the average travel time per transit route can be reduced substantially.

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

The success of this type of program is demonstrated by two cities already employing priority strategies. Los Angeles has incorporated the signal priority on two routes called the Metro Rapid along the Whittier-Wilshire Boulevard and Ventura Boulevard. Total travel time for each Metro Rapid route has dropped by 25% compared to regular local service. Vancouver , Canada introduced the 99 B-line rapid bus along a 11mile cross town route with 14 stops. Travel times for this route were reduced by 20-40% compared to the local bus travel times. This program was successful enough to add a second rapid bus route in September of 2000.[10]

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.

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[11].

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

[10] Bus Rapid Transit Web Site, brt.volpe.dot.gov/guide/signal.html, February 14, 2001.
[11] Tech Environmental, Inc., Air Quality Benefit Study of the SmarTraveler Advanced Traveler Information Service, July 1993.

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.[12]

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.

Lane Control and Reversible Lanes

Lane Control utilizes various forms of dynamic message signs and specific lane control signs to convey directional, speed regulatory, warning and travel information to freeway users. There are several ways lane controls can be used. One example of lane control is when a reversible lane is used to convey high traffic volumes for each approach. The lane control signs, which are usually displayed well in advance of a merge, are used to close a lane on whichever approach has the lower volume during a given time period and keeps all lanes open for the higher volume approach. Additionally, lane control displays are used to convey messages of speed control for particular lanes due to accidents, weather conditions, construction or special events. Lane control is beneficial because it can decrease traffic congestion and reduce vehicle delays. Moreover, with a reduction in idling vehicles, lane control will also help to reduce air polluting vehicle emissions. Another Lane control benefit is the reduction in vehicular accidents. In England, a system incorporating lane control paid for itself within a year based solely on accident reductions[13].

[12] City of Los Angeles Department of Transportation, "Automated Traffic Surveillance and Control (ATSAC) Evaluation Study," June 1994.
[13] Freeway Lane Control, www.bts.gov/ntl/99030/s03/body_s03.html, accessed 2/28/01

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.[14]

The intent of the regional architecture is to document the flows of data between the many elements that are currently and will ultimately be deployed throughout the Metrolina 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 shelf. 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 compliance 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 Communication 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 identified for the Metrolina region have been identified through the use of Turbo Architecture[15]. 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

[14] The architecture was developed using Turbo Architecture 2000 version 1.0, developed by FHWA.
[15] This list has been complied from the output produced from the Turbo Architecture tool.

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 Metrolina Region is to comply with national standards. However, a number of choices were made in the development and deployment of the TRTMC and other systems over the past few years that will affect 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 Opticom® equipment either be 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 Metrolina Region's ITS deployment plan is to continue to expand the MRTMC. Through this expansion, data and video will be more readily shared amongst all of the agencies in the region, which will permit a more efficient dissemination of information to travelers. This system, will require a virtual regional database of traffic conditions and traveler information from which the users can obtain the information they require. This regional system, with the various inputs and outputs is shown in **Figure 11**.

The concept of the architecture is that all of the agencies and traffic operation centers both regionally and, to some extent, statewide, will 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 12**. NCDOT has the foundation for either type of system in place with ncsmartlink.org operating in both modes. This is known as a hybrid system.

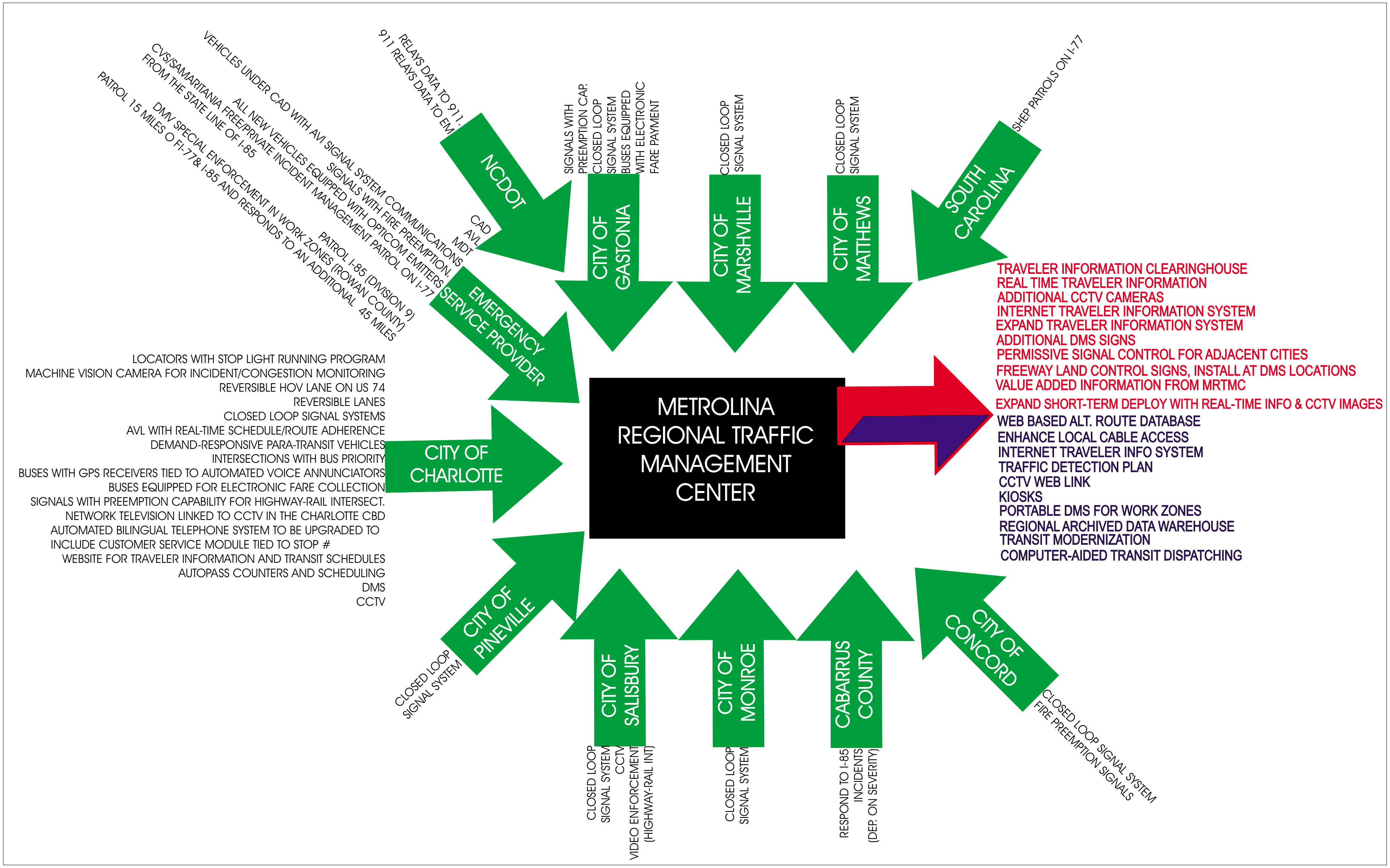

FIGURE 11. GENERIC REGIONAL ARCHITECTURE

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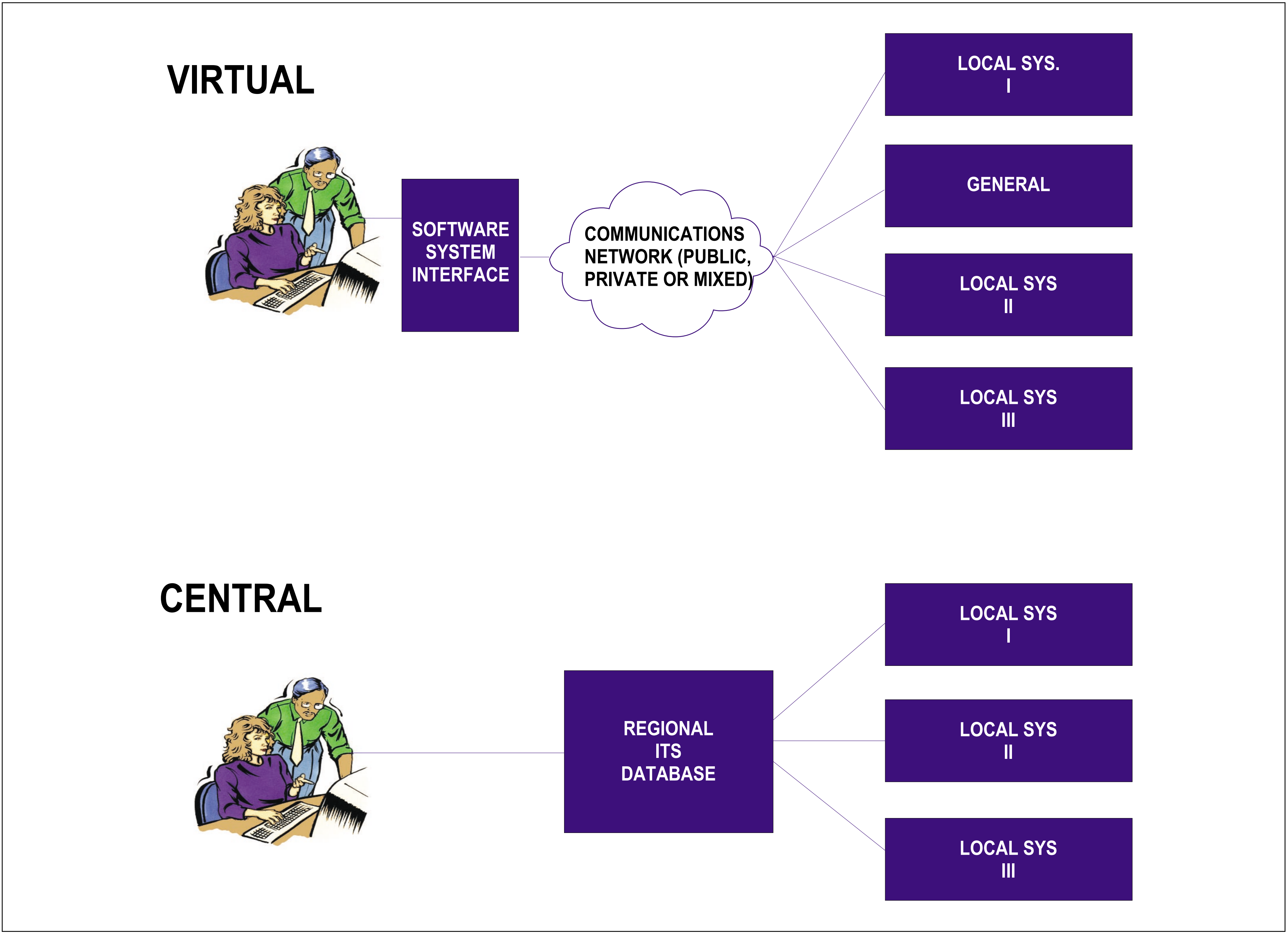


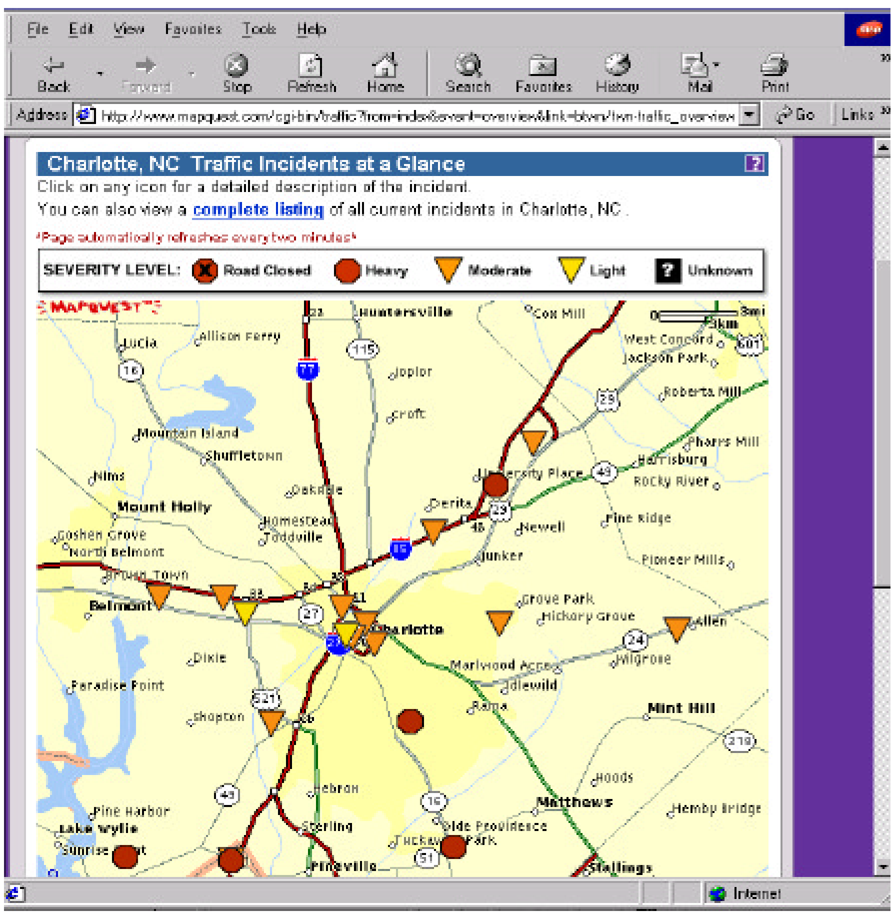
Figure 12. Central vs. Virtual Information System

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. 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 13**.[16]

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 13. Sample MapQuest Image.



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16 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).

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 would require 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 that is 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 only 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 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 users. This problem can be eliminated by standardizing the front ends of the various systems.

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 Metrolina region is a mature region with respect to ITS and traveler information systems. The development of the MRTMC (formerly Congestion Avoidance and Reduction for Automobiles and Trucks (CARAT)) has provided a centralized point to which all of the traffic information can be transmitted and from where all of the traveler information can be disseminated. In addition, the proposed expansion of MRTMC throughout the entire Charlotte area will permit growth of the system and the development of a full regional communication network.

For these reasons, it is recommended that a centralized system continue to be developed in the Metrolina region. The MRTMC will continue to operate as the main "hub" for communications throughout the region, and provide control of systems during emergencies, incidents and special events. Local agencies will continue to provide control of their systems during typical conditions.

Until the communications infrastructure is expanded through MRTMC expansion and other projects, the region will operate as a hybrid type system, with leased telephone, Integrated Services Digital Network (ISDN) and other technologies providing communications between MRTMC and various local agencies.

Communication System

The Metrolina regional communication system will be made up of a fiber optic network in a “star” topology as shown in **Figure 14**. The star will have MRTMC as the center. Each major corridor will consist of a collapsed ring. The expansion along the I-485 loop will provide significant redundancy in the event of a failure at any point along the system.

The communications system for MRTMC uses SONET standards at a bandwidth of OC-12. The bandwidth associated with this system is approximately 620 Mbps. If the communications network were devoted solely to standard NTSC video transmissions, approximately 120 full-frame, full-motion images could be broadcast simultaneously[17].

The infrastructure required for this project will be developed as part of the short- and long-term projects. Each project requires communications internal to the project, however the addition of fiber for the regional system will add an insignificant cost (The vast majority of installing fiber optic cable is in the trench, conduit and labor to install the cable. Adding additional strands only adds an insignificant amount per linear foot of cable).

Communications Assessment

The bandwidth necessary for the deployment of this system is easily accommodated by the SONET OC-12 architecture deployed through MRTMC. This architecture permits each of the agencies tied into the system to connect to the system easily if fiber optic cable enters each facility. NCDOT has been preparing for this type of deployment with the initial CARAT design and with the various plans for expansion. Examples include providing a connection to the Charlotte Signal system, and providing a pull box with coiled fiber outside of the CATS facility.

As the data on the network grows, the only changes necessary involve the end equipment. Bandwidth across the network can be expanded from the existing OC-12 (620 Mbps) OC-48(2.49 Gbps) by replacing network cards.

Additionally, the entire communication network can be upgraded as technology continues to advance to utilize some of the advanced technologies available. These include breaking the existing network into smaller OC-3 segments, permitting data and video to be transmitted from site to site or from center to center. This architecture will permit, for example, the City of Charlotte and NCDOT to be on their own “private” network within the region. Information from this network can be easily shared, however only the pertinent information needs be bridged from the smaller network to the MRTMC network, using the same end equipment and inactive elements (fiber, etc.).

For those facilities that are not part of the MRTMC network, such as emergency services and others, data and video can be shared through different means. The two most appropriate methods are to use local networks and dial-up networks.

If an agency does not share a facility with an existing or proposed traffic operations center, but is on a local or wide area network, that network can be used to transmit information. For instance, if the Concord Police Department is located in a separate facility from the Concord Traffic Department, but is on the Concord Local Area Network, bridging equipment can be installed to permit the transfer of information from the MRTMC network at Concord Traffic to the LAN and across to the Police Department.

[17] Standard full-frame, full-motion video uses approximately 4.5 Mbps. SONET has an overhead rate of between 10 and 20%.

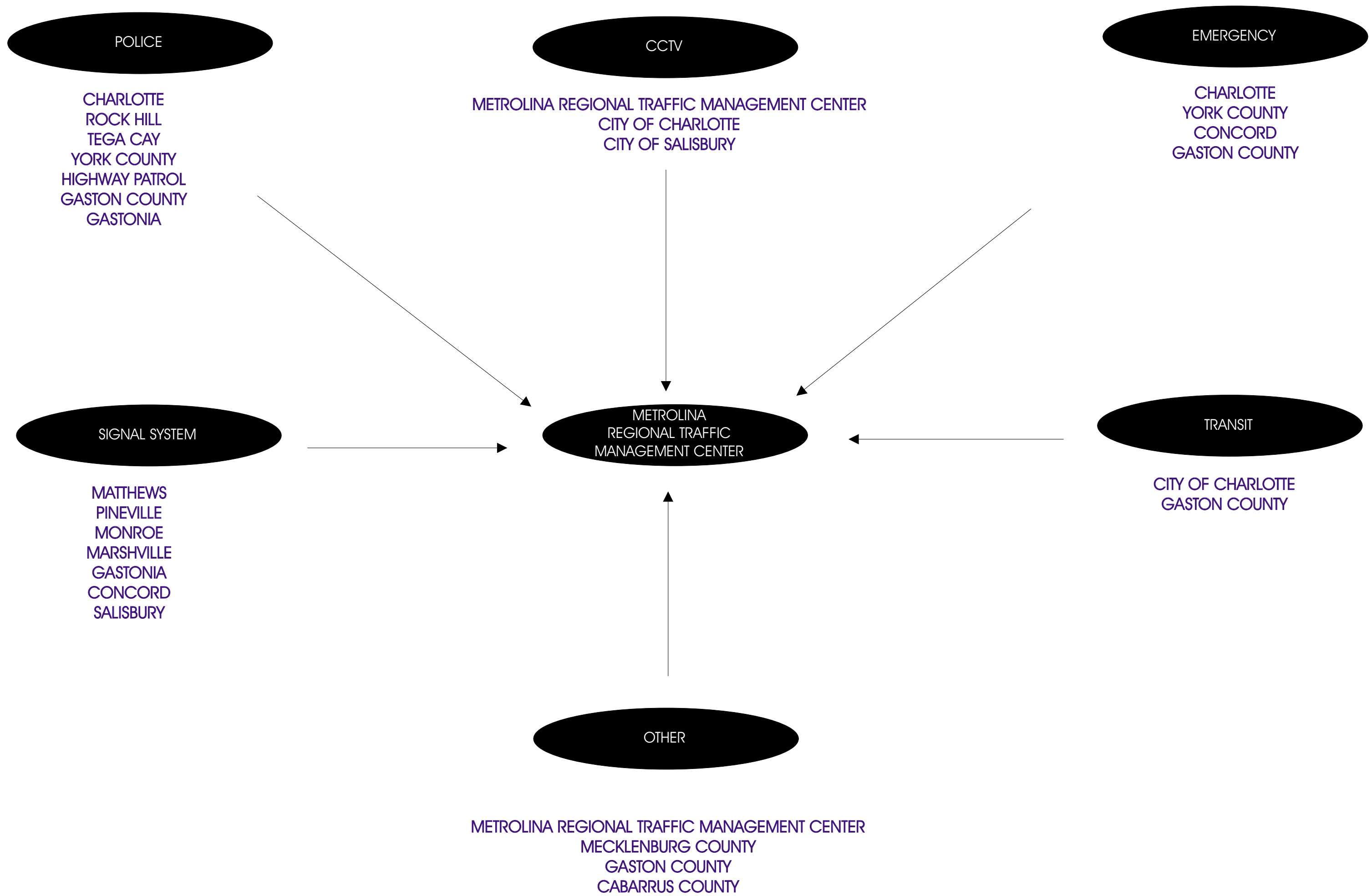

FIGURE 14. PROPOSED COMMUNICATION TOPOLOGY

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Dial-up networks permit remote access to information from anywhere. ISDN and Digital Subscriber Line (DSL) type connections limit that access to the specific locations where the DSL or ISDN drop is located. However, the need for access in the Metrolina region to those who are not on the MRTMC network is typically static in nature, and such technologies will permit access to the required data and video.

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 MRTMC and the other traffic control centers in the Metrolina area can vary depending on the bandwidth available, and expanded 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 (kilobytes per second). 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.

Communications Plan

The proposed communications plan for the Metrolina Region is shown in **Figure 15.** This figure represents the number of video images being simultaneously transmitted over a link at any given time. It also shows the bandwidth required for data and video transmission.

Most of the required communication links already either exist, have been designed, or are under construction. The completion of I-485 around Charlotte will provide redundancy for the entire network.

Formal Communication Plan

The purpose of this document is to outline an overall ITS plan for the Metrolina Region. The regional communication architecture and this communication plan are intended as a guide for further development. It is vital that a formal, coordinated, regionally developed and approved communication plan be prepared. This plan needs to document, in very specific term, the fiber optic backbone and spurs, down to the fiber number (tube and fiber color). In addition, a specific network architecture (SONET, ATM, proprietary) needs to be identified and agreed upon, in addition to video transmission standards (MPEG 1, 2, MJPEG, etc.) and methods (point to point, broadcast, etc.).

By making these decisions as a region, each agency can begin to plan to purchase the required end equipment that is necessary to create a compatible system that enables the entire region to share data and video seamlessly. In addition, this plan will permit the region to hire the personnel required to operate and maintain the high-end electronics necessary to operate the communication system, as opposed to having one or two people from each agency responsible for their own maintenance, with little training or experience.

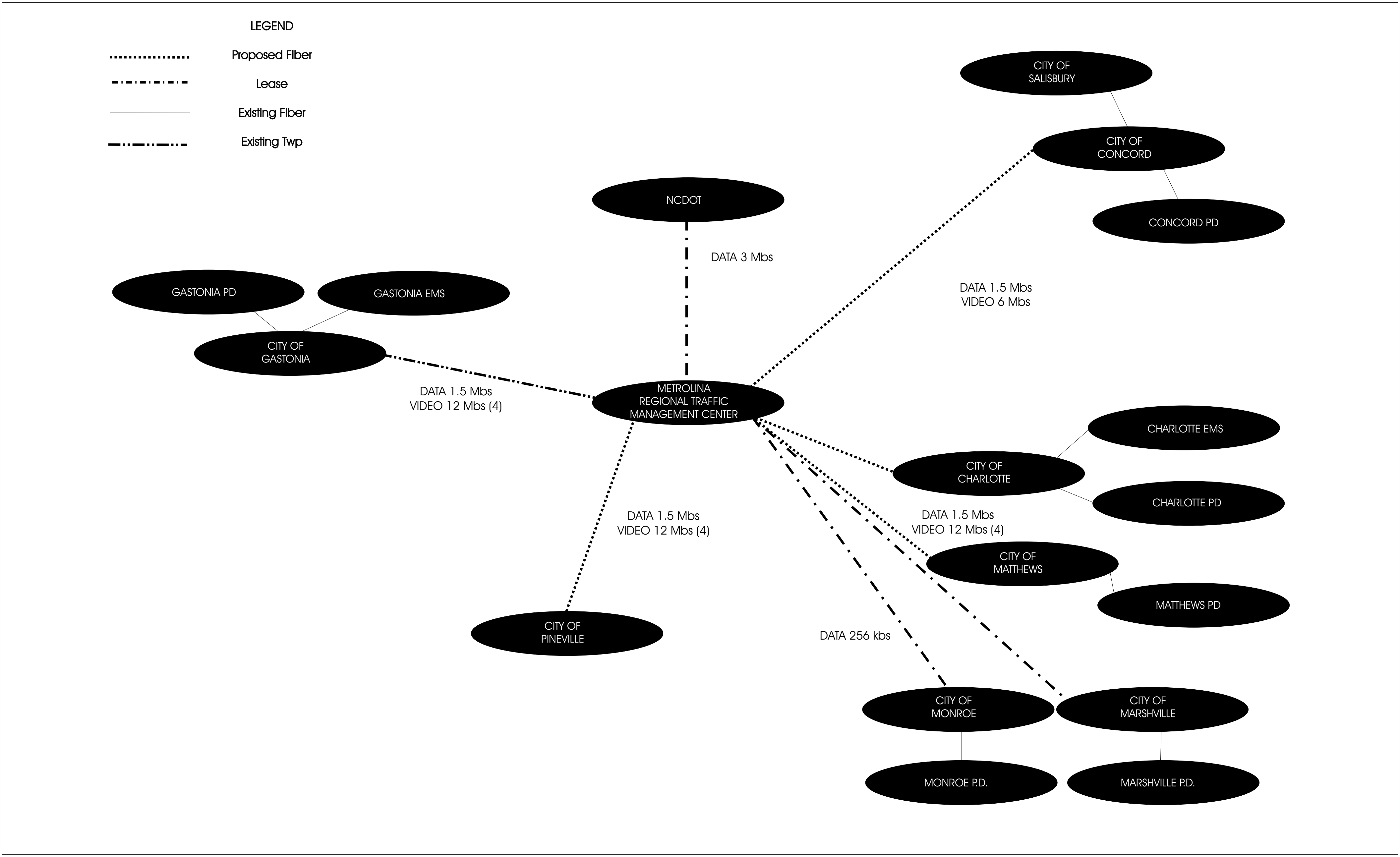

FIGURE 15. METROLINA REGION COMMUNICATION PLAN

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Continued Access Locations

There are two locations where continued access to the data and video is absolutely critical for safety. These are the reversible HOV lanes on US74 and US29. Communications between these two sites, when operating in fully automated modes, is an absolute necessity to permit safe operations. It is recommended that a redundant communications link be established between MRTMC and these two sits.

To permit this redundancy, a low-speed connection, such as a leased DSL is acceptable. Although these connections, as described above, do not permit full-screen full-motion video, lower speed video or still frame video will permit operators to verify that the settings of gates, signs, and other components are correct before opening the lanes.

Statewide Link

The statewide link is necessary for numerous reasons, most notably to monitor traffic status in the Triangle and Triad regions, and for those regions to view traffic in the Metrolina region. 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 within the Metrolina region are planned to be transmitted at the television standard of between 3 and 6 Mbs, statewide video transmission is recommended to be limited to 384 Kbs.

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 three T-1 connections be provided from the Metrolina region to NCDOT headquarters in Raleigh. The cost to lease the bandwidth required to connect these two centers would be approximately $30,000 per year, in addition to a one-time setup and installation cost of approximately $20,000.

One of the projects identified as a long-term goal is the connection of the MRTMC in Charlotte to the WTRTMC in Winston-Salem. The completion of this project is dependent on the completion of multiple projects in both the Triad region as well as the Metrolina region.

South Carolina Link

One of the goals of the regional team was to include South Carolina DOT in both the development and subsequent development. Immediately south of the North Carolina border, South Carolina has installed freeway and incident management systems. As part of the expansion of the MRTMC, these two systems will be connected to permit video and data sharing, as well as closer coordination in responding to incidents. Both systems are currently fiber optic based, so tying them together will only require coordination and integration of the communication networks.

APPENDIX

Meetings

Summits

NIA Compliance

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

Turbo Architecture Output

Metrolina Region Sausage Diagram

Metrolina Turbo Architecture Interconnect Diagram

Metrolina Turbo Architecture Flow Diagram

Metrolina Inventory to Market Package Comparison

Metrolina Market Packages Report

Metrolina Relevant Standards Activities

Metrolina Stakeholders Report

Metrolina Regional Architecture (Sample)

- Complete architecture is 767 pages long and included in a separate appendix.