Triad Regional Report

SMARTlink
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.

[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.

CVISN	*Commercial Vehicle Information Systems and Networks.* Refers to the ITS information system elements that support CVO.
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 from the stakeholders in the Triad 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 Triad Region of North Carolina encompasses Guilford, Forsyth, Davidson and Alamance Counties, as well as part of Randolph County. Major cities in the area include Greensboro, Winston-Salem, High Point, and Burlington-Graham. Although ITS is relatively new, there are many ITS deployments that are either fully functional, in construction, or in the planning stages throughout the Triad Region. This region has one of the more mature levels of existing ITS deployment in the state, including multiple Transportation Management Centers (TMC).

From the stakeholder input process, the ITS Strategic Deployment Plan process identified 36 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 Triad 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 Triad 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 Greensboro 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 Winston-Salem, Greensboro, 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 Triad 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 Triad 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, though 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 safe and efficient operation of the nation's highway system, particularly system aspects that will increase safety. Identify system aspects that may degrade 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 is occurring 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[2].

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 portray weather information, real-time traffic conditions, incidents, etc. They are a basic, in-place building block for an Advanced Traveler Information System (ATIS) in this region. Similar facilities exist at all 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 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 on I-40 through the extreme Fayetteville end of I-40 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 on a remote section of highway through the mountains and the Pigeon River Gorge. NCDOT

2 Benefits data is taken from various sources, including: Meyer, M., “A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility,” Institute of Transportation Engineers, 1997; Intelligent Transportation Systems: Real World Benefits, prepared for FHWA Intelligent Transportation Systems Joint Program Office, Apogee/Hagler Bailly, January 1998; and, «Review of ITS Benefits: Emerging Successes», Prepared for Federal Highway Administration, MITRETEK Systems, September 1996.

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 Traffic Operations Center (TOC) in Asheville, 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 Triad 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 Triad Region.

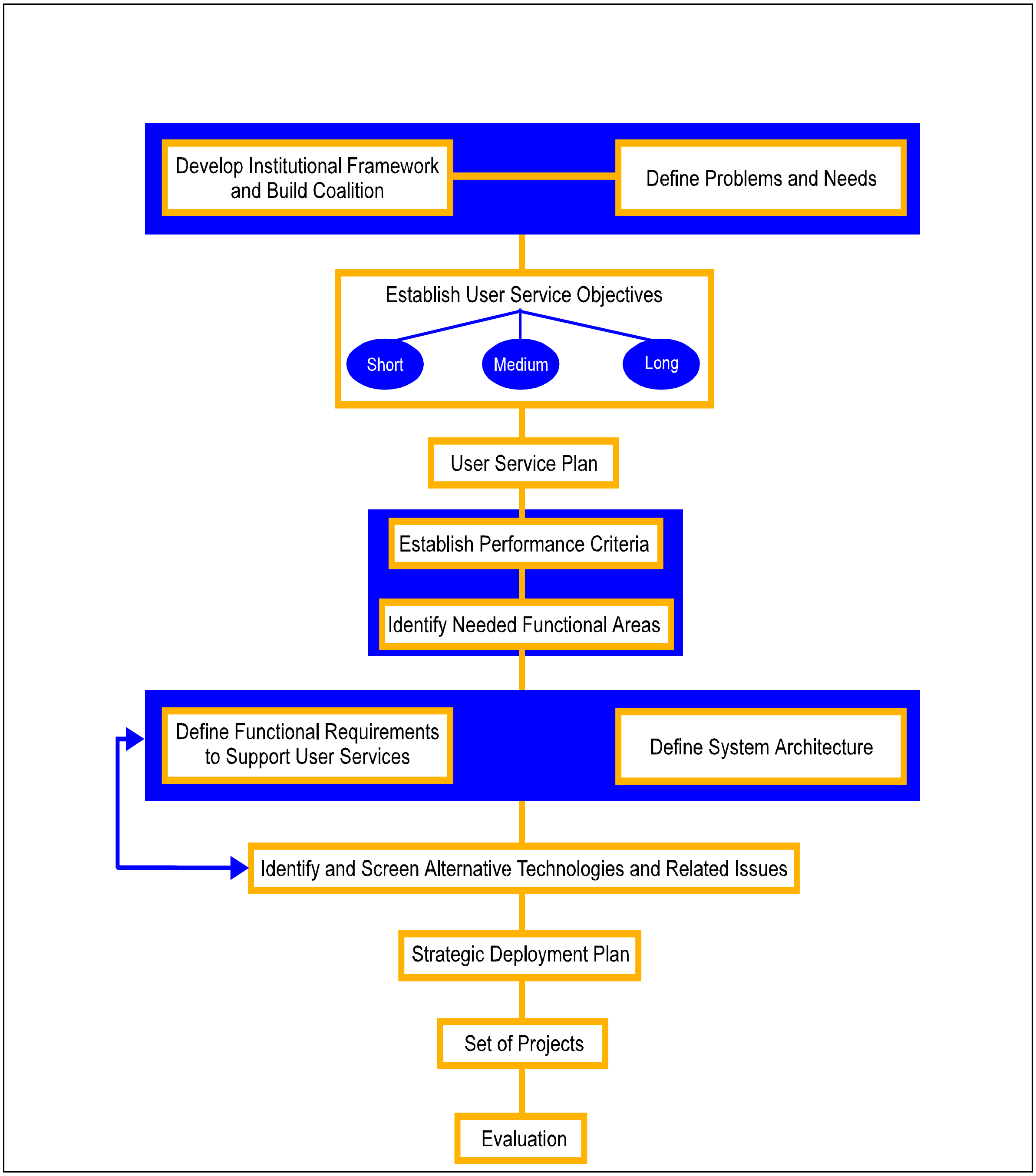


Figure 1. ITS Planning Process.

Background

Project Background

Statewide

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

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

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

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

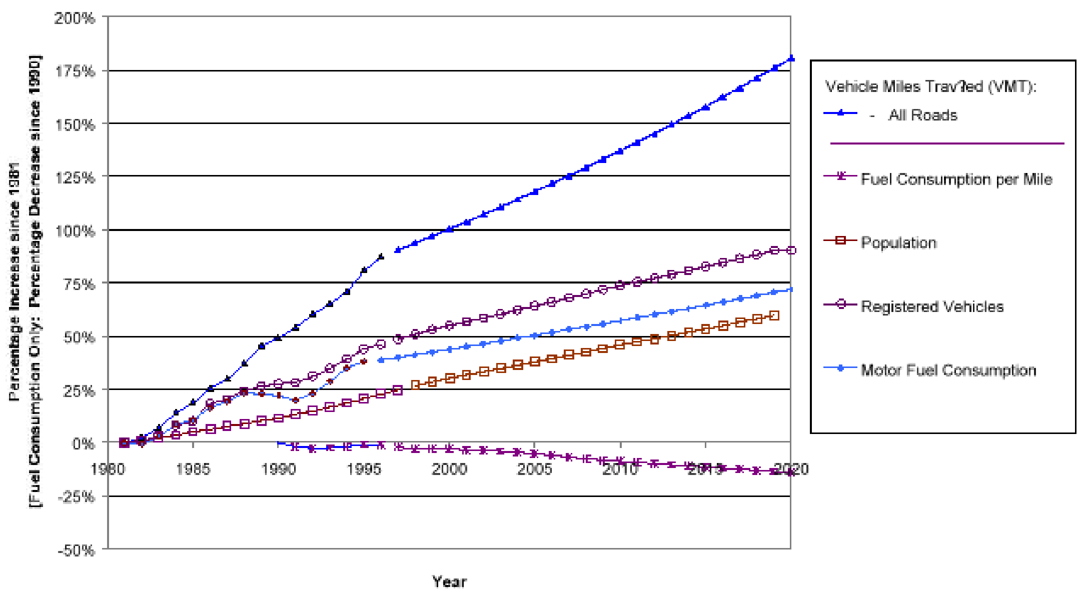


Figure 2. Projection of Key Transportation Indicators for North Carolina.

NCDOT Regional Plans

The North Carolina ITS Strategic Deployment Plan comprises nine regional plans, as shown in **Figure 3** (the I-95 Region is included in the Statewide Report in the interstate system). These regions are grouped according to the ITS needs within each region. For instance, the needs in the 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 Triad Regional ITS Deployment Strategy must be compatible not only with the regional and local goals set forth by municipalities and countries 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
- ITS Integration – acceleration of the integration and interoperability of ITS

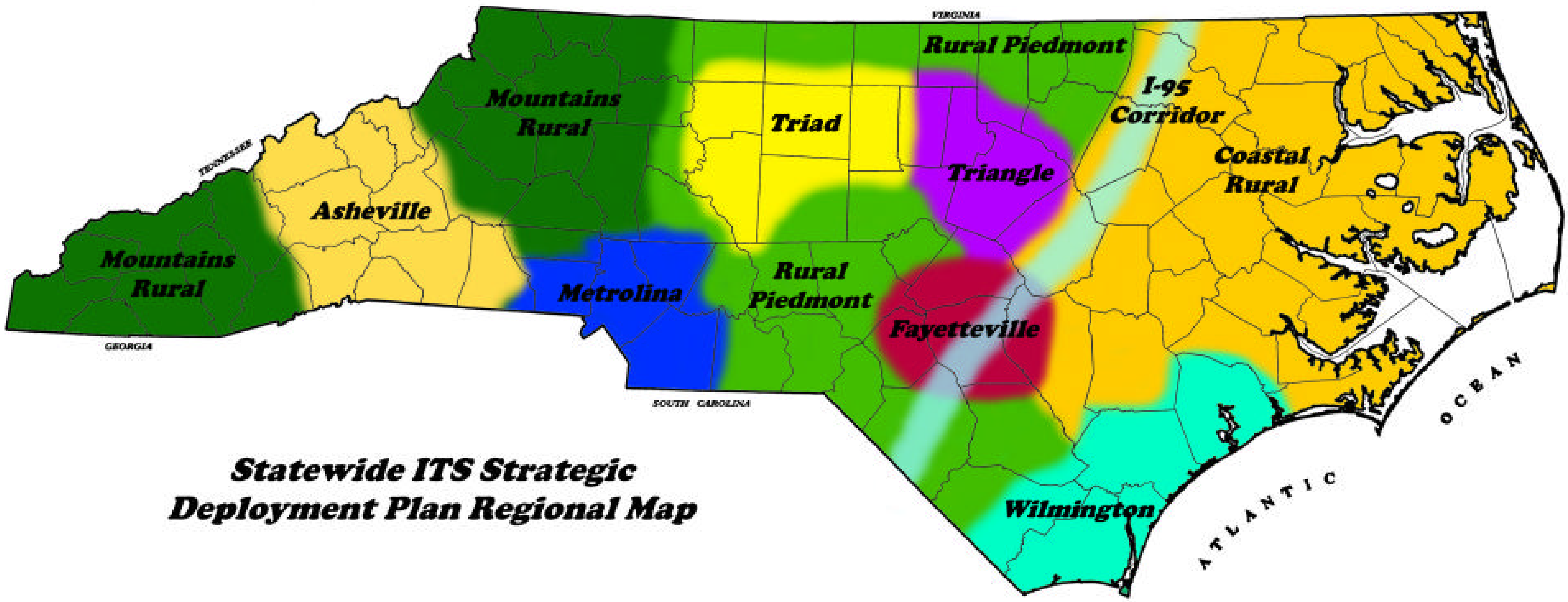


Figure 3. North Carolina ITS Strategic Deployment Plan Regions

- 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 [3]
- 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

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

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

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

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

- Goal 2: Provide quality customer service.

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

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

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

- Goal 4: Demonstrate responsible stewardship of fiscal resources.

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

- Goal 5: Demonstrate responsible stewardship of other resources.

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

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

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

- Goal 7: Maintain a quality workforce.

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

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

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

Regional ITS Goals

Two types of regional 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
- Provide a centralized, statewide TMC

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 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.

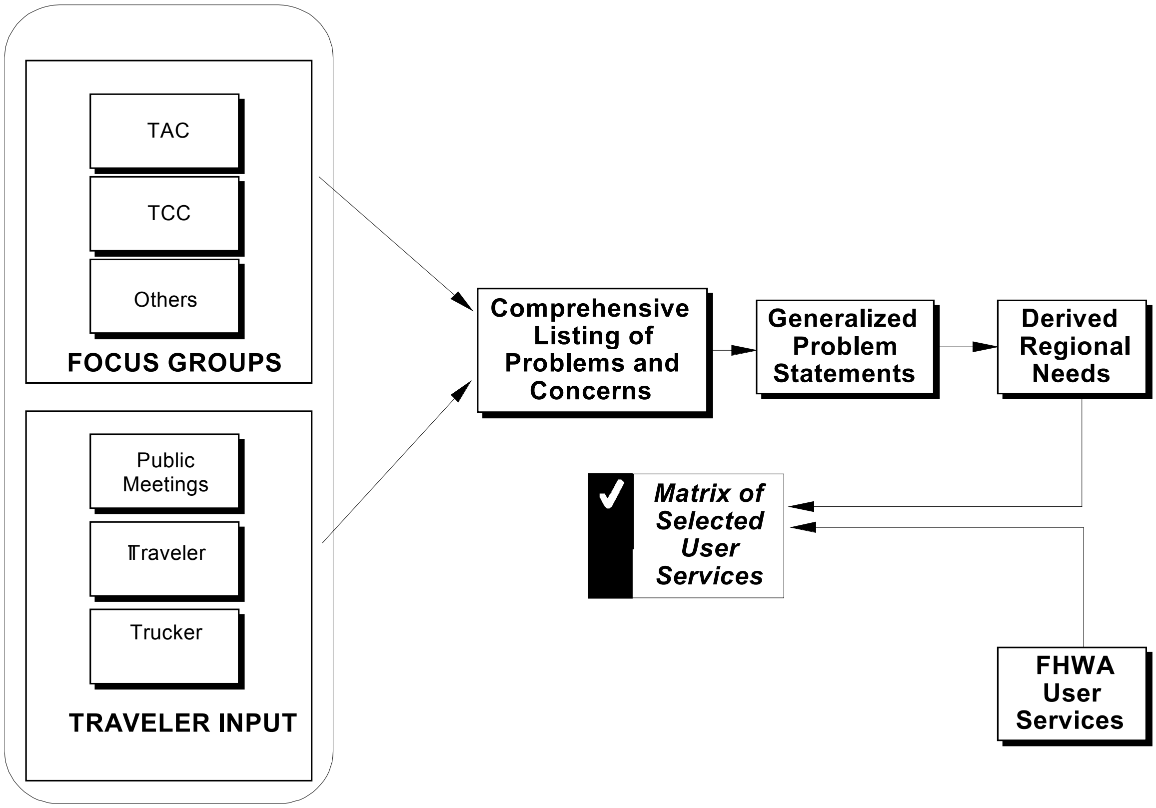


Figure 4. Identification of Needs and User Services

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 Triad Region.

The following example illustrates the benefit of this categorization of market packages. The Regional ITS Summit in the Triad 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**.

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).

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

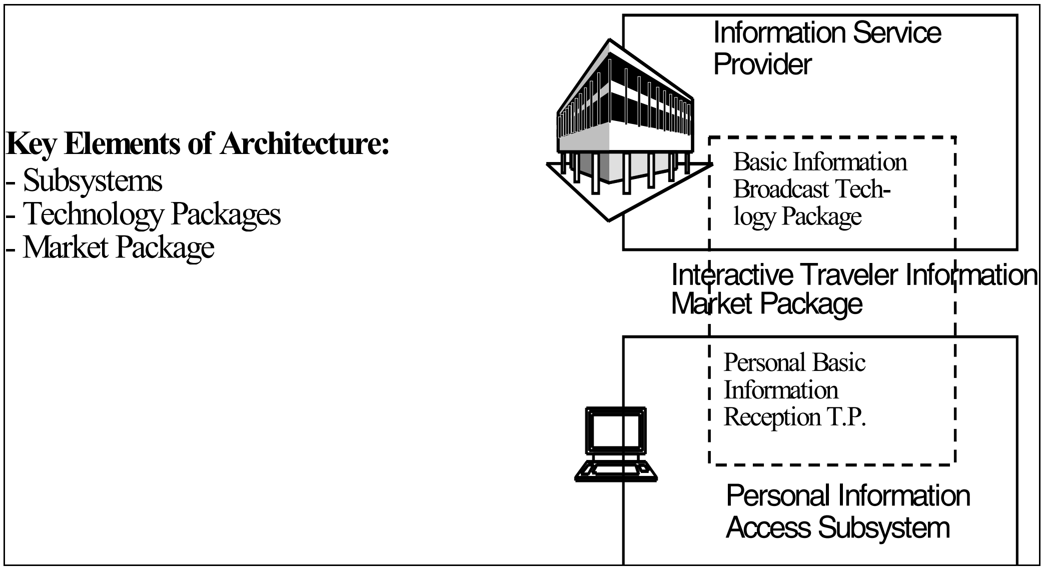


Figure 5. Relationship of Market Packages, Technology Packages, and Subsystems

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 Triad Region encompasses Guilford, Forsyth, Davidson, and Alamance Counties, as well as part of Randolph County. The Triad Region has a population of approximately 958,000 inhabitants and includes the area surrounding the Cities of Greensboro and Winston-Salem. Other cities in the Triad Region and major roadways are shown in **Table 2**. The Triad Region includes portions of NCDOT Divisions 7, 8, and 9. Interstate 40 runs east/west through the Triad Region, connecting the region with Raleigh to the east and Statesville to the west. Interstate 85 runs east/southwest through the Triad Region, connecting the region with Durham to the east and Charlotte to the southwest.

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

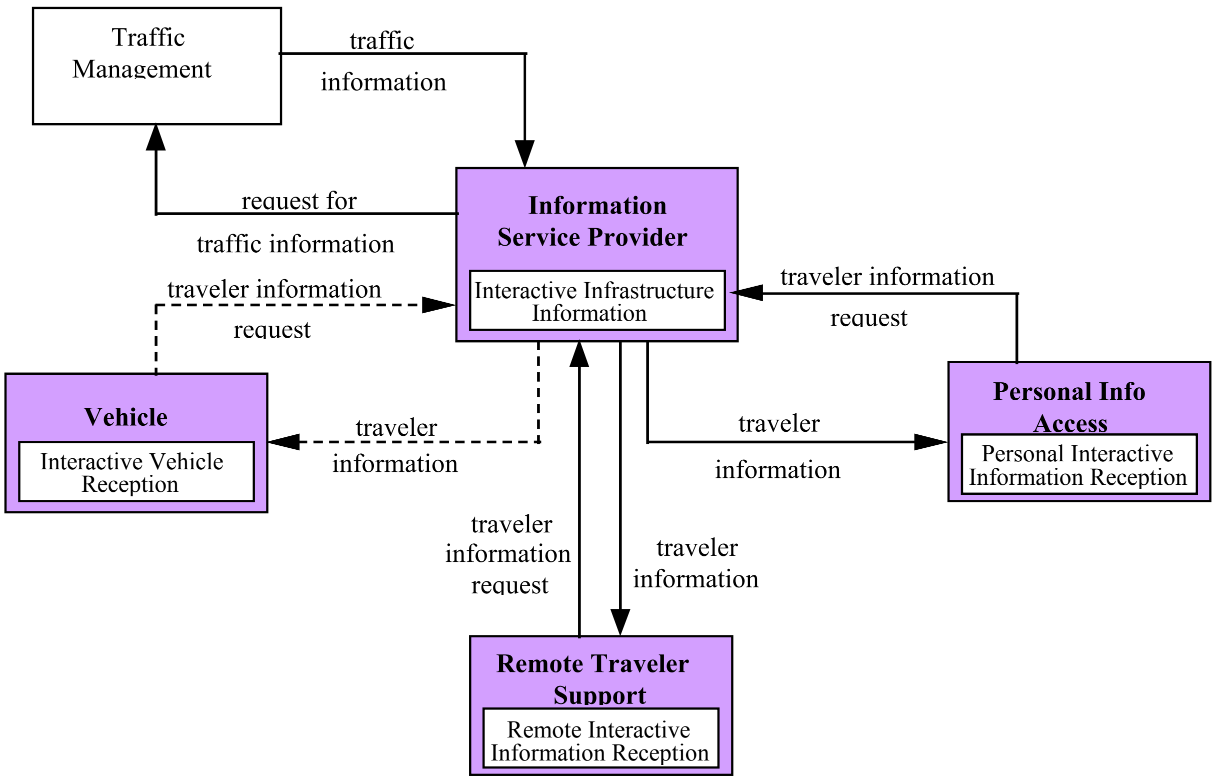


Figure 6. Interactive Traveler Information Market Package

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 Triad Region. At the heart of the existing deployments in the Triad Region are the Eastern and Western Triad Regional Transportation Management Centers (ETRTMC and WTRTMC). This center currently manages the system of cameras and message boards on several roads in the Greensboro and Winston-Salem areas and in the future will be combined to form a single TMC that will be the central hub for the entire Triad 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.

Table 2. Triad Region General Information.

Triad					
County	**NCDOT Div.**	**Population**	**Major Cities**	**Major Roads**	**Military/Universities**
Guilford	7	393,000	Greensboro	I-40, I-73/74, I-85	UNC-Greensboro
			Forest Oaks	US 29, US 70, US 158, US 220	Bennett College
			Stokesdale	US 311, US 421	Greensboro College
				NC 62, NC 68, NC 150	Guilford College
					North Carolina A&T
Forsyth	9	289,000	Winston-Salem	I-40	Wake Forest University
			Kernersville	US 52, US 158, US 311, US 421	NC School of the Arts
			Clemmons	NC 8, NC 66, NC 67, NC 109	Piedmont Baptist College
			Lewisville		Salem College
					Winston-Salem State University
Davidson	9	143,000	Lexington	I-85	Davidson College
			Thomasville	US 29, US 52, US 64	
			Denton	NC 8, NC 47, NC 49, NC 109 NC 150, NC 336	
Alamance	7	121,000	Burlington	I-40, I-85	Elon College
			Graham	US 70	
			Mebane	NC 49, NC 54, NC 61, NC62	
			Elon College	NC 87, NC 100, NC 119	
Randolph	8	12,000	High Point	I-85	High Point University
				US 311	
	Total	**958,000**			

TIP/STIP Project Listing

NCDOT Divisions 7 and 9 have a very aggressive plan for ITS deployment over the next few years. This includes a number of projects that are on the Transportation Improvement Plan (TIP) as well as some that are planned but not funded. These are all listed and described in this section. Some of these projects included in **Table 4**, are included as recommended short and long term deployments listing later in this document.

Table 3. TRIAD REGION ITS DEPLOYMENTS

LEGEND

Existing
Planned/Under Construction

Freeway Management

- Eastern Triad Regional Transportation Management Center (ETRTMC)– 14 CCTV, 16 DMS and 1 HAR
- Western Triad Regional Transportation Management Center (WTRTMC) – 22 CCTV, 18 DMS, 4 HAR, loop detectors and wireless in-pavement detectors

Incident Management

- Greensboro Area – Motorist Assistance Patrols, DMV special enforcement though I-2201 work zone
- Winston-Salem Area – Motorist Assistance Patrols

Traffic Control

Closed Loop Signal Systems

- Randolph County – 79 signals, 8 under closed-loop control
- Forsyth County – 90 signals, 9 under closed-loop control

City Signal Systems

- Greensboro– 65 signals in CBD (54 with preemption), 335 signals outside CBD (70 with preemption), 6 CCTV
- Winston Salem– 100 signals in CBD (*100 traffic responsive*), 225 signals outside CBD (*160 traffic responsive*) 9 CCTV
- *High Point Signal System-170 signals 25 CCTV (under construction)*
- *Burlington-Graham - 150 signals, 6 CCTV (under construction)*

Transit Management

- Greensboro Transit Authority – 25 buses
- High Point Transit – 16 buses, 3 are demand-responsive
- Winston-Salem Transit Authority – 58 buses, 22 are demand-responsive
- Winston-Salem RSVP – rideshare matching program
- Regional Transit Hub at Airport
- *Phase I Mobility Manager (Computer Aided Dispatch, test of AVL, MDT's and Smart Card)*
- *Phase II Mobility Manager (Expand Phase I, Automated Telephone Telephone Information AVL, MDT's, Trip Planning Software, IVR upgrade to Trapeze 4)*

Electronic Fare Payment

- *Greensboro Transit Authority – 25 buses with electronically registering fareboxes*
- Winston-Salem – electronic fare boxes on 58 buses

Emergency Management

Enforcement, Fire and Rescue

- City of Greensboro Police Depmartment (PD) – 283 vehicles, 179 with CAD, in vehicle computers
- City of High Point PD – 178 vehicles, 178 with CAD
- Winston-Salem PD – 365 vehicles, 365 with CAD, 34 fire trucks with in route mapping
- Davidson County Sheriff – 75 vehicles, 75 with CAD, 65 with automated vehicle identification (AVI)
- B-G PD
- Guilford Co. PD
- Forsyth Co. PD
- Alamance Co PD

Highway-Rail Intersections

- City of Greensboro maintains 95 highway-rail intersections,18 with signal preemption capability
- City of High Point maintains 27 highway-rail intersections, 2 with signal preemption, 2 predict train arrivals electronically
- City of Winston-Salem maintains 44 highway-rail intersections, 13 with signal preemption, 13 predict train arrivals electronically

Regional Traveler Information

- Various media sources provide travel times, speeds or conditions and TV picture of roadway conditions
- City of Greensboro has public access cable channel that shows video from the CCTV cameras

Other Deployments

- Weigh in Motion (WIM) weigh station in Alamance County
- Traffic management/ Parking management at the Coliseum in Greensboro
- Public/ Private partnership on communication cable

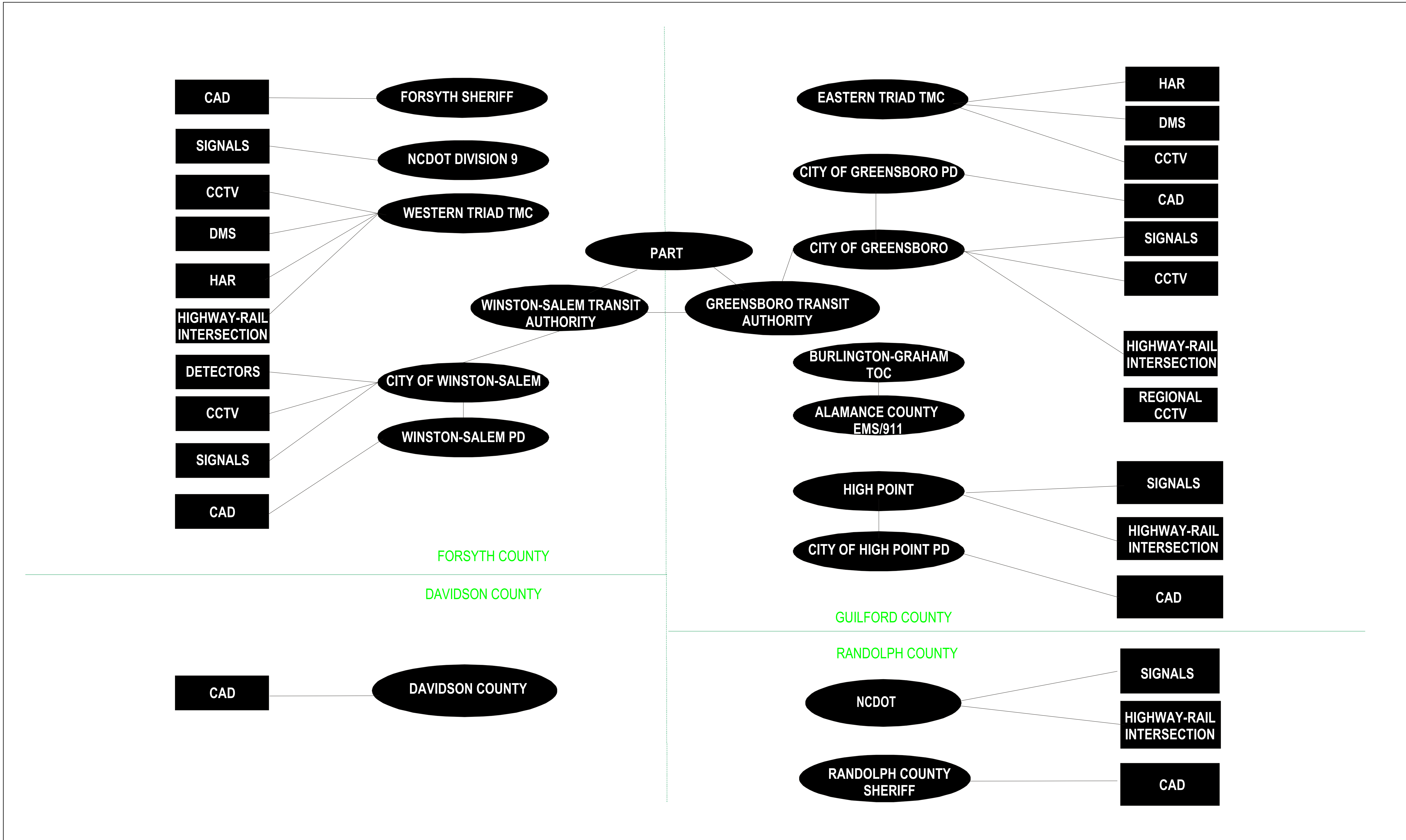


FIGURE 7. SCHEMATIC REPRESENTATION OF TRIAD REGION ITS ELEMENTS

Kimley-Horn and Associates, Inc

Table 4. Funded and Unfunded Projects in Divisions 7 and 9.

Division 7			Division 9		
Funded			**Funded**		
Project Name	**Number**	**Cost**	**Project Name**	**Number**	**Cost**
I-40 Communications	I2201E	$1,775,500	US 421 CCTV 1	R-0952A	$729,450
I-40 DMS 1	I2201F	$1,452,850	US 421 CCTV 2	R-0952B	$4,205,900
I-85 DMS 1	I-2402A	$600,000	W-S Western Loop 1	R-2247A	$4,330,350
I-85 DMS 2	I-2402B	$2,451,700	Northern Beltway 1	R-2247BA	$414,550
I-85 CCTV 1	I-2402C	$1,350,700	Northern Beltway 2	R-2247BB	$277,000
I-85 DMS 3	I-2402D	$600,000	Northern Beltway 3	R2247CA	$2,263,600
Division 7 DMS 1	I-2402S	$6,960,650	Northern Beltway 4	R-2247CB	$1,668,400
Western Loop 1	U-2524AB	$1,533,150	Northern Beltway 5	R-2247D	$1,856,600
Western Loop 2	U-2524AC	$1,431,200	Northern Beltway 6	R2247E	$3,429,200
Western Loop 3	U-2524BA	$1,864,350	Northern Beltway 7	U-2579	$6,909,550
Western Loop 4	U-2524BB	$1,052,200	US -52 1	U-2826A	$769,584
Western Loop 5	U-2524C	$1,200,850	US-52 2	U-2826B	$3,845,200
Division 7 DMS 2	U-2524D	$634,550	US-52 3	U-2826C	$6,319,350
Eastern Loop 1	U-2525A	$1,224,050	I-40 Business 1	U-2827B	$463,980
Eastern Loop 2	U-2525B	$1,700,000	I-40 Business 2	U2827C	$3,058,800
Eastern Loop 3	U-2525C	$2,075,200			
	TOTAL	**$27,906,950**		**TOTAL**	**$40,541,514**
Division 7			**Division 9**		
Unfunded			**Unfunded**		
Project Name	**Number**	**Cost**	**Project Name**	**Number**	**Cost**
I-85 DMS 3	Unfunded	$3,123,250	I-40	Unfunded	$5,296,500
US 29 DMS 1	Unfunded	$6,084,550	US-52 1	Unfunded	$4,903,900
US 220 DMS 1	Unfunded	$4,827,400	US-421 1	Unfunded	$2,638,700
US 220 DMS 2	Unfunded	$2,638,700	US 311 1	Unfunded	$3,075,200
Division 7 Detection	Unfunded	$12,500,000	NC 150	Unfunded	$1,870,650
	TOTAL	**$29,173,900**		**TOTAL**	**$17,784,950**
Other Unfunded					
Triad Region Projects					
Project Name	**Number**	**Cost**			
I-85	Unfunded	$8,953,250			
I-85/I-40	Unfunded	$11,326,500			
	TOTAL	**$20,279,750**			

Division 7 Projects

The projects listed below are planned in Division 7. These projects - all of which are part of the recommended deployment in the Triad Region over the next 10 years - have been broken down into funded and unfunded projects. Some of these projects have been included in the project list (**Table 4**). The costs have been provided by NCDOT as a preliminary estimate for construction.

Funded

I-40 Communications (I-2201E). Install fiber optic cable and conduit along I-40 from SR 1850 at Kernersville to east of SR 1554. This project is estimated to cost $1,775,500.

I-40 DMS 1 (I-2201F). Install one DMS and fiber optic cable and conduit along I-40 from SR 1554 to SR 1616. This project is estimated to cost $1,452,850.

I-85 DMS 1 (I-2402A). Install two DMS along I-85 bypass between Greensboro and ER 3300. This project is estimated to cost $600,000.

I-85 DMS 2 (I-2402B). Install four DMS and four Closed Circuit Television (CCTV) cameras along I-85 bypass between SR 3300 and SR3314. This project is estimated to cost $2,451,700.

I-85 CCTV 1 (I-2402C). Install seven CCTV cameras along I-85 between SR 3314 and SR 3000. This project is estimated to cost $1,350,700.

I-85 DMS 3 (I-2402D). Install two DMS along I-85 between SR 3000 and SR 3041. This project is estimated to cost $600,000.

Division 7 DMS 1 (I-2402S). Install eighteen CCTV cameras in Guilford County (location not specified). Install approximately 23 miles of fiber optic cable and conduit. This project is estimated to cost $6,960,650.

Western Loop 1 (U-2524AB). Install five CCTV cameras, two DMS and approximately 3 miles of fiber optic cable and conduit along the Western Loop from I-85 near Groometown to High Point Road. This project is estimated to cost $1,533,150.

Western Loop 2 (U-2524AC). Install four CCTV cameras, two DMS and approximately 2.75 miles of fiber optic cable and conduit along the Western Loop from High Point Road to SR 1541. This project is estimated to cost $1,431,200.

Western Loop 3 (U-2524BA). Install four CCTV cameras, three DMS and approximately 3 miles of fiber optic cable and conduit along the Western Loop from I-40 to SR 2147. This project is estimated to cost $1,864,350.

Western Loop 4 (U-2524BB). Install two CCTV cameras, one DMS and approximately 2.5 miles of fiber optic cable and conduit along the Western Loop from SR 2147 to Bryan Blvd. This project is estimated to cost $1,052,200.

Western Loop 5 (U-2524C). Install five CCTV cameras and approximately 4 miles of fiber optic cable and conduit along the Western Loop from Bryan Blvd. to SR 2340. This project is estimated to cost $1,200,850.

Division 7 DMS 2 (U-2524D). Install one DMS and approximately 1 mile of fiber optic cable and conduit at the intersection of Greensboro Bypass and Old Battleground Rd. This project is estimated to cost $634,550.

Eastern Loop 1 (U-2525A). Install three CCTV cameras, two DMS and approximately 2 miles of fiber optic cable and conduit along the Eastern Loop from SR 3041 to US 70 Relocation. This project is estimated to cost $1,224,050.

Eastern Loop 2 (U2525B). Install four CCTV cameras, one DMS and approximately 4 miles of fiber optic cable and conduit along the Eastern Loop from the US 70 Relocation to US 29. This project is estimated to cost $1,700,000.

Eastern Loop 3 (U-2525C). Install six CCTV cameras, one DMS and approximately 6 miles of fiber optic cable and conduit along the Eastern Loop from US 29 to SR 2303. This project is estimated to cost $2,075,200.

Unfunded Projects

I-85 DMS 3. Install five CCTV cameras, three DMS and approximately 6 miles of fiber optic cable and conduit along I-85 from the I-40 split to the Guilford/Randolph County Line. This project is estimated to cost $3,123,250.

US 29 DMS 1. Install eleven CCTV cameras, three DMS and approximately 20 miles of fiber optic cable and conduit along US 29 from the Rockingham/Guilford County line to I-40. This project is estimated to cost $6,084,550.

US 220 DMS 1. Install five CCTV cameras, three DMS and approximately 14.7 miles of fiber optic cable and conduit along US 220 from the Rockingham/Guilford County line to US 70. This project is estimated to cost $4,827,400.

US 220 DMS 2. Install five CCTV cameras, two DMS and approximately 7.4 miles of fiber optic cable and conduit along US 220 from I-40 to the Guilford/Randolph County line. This project is estimated to cost $2,638,700.

Division 7 Detection. Install approximately 800 detectors throughout Division 7 for the purpose of incident detection. This project includes the software and integration necessary to incorporate the detection into the Eastern Triad Regional Transportation Management Center (ETRTMC). The detection will be non-intrusive. This project is estimated to cost $12,500,000.

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 Triad Region over the next 10 years - have been broken down into funded and unfunded projects. Some of these projects have been included in the project list (**Table 4**). The costs have been provided by NCDOT as a preliminary estimate for construction.

Funded

US 421 CCTV 1 (R-0952A). Install two CCTV cameras and approximately 2 miles of fiber optic cable and conduit along US 421 between US 158 and SR 2662. This project is estimated to cost $729,450.

US 421 CCTV 2 (R-0952B). Install eight CCTV cameras, two DMS and approximately 6 miles of fiber optic cable and conduit along US 421 between SR 2662 to SR 1850. This project is estimated to cost $4,205,900.

W-S Western Loop 1 (R-2247A). Install three CCTV cameras, one DMS and approximately 2 miles of fiber optic cable and conduit on the Winston-Salem Western Loop from US 158 to I-40. This project is estimated to cost $4,330,350.

Northern Beltway 1 (R-2247BA). Install four CCTV cameras and approximately 1 mile of fiber optic cable and conduit at the Northern Beltway interchange with I-40. The fiber will tie into the HUB at Cloverdale through another project. This project is estimated to cost $414,550.

Northern Beltway 2 (R-2247BB). Install approximately .75 miles of fiber optic cable and conduit along the W-S Northern Beltway between I-40 and US 421. The fiber will tie into the hub at Cloverdale through another project. This project is estimated to cost $277,000.

Northern Beltway 3 (R-2247CA). Install four CCTV cameras and approximately 8 miles of fiber optic cable and conduit along the W-S Northern Beltway at the interchanges with US 421 and Peace Haven Road. This includes the approximately 3.25 miles of fiber optic cable and conduit necessary to tie into the hub at Cloverdale. This project is estimated to cost $2,263,600.

Northern Beltway 4 (R-2247CB). Install four CCTV cameras, two DMS, and approximately 3.5 miles of fiber optic cable and conduit along the W-S Northern Beltway from US 421 to SR 1314. The fiber will tie into the HUB at Cloverdale through another project. This project is estimated to cost $1,668,400.

Northern Beltway 5 (R-2247D). Install five CCTV cameras, one DMS and approximately 5 miles of fiber optic cable and conduit along the W-S Northern Beltway from SR 1314 to NC 67. This project is estimated to cost $1,856,600.

Northern Beltway 6 (R-2247E). Install five CCTV cameras, three DMS and approximately 8 miles of fiber optic cable and conduit along the W-S Northern Beltway from NC 67 to US 52. This project is estimated to cost $3,429,200.

Northern Beltway 7 (U-2579). Install eleven CCTV cameras, 76 non-intrusive detectors, 7 DMS and approximately 10 miles of fiber optic cable and conduit along the W-S Northern Beltway from US 52 to US 421/I-40. This project includes the cost of software and integration into the Western Triad Regional Transportation Management Center (WTRTMC). This project will be divided into smaller segments. This project is estimated to cost $6,909,550.

US-52 1 (U-2826A). Install six CCTV cameras, one DMS and approximately 6.3 miles of fiber optic cable (no conduit) in Winston-Salem along US 52. This project is estimated to cost $769,584.

US-52 2 (U-2826B). Install six CCTV cameras, two DMS and approximately 6.3 miles of fiber optic cable in Winston-Salem along US 52 from I-40 Business to Patterson Avenue. This project includes the cost of software and integration for the ITS elements along the US-52 corridor. This project is estimated to cost $3,845,200.

US-52 3 (U-2826C). Install six CCTV cameras, three DMS, 96 non-intrusive detectors, and approximately 12.6 miles of fiber optic cable and conduit along US 52 from the I-40 Bypass to the proposed W-S Western Loop interchange. This project includes the cost of software and integration for the incident detection system. This project is estimated to cost $6,319,350.

I-40 Business 1 (U-2827B). Install approximately 2.3 miles of fiber optic cable and 1.3 miles of conduit along I-40 Business/US 421 from 4th Street to Water Street in Winston-Salem. This project is estimated to cost $463,980.

I-40 Business 2 (U2827C). Install 64 non-intrusive detectors, 1 roadway weather information system (RWIS) and approximately 3 miles of fiber optic cable and conduit along I-40 Business/US 421 from US 311 to US 158. This project includes the cost of software and integration for the incident detection elements to be integrated into the WTRTMC. This project is estimated to cost $3,058,800.

Unfunded Projects

I-40 1. Install ten CCTV cameras, two DMS and approximately 16.8 miles of fiber optic cable and conduit along I-40 from US 52 to Sandy Ridge Road. This project is estimated to cost $5,296,500.

US-52 1. Install eight CCTV cameras, four DMS, and approximately 13.7 miles of fiber optic cable and conduit along US 52 from University to Stokes/Surry County Line. This project is estimated to cost $4,903,900.

US 421 1. Install five CCTV cameras, two DMS and approximately 7 miles of fiber optic cable and conduit along US 421 from Lewisville Clemmons Road to Yadkin River. This project is estimated to cost $2,638,700.

US 311 1. Install five CCTV cameras, two DMS, 48 non-intrusive detectors, and approximately 6 miles of fiber optic cable and conduit along US 311 from I-40 to the Forsyth/Guilford County Line. This project is estimated to cost $3,075,200.

NC 150. Install five CCTV cameras, one DMS and approximately 5 miles of fiber optic cable and conduit along NC 150 from the Davidson/Forsyth County line to I-40. This project is estimated to cost $1,870,650.

Other Unfunded Triad Region Projects

In addition to those projects listed above, there are two projects that are planned in the Triad Region that do not have funding. These two projects are:

I-85. Install ten CCTV cameras, six DMS and approximately 26.25 miles of fiber optic cable and conduit along I-85 from the Guilford/Randolph County Line to the US 29/70/52 merge in Davidson County. This project is anticipated to cost $8,953,250.

I-85/I-40. Install fifteen CCTV cameras, six DMS and approximately 34.7 miles of fiber optic cable and conduit along I-85/I-40 from NC 6 to the I-85/I-40 split in Orange County. This project is anticipated to cost $11,326,500.

Regional Strategic Deployment Plan Process

Meetings

In preparation for the Triad Regional Summit, two planning meetings were held. The first was a consensus-building meeting held on July 7, 1999. The second was a planning meeting on August 9, 1999. The purpose of these two meetings was to prepare and plan for the Triad Regional summit. 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.

Summit

Following the initial planning and consensus-building meetings, the regional summit meeting was held on October 12,1999.

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, 36 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:

- Route guidance and traveler information both before and during a trip
- Improved coordination of signals, especially across jurisdictional boundaries
- Increased High Occupancy Vehicle (HOV) numbers by providing travel time benefits, including allowing transit vehicles on HOV lanes and transit priority
- Guidance for parking lot choice based on up-to-date availability

Regional Team Meetings

The regional team meetings involved the same transportation professionals as the planning meeting. This team met four times during the course of the project. The first time (September 7, 1999) was the planning meeting to discuss preparation for the summit. The second meeting (October 12, 1999) was held immediately after the summit meeting to discuss the results of the summit and the architecture process. The third (January 31, 2000) was to review and comment on the regional deployment plan and rank the potential projects. The fourth and final regional team meeting was held on February 24, 2000. The purpose of this meeting was to finalize the existing deployments and discuss potential short- and long-term deployment packages.

Identification of Transportation Needs or Issues

As a result of the meetings, summits, and breakout groups, three key areas for in the Triad Region 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. Thirty-nine specific issues were identified in the transportation summits. Of the 36 needs, eight subcategories were identified, as follows:

Traveler Information
- Lack of 24-hour, accurate location specific pre-trip and en-route traveler information (route guidance)
- Lack of 24-hour, real-time alternate route information
- Additional DMS with current traveler information
- Traveler information customized to type of motorist
- Advanced warning of work zones and better traffic control for work zones
- Centralized information clearinghouse with current traveler and road conditions information (weather, visibility-fog)
- Provide real-time or near real-time video of traffic conditions
- Web-based, real-time transit information
- Better planning to reduce changes in travel modes
- Include ride-sharing in transit management
- Improve route choices for public transit-3
- Increase incentives to use transit
- Allow drivers to update traffic and roadway conditions database
- Lack of access to up-to-date traveler information at public venues
- Provide remote, interactive voice access to traveler information
- Improve route choices for public transit
- Arterial Congestion

Inter-jurisdictional Coordination
- Lack of multi-jurisdictional signal coordination
- Lack of current and historical traffic data sharing between agencies for improved traffic management and planning

Traffic Signal Coordination
- Emergency Vehicle Preemption
- Lack of multi-jurisdictional signal coordination
- Improve signal progression (including adding new signal coordination) to reduce travel time for commuters
- Signal priority for transit vehicles
- Too many single occupant vehicles

Freeway Management
- Freeway Congestion
- Freeway lane control capability for better incident management
- Allow transit vehicles on HOV lanes
- Too many single occupant vehicles

Data Collection
- Better planning to reduce changes in travel modes
- Better integration of transit with other modes (school, commuter, park & ride)
- Improve quality of traffic forecasts
- Adjust transit scheduling and routing to better address routes with higher demand
- Optimize transit routes to reduce travel time
- Allow drivers to update traffic and roadway conditions database

Operations and Maintenance
- Develop additional maintenance measures for ITS technologies

Parking Management
- Integrate spare parking supply into park & ride using up-to-date parking availability information

Other
- Reduce traffic delays and accidents caused by "rubber-necking" during incident removal
- Lack of toll lane facilities for faster travel
- Lack of widespread electronic transit fare payment systems
- Improve transit access in rural areas

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

Several needs that were not identified in the Triad Regional summit were identified in one or more of the previous 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 Triad Region and how to phase their implementation (i.e., in the short- or long-term timeframes). Since delivering a user service takes more than just one piece of equipment, the ITS architecture groups equipment into market packages.

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

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

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

The following section 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 Triad 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 Triad Region. Several overlapping needs that were identified in the other urban regions (Triangle and Metrolina) were carried over to the Triad 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.

Input Mapping to User Services

The transportation needs for the Triad 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 36 needs identified by the stakeholders. The Triad 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 Triad region.

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

The user services shown in **Figure 8** were identified as most likely to achieve strategic planning success in the Triad Region. This selection was not intended to exclude other user services that are needed in specific areas. The list of user services does, however, represent recommendations of regional needs on which the remainder of this strategic plan was based.

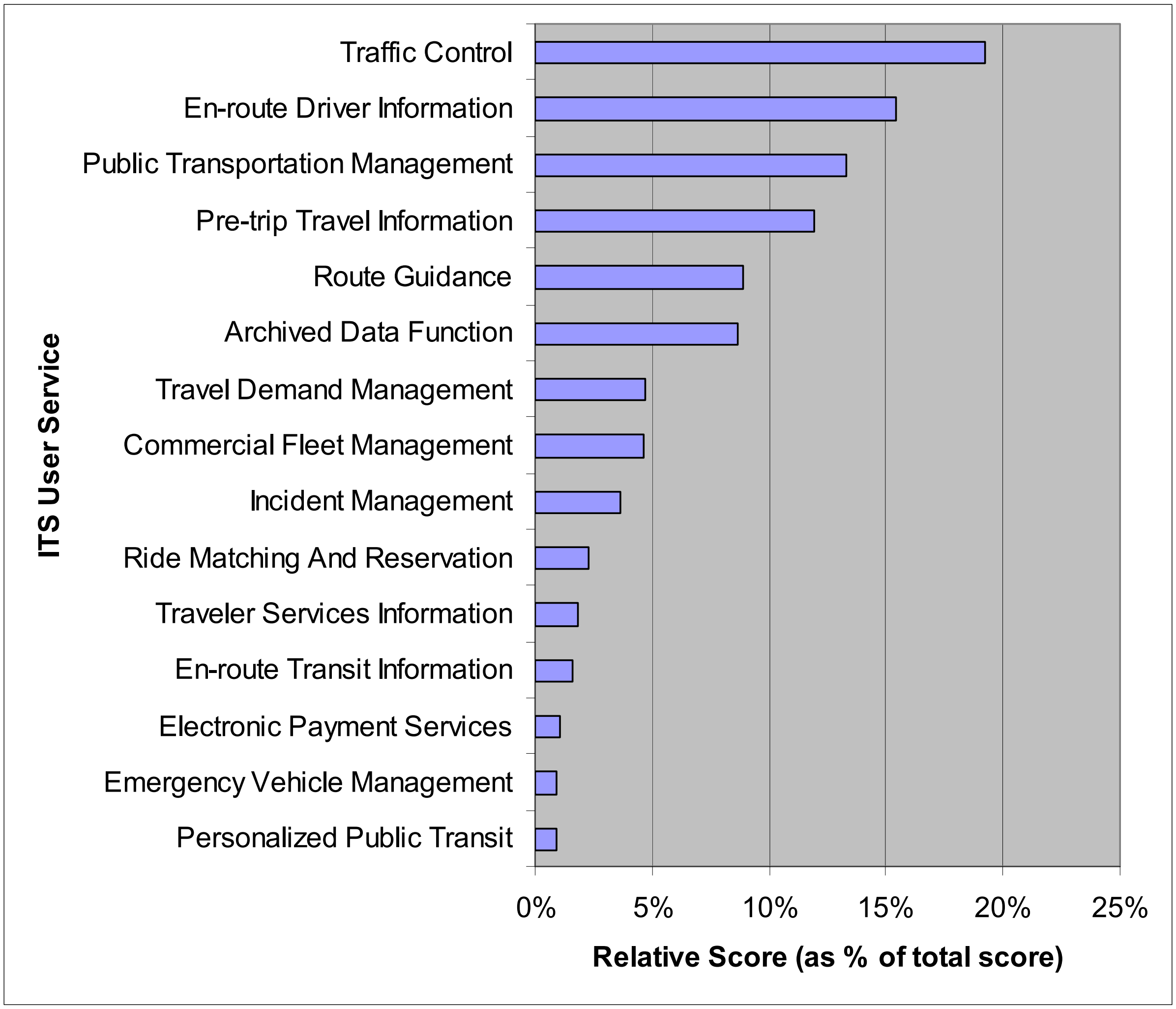
Table 6: Matching User Needs to ITS User Services

ID#	TRIAD 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
	User Services:	Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other	
1	24-hr, accurate, location-specific pre-trip and en-route traveler information (route guidance)	X	X	X		X							X																				Free traffic conditions data access for value-added private partners for digital broadcasts (SmartRoutes, ETAK, etc.)
2	24-hr, real-time alternate route information		X	X			X																										VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection. FM subcarrier incident location feeds to in-vehicle devices with map and alternate route databases. Centrally located alternate route database system. Commercial radio and HAR broadcasts with alt. route information. Internet based incident/closure location data with date, time, and alt. route suggestions.
3	Additional operational DMS with current traveler information		X	X			X																										Variable Message Signs on freeways and arterials with frequent and accurate message updates.
4	Additional traffic conditions (including congestion status and incidents) radio broadcasts, including commercial radio, HAR, customized to type of motorist.		X			X	X															X											AM and FM - based Highway Advisory Radio (freeways and arterials), Kiosks in public places, FM radio station traffic information
5	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.
6	Centralized information clearinghouse with current traveler and road conditions information (weather, visibility-fog)	X	X	X			X					X										X											Traveler information clearingouse(s)
7	Provide real-time or near-real-time video of traffic conditions	X					X		X																									Closed circuit television cameras or still-frame cameras on freeways and along arterial corridors with feed to the Traffic Management Center(s)
8	Alleviate Arterial Congestion		X				X		X																						X		Coordinated signal system upgrades.
9	Multi-jurisdictional signal coordination						X																									X		Signal system upgrades. Permissive signal control for adjacent agency's signals.
10	Improve signal progression (including adding new signal coordination) to reduce travel time for commuters						X																									X		Signal timing optimization along corridors. New signal systems or TBC where non exist.
11	Freeway lane control capability for better incident management						X	X																X											Freeway lane control changeable signs.
12	Signal priority for transit vehicles						X					X																							Signal system software and hardware upgrades to accommodate bus priority processing.
13	Allow transit vehicles on HOV lanes.						X					X																							Signing (Non-ITS)
14	Decrease the amount of single occupancy vehicles				X				X	X																							X		Congestion pricing strategies (HOV lane use toll, toll lanes, parking fees). Upgrades to transit system operations - more efficient transit systems using modern dispatching methods and AVL for buses.
15	Better planning to reduce changes in travel modes											X																							Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers.
16	Alleviate freeway congestion	X	X	X			X	X	X														X											Incident Management Plan, Ramp meters, HOV/HOT lanes.
17	Web-based real-time transit information	X		X								X																							Internet interface to the central traveler information clearinghouse.
18	Better integration of transit with other modes (school, commuter, park & ride)	X			X	X				X		X																							Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers. Shared, real-time demand tracking databases. Modern transit dispatching centers. Advanced demand estimation modeling based on archived data.
19	Include ridesharing in transit management				X					X		X																							Upgrades to transit public information system. Web and voice based rideshare systems tied to transit schedules.
20	Improve route choices for public transit	X										X	X	X																					Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers. Shared, real-time demand tracking databases. Modern transit dispatching centers. Advanced demand estimation modeling based on archived data.
21	Increase incentives to use public transit								X	X		X	X			X																			Improvements to the efficiency of the existing transit system.
22	Improve lane use balance on surface streets						X																												Advanced traffic control based on real-time system detector data.
23	Reduce traffic delays and accidents caused by rubber-necking during incident removal.						X	X																											Increase the height of medians.
24	Increased toll lane facilities for faster travel								X							X																			Toll highways or lanes.
25	Allow drivers to update traffic and roadway conditions database		X			X																													Toll free telephone number for traveler information/incident reporting.
26	Improved access to up-to-date traveler information at public venues	X		X		X																													Traveler information kiosks located at high-pedestrian traffic areas (office buildings, banks, stores, hotels, restaurants, visitor centers, chambers of commerce, etc.)
27	More current and historical traffic data sharing between agencies for improved traffic management and planning						X		X																							X		Regional and statewide archived data warehouses.
28	Provide remote, interactive voice access to traveler information	X	X			X							X																						VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection.
29	Develop additional maintenance measures for ITS technologies											X																							Vehicle status monitoring devices.
30	Improve quality of traffic forecasts	X	X				X		X			X										X										X		Archived data warehouses for more complete and detailed traffic data storage and retrieval for planning.
31	Adjust transit scheduling and routing to better address routes with higher demand								X			X																							Improvements to transit route planning through state of the art demand forecasting models. Shared, real-time demand tracking databases. Modern transit dispatching centers. Advanced demand estimation modeling based on archived data.
32	Integrate spare parking supply into park-and-ride using up-to-date parking availability information					X						X																							Parking management systems integrated with park-and-ride.
33	Improve transit access in rural areas								X			X																							Improvements to route planning and demand forecasting for rural transit.
34	Optimize transit routes for commute speed											X																							State of the art adaptive transit route selection. Improved route planning models based on archived data.
35	More widespread electronic transit fare payment systems								X			X				X						X											Smart Card
36	Emergency vehicle preemption		X	X			X																	X											Emergency Vehicle Preemption System

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

ID #	Identified Need	Ranking
2	Lack of 24-hr, real-time alternate route information	1
3	Additional DMS with current traveler information	2
7	Provide real-time or near-real-time video of traffic conditions	3
5	Advance warning of work zones and better traffic control for work zones	4
10	Improve signal progression (including adding new signal coordination) to reduce travel time for commuters	5
29	Develop additional maintenance measures for ITS technologies	6
8	Arterial Congestion	7
1	Lack of 24-hr, accurate, location-specific pre-trip and en-route traveler information (route guidance)	8
27	Lack of current and historical traffic data sharing between agencies for improved traffic management and planning	9
6	Centralized information clearinghouse with current traveler and road conditions information (weather, visibility-fog)	10
16	Freeway Congestion	11
11	Freeway lane control capability for better incident management	12
30	Improve quality of traffic forecasts	13
14	Too many single occupancy vehicles	14
19	Include ridesharing in transit management	15
17	Web-based real-time transit information	16
26	Lack of access to up-to-date traveler information at public venues	17
18	Better integration of transit with other modes (school, commuter, park & ride)	18
21	Increase incentives to use public transit	19
36	Emergency Vehicle Preemption	20
20	Improve route choices for public transit	21
23	Reduce traffic delays and accidents caused by ”rubber-necking” during incident removal	22
31	Adjust transit scheduling and routing to better address routes with higher demand	23
28	Provide remote, interactive voice access to traveler information	24
13	Allow transit vehicles on HOV lanes	25
34	Optimize transit routes to reduce travel time	26
33	Improve transit access in rural areas	27
9	Lack of multi-jurisdictional signal coordination	28
35	Lack of widespread electronic transit fare payment systems	29
12	Signal priority for transit vehicles	30
15	Better planning to reduce changes in travel modes	31
32	Integrate spare parking supply into park-and-ride, using up-to-date parking availability information	32
4	Traveler information customized to type of motorist	33
25	Allow drivers to update traffic and roadway conditions database	34
22	Improve lane use balance on surface streets	35
24	Lack of toll lane facilities for faster travel	36

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



Selection of Market Packages

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

Market packages are also identified to segregate services that are likely to encounter technical and non-technical challenges from low 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 both 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 Triad Region of North Carolina. The NIA provides a matrix connecting the 31user services and the 63 market packages. This matrix allows market packages and user services to be traced 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 Triad Region stakeholder needs are indicated with a "NO".

Note that 38 of the possible 63 market packages were identified as potentially deployable in the Triad Region. This is due to the fact that deployment of several identified user services will require portions of numerous market packages. For example, the 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.

Table 8: Market Packages Mapped to User Services Relationships

		User Services																															
	TRIAD	Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	2.3	2.4	3.1	4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2	6.1	6.2	6.3	6.4	6.5	6.6	6.7	7.1	8.1
Market Packages		Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Emissions Testing and Mitigation	Highway-Rail Intersection	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Public Travel Security	Electronic Payment Services	Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-board Safety Monitoring	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Longitudinal Collision Avoidance	Lateral Collision Avoidance	Intersection Collision Avoidance	Vision Enhancement For Crash Avoidance	Safety Readiness	Pre-crash Restraint Deployment	Automated Vehicle Operation	Archived Data Function	Other
ad1	ITS Data Mart																															YES	
ad2	ITS Data Warehouse																															YES	
ad3	ITS Virtual Data Warehouse																															YES	
apts1	Transit Vehicle Tracking											YES	YES	YES	NO																		
apts2	Transit Fixed-Route Operations											YES	YES																				
apts3	Demand Response Transit Operations											YES	YES	YES																			
apts4	Transit Passenger and Fare Management												YES			YES																	
apts5	Transit Security											YES			NO																		
apts6	Transit Maintenance											YES																					
apts7	Multi-modal Coordination						YES		YES			YES																					
apts8	Transit Traveler Information											YES	YES																				
atis1	Broadcast Traveler Information	YES	YES										YES																				
atis2	Interactive Traveler Information	YES	YES		YES	YES							YES	YES		YES																	
atis3	Autonomous Route Guidance		YES	YES																													
atis4	Dynamic Route Guidance		YES	YES		YES		YES					YES																				
atis5	ISP Based Route Guidance	YES	YES	YES												YES																	
atis6	Integrated Transportation Management/Route Guidance		YES	YES												YES																	
atis7	Yellow Pages and Reservation	YES	YES		YES	YES							YES			YES																	
atis8	Dynamic Ridesharing	YES	YES	YES	YES				YES				YES	YES		YES																	
atis9	In Vehicle Signing		YES				YES				NO																						
atms01	Network Surveillance						YES																										
atms02	Probe Surveillance						YES																										
atms03	Surface Street Control						YES	YES			NO																						
atms04	Freeway Control						YES	YES	YES																								
atms05	HOV Lane Management						YES		YES																								
atms06	Traffic Information Dissemination						YES				NO																						
atms07	Regional Traffic Control						YES																										
atms08	Incident Management System							YES																									
atms09	Traffic Forecast and Demand Management						YES		YES																								
atms10	Electronic Toll Collection															YES																	
atms11	Emissions Monitoring and Management									NO																							
atms12	Virtual TMC and Smart Probe Data		YES				YES	YES																									
atms13	Standard Railroad Grade Crossing										YES																						
atms14	Advanced Railroad Grade Crossing										YES																						
atms15	Railroad Operations Coordination										NO																						
atms16	Parking Facility Management								YES																								
atms17	Reversible Lane Management																																
atms18	Road Weather Information System		YES				YES	YES																									
atms19	Regional Parking Management								YES																								
avss01	Vehicle Safety Monitoring																												NO	NO			
avss02	Driver Safety Monitoring																												NO				
avss03	Longitudinal Safety Warning																								NO				NO				
avss04	Lateral Safety Warning																									NO			NO				
avss05	Intersection Safety Warning										YES																NO		NO				
avss06	Pre-Crash Restraint Deployment																												NO	NO			
avss07	Driver Visibility Improvement																											NO					
avss08	Advanced Vehicle Longitudinal Control																								NO								
avss09	Advanced Vehicle Lateral Control																									NO							
avss10	Intersection Collision Avoidance										NO																NO						
avss11	Automated Highway System																														NO		
cvo01	Fleet Administration			YES																		YES											
cvo02	Freight Administration																				NO												
cvo03	Electronic Clearance																NO			NO													
cvo04	CV Administrative Processes																NO			NO													
cvo05	International Border Electronic Clearance																NO			NO													
cvo06	Weigh-In-Motion																NO																
cvo07	Roadside CVO Safety																	NO															
cvo08	On-board CVO Safety																		NO														
cvo09	CVO Fleet Maintenance																		NO			YES											
cvo10	HAZMAT Management							YES													NO	YES											
em1	Emergency Response																						NO	NO									
em2	Emergency Routing						YES																	YES									
em3	Mayday Support																						NO	NO									

Triad 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 Triad Region architecture.

The national ITS plan originally defined a series of short-, medium-, and long-term deployment timeframes for ITS. Several of years have passed since this timeframe was developed, and the initial goal was to match schedules with the reauthorization of ISTEA. This schedule reflected the 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 the regional implementation of the 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 Triad Regional ITS Plan, consistent with the other regional plans in North Carolina:

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**.

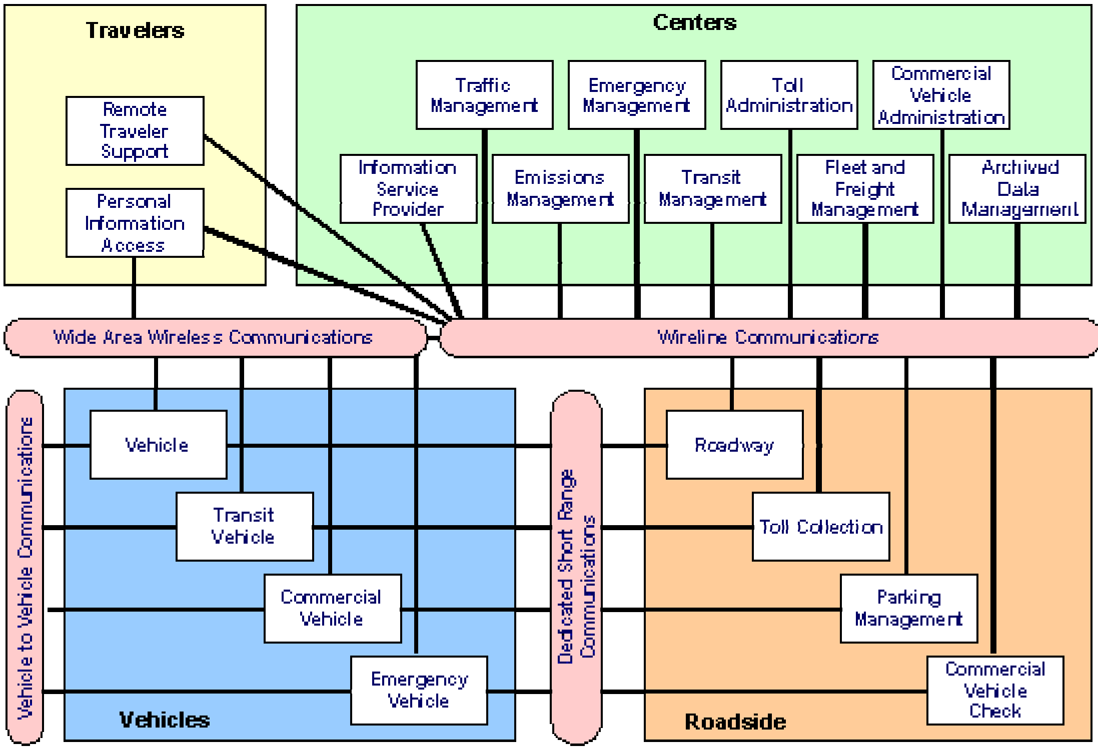


Figure 9. Very Top Level Simplified Architecture Diagram.

Another element of the architecture is the institutional layer, which documents the policies, funding incentives, working arrangements, and jurisdictional structure that supports the transportation and communication layers of the architecture. The institutional layer describes who is responsibility for deploying 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 Physical 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 transportation needs. Based on this input, the regional team identified market packages for the selected user services, as well as the priority of projects 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

Table 9. Market Package Deployment, by Timeframe.

		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3	3.1	4.6	5.2	t
ID#	**Market Packages**	Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Electronic Payment Services	Commercial Fleet Management	Emergency Vehicle Management	Archived Data Function
AD1	ITS Data Mart															L
AD2	ITS Data Warehouse															L
AD3	ITS Virtual Data Warehouse															L
APTS1	Transit Vehicle Tracking									S	S	S				
APTS2	Transit Fixed-Route Operations									S	S					
APTS3	Demand Response Transit Operations									S	S	S				
APTS4	Transit Passenger and Fare Management										S		L			
APTS5	Transit Security									S						
APTS6	Transit Maintenance									S						
APTS7	Multi-modal Coordination						S		S	S						
APTS8	Transit Traveler Information									S	S					
ATIS1	Broadcast Traveler Information	S	L								L					
ATIS2	Interactive Traveler Information	S	L	S	L						L	L				
ATIS3	Autonomous Route Guidance		L	L												
ATIS4	Dynamic Route Guidance		L	L		L		S			L					
ATIS5	ISP Based Route Guidance	L	L	L									L			
ATIS6	Integrated Transportation Management/Route Guidance		L	S									L			
ATIS7	Yellow Pages and Reservation	L	L		L	L					L		L			
ATIS8	Dynamic Ridesharing	S	S	S	L				L		L	L	L			
ATIS9	In Vehicle Signing		L				L									
ATMS1	Network Surveillance					S										
ATMS2	Probe Surveillance						L									
ATMS3	Surface Street Control						S	S								
ATMS4	Freeway Control						L	L	L							
ATMS5	HOV Lane Management						L		L							
ATMS5	Traffic Information Dissemination						L									
ATMS7	Regional Traffic Control						L									
ATMS8	Incident Management System							L								
ATMS9	Traffic Forecast and Demand Management					L		L								
ATMS10	Electronic Toll Collection												L			
ATMS12	Virtual TMC and Smart Probe Data		L				L	L								
ATMS16	Parking Facility Management								L							
ATMS18	Road Weather Information System		L				L	L								
ATMS19	Regional Parking Management								L							
CVO1	Fleet Administration			L										L		
CVO9	CVO Fleet Maintenance													L		
CVO10	HAZMAT Management							L						L		
EM2	Emergency Routing														L	

S - Short-term Implementation (2006)
L - Long-term Implementation (2011)

Recommended Projects and Technologies

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

Short-Term (2006) Technologies

- Web-based mapping and route identification
- Broadcast video and data (via partnerships with local television stations)
- Web-based data and video
- Traveler information kiosks
- Portable DMS
- Traffic signal systems
- Transit AVL
- CAD
- Rideshare database

Long-Term (2011) Technologies

- Database of archived data
- Advanced traveler information
- En-route access to traffic information
- Additional deployments of DMS and CCTV
- Regional system integration
- Freeway lane control signals
- Smart Cards

Technologies Especially Applicable to Urban Areas

There are many concepts of ITS projects and components. The general description of ITS as the use of active and passive technology to improve mobility leaves plenty of room for interpretation. Below are various ITS technologies that have been deployed in 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.)

Lateral Warning and Guidance System. This magnetic tape helps snowplow operators during difficult winter weather conditions. Magnetic tape is grooved into the pavement, typically along the center lane markings or along the edge line. Magnetic media and pliant polymer pavement markings are two technologies that work together in this system. This system is adapted for all-weather, all-light condition performance. Source: 3M Safety and Security Systems Division, St. Paul, Minnesota.

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 Triad Regional ITS Strategic Plan has identified the needs of the Triad 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 deployments. This modified schematic is shown in **Figure 10**.

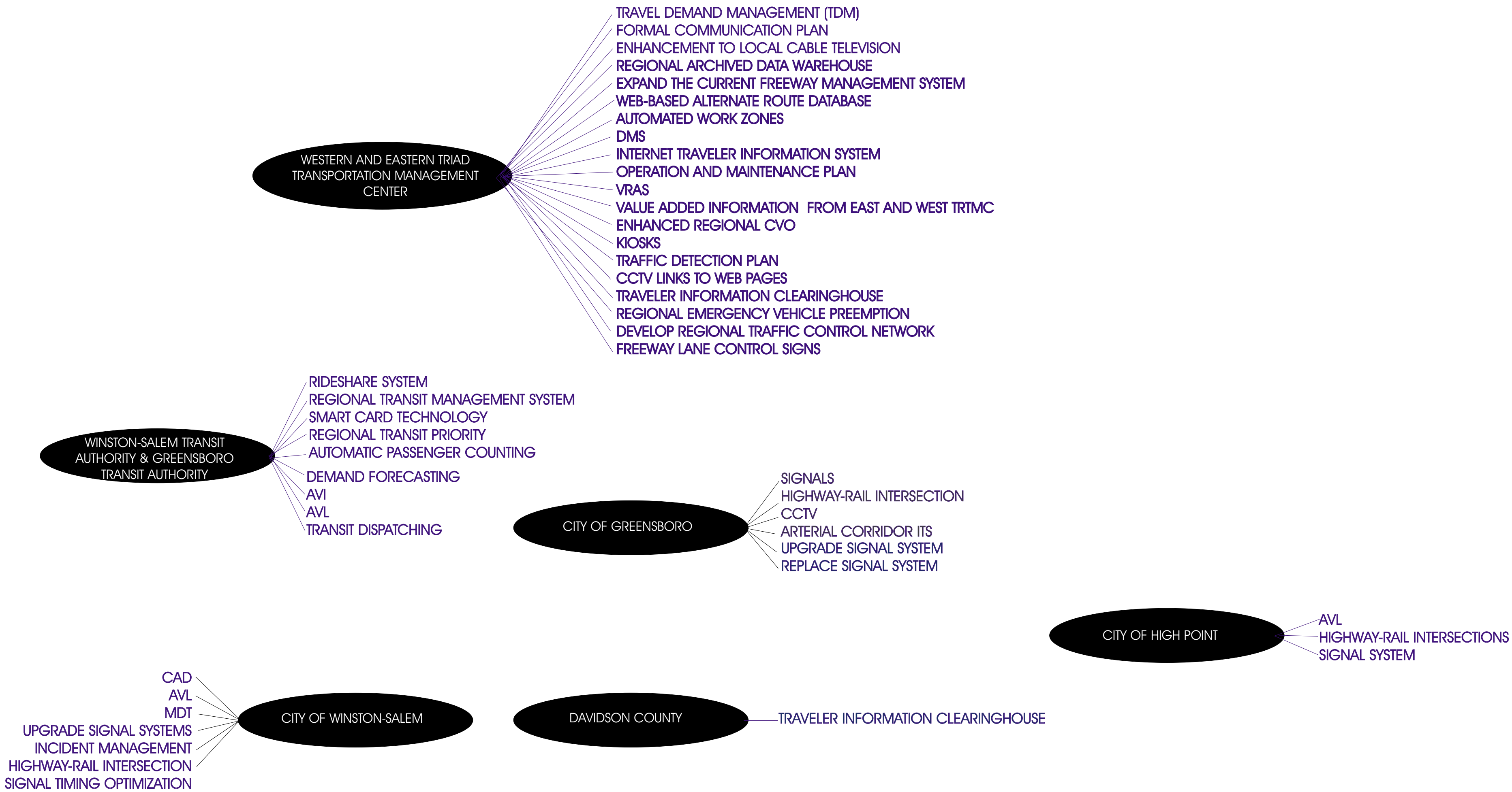


FIGURE 10. SHORT AND LONG TERM ITS DEPLOYMENTS IN THE TRIAD REGION

Kimley-Horn and Associates, Inc.

Short-Term Projects

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

All costs shown are in year 2001 dollars.

Traveler Information System

Traffic Detection Plan. The first phase of a regional traveler information system is the development of a regional traffic detection plan. This plan will identify the locations throughout the region where detection is required. Based on this plan the locations of new and existing detection can be easily identified. The development of this plan for the entire region is anticipated to cost approximately $250,000. The freeway segment of this plan will account for approximately 50% of the project cost. The remaining $125,000 will be to identify system detector locations in Burlington-Graham, Greensboro, Winston-Salem and High Point which will be used to implement signal plans in the event of a major regional incident.

Web-based alternative route database. The web-based alternative route database will enable users to look up route alternatives throughout the Triad Region. This system will work in conjunction with the NCDOT road closure reporting system. Parts of this project are already being developed by NCDOT, including the development of real-time mapping and a dial-up information hotline. The anticipated cost of this project is $81,500.

Enhancements to local cable television. The Cities of Greensboro and Winston-Salem currently broadcast live video and traveler information over their cable access channels during peak travel time. The cities of High Point and Burlington-Graham are planning to broadcast similar information. This system will be enhanced to provide additional video images from throughout the region and increase coverage beyond the peak travel times. As video from other regions becomes available, specifically the Triangle and Metrolina Regions, this information will also be broadcast. The anticipated cost of implementing the new channels and upgrading the existing equipment is $1,000,000. The Burlington-Graham connection will be most effective when full motion video is available from both Winston-Salem and Greensboro and the Triangle Region.

Internet Traveler Information System. NCDOT will develop a website or set of pages at an existing website to provide static traveler information. This information may include transit schedules, transit fares and routes, published road closures, traffic policies, major generator and special event information, rideshare matching information, and links to other city and NCDOT websites. NCDOT is already preparing a base website for this information to be used throughout the state. A majority of the costs of this project are internal to NCDOT. The anticipated external cost of this project is $150,000.

CCTV Links to Web Pages. NCDOT will develop a website for the Triad Region — similar to one previously developed for the Triangle Region — that displays static images of the CCTV cameras. The base web site design has already been developed by NCDOT, and the majority of the costs associated with the modifications and web hosting are being borne internally to NCDOT. The anticipated external cost of this project is $75,000, which includes the video capture devices, servers, and other required hardware and software.

Kiosks at major public venues. NCDOT and the surrounding cities in the Triad Region will develop and install 10 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 the Greensboro Coliseum, Winston-Salem Coliseum, Winston-Salem Transit Center, Greensboro Four Seasons Mall and Hotel, Winston-Salem Adams Mark Hotel, Triad Region Airport, Burlington Mall Outlet Center, Visitor and Convention Center, and the High Point Oak Hollow Mall.

Kiosks provide NCDOT with 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 10 kiosks throughout the Triad Region is approximately $1,250,000. 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 kiosk 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.

Traveler Information Clearinghouse. A clearinghouse will be established to store data for traveler information collected from various sources throughout the region, including NCDOT, the cities and transit agencies. This system will feature data from system loops, intersections, detector station, posted incident reports, IMAP incident reports, and live bus schedule information. All this information will be accessible from a central location, whether it is stored locally or remotely. The clearinghouse will be used in to provide live and historical data to kiosks and websites, with the development geared for long-term projects, such as a voice activated system. The anticipated estimated cost of this system is $1,500,000.

511 Dial-up Conversion. In the summer of 2000, the Federal Communications Commission (FCC) ruled that the phone number 511 will be reserved for traffic and traveler information nationwide. The Piedmont Authority for Regional Transportation (PART), which encompasses the Triad Region, will be applying for federal funds to convert existing dial-up phone numbers to 511 for traveler and traffic information. The number will provide travelers information on transit schedules, weather conditions, congestion, accidents, and construction activities in the Triad Region. Currently, the Winston-Salem Transit Authority (WSTA) provides separate telephone numbers for several services including bus routes, trolley rides, park & ride, park & shuttle, ridesharing and vanpooling, bike & ride, transportation for the physically disabled, and transportation for the elderly. The 511 conversion will create one number for each of these services.

To assist in the conversion, funding is available from section 5001(a)(5) of the Transportation Equity Act for the 21st Century (TEA-21), Public Law 105-178, 112 Stat. 107, 419 (1998). The maximum amount of money granted to an application is $50,000 per fiscal year and supports system design, conversion support including hardware and software modifications, and system acceptance and testing. No additional monies should be required for the conversion.

Travel Demand Management (TDM). NCDOT is currently working with business in urban areas throughout the state to implement TDM. TDM consists of reducing peak hour commuters by varying work arrival and departure times or by offering telecommuting or other methods to reduce travel demand on the network. NCDOT is currently offering many employees the opportunity to work at home on a part time basis. Although there is no direct cost to NCDOT associated with this project, there is the potential for better implementation by offering incentives to companies and through a more focused marketing and outreach campaign to document the effort and the potential benefits. The incentives and outreach campaign can all be performed by NCDOT employees at no direct cost. These TDM efforts should be implemented in the Triad Region as well.

Traffic Control Systems

Expand the Current Freeway Management System (FMS). The current FMS in the Triad region includes DMS, CCTV cameras, and detection. This system will be expanded to include an additional 10 signs. Additional detection, using non-intrusive detection methods, also will be installed to expand the existing system and obtain better accuracy within the existing system. The anticipated cost for these improvements is $3,000,000. This cost is above and beyond the costs shown for the funded and unfunded TIP/STIP projects previously listed.

The key corridors in the region, including US-52, US-220, I-85 and I-85 Business are all in need of ITS elements, including communications, detection, surveillance and signing. A formal study for each of the key corridors should be completed to identify the location of devices and specific projects. Although the study will be done in the short-term horizon, the construction will occur over the long-term horizon. The study phase of these projects is anticipated to cost $1,200,000. The design phase of these corridors, for the ITS elements only, is anticipated to cost $2,300,000.

It is the desire of NCDOT to collocate the operations of the ETRTMC and WTRTMC. During the short-term horizon, a study should be completed to determine where the Triad Region TMC should be located as well as a transition plan prepared for relocating devices and personnel to the proposed location. Bid documents will be prepared for the new facility and the move. The planning and design of the collocated Triad TMC is anticipated to cost $1,350,000.

The total short-term anticipated cost for the Triad Region for expanding the current FMS is $7,850,000.

Portable DMS for Work Zones. Portable DMS for work zones are needed to warn and direct traffic of upcoming road and lane closures. Each NCDOT division will purchase five additional signs for deployment during preplanned events, long-term incidents, and in work zones. The anticipated cost for these 10 additional signs is $250,000.

Signal System Upgrade for Greensboro. The signal system in Greensboro needs improvements to reduce delay and travel time. The City of Greensboro will replace their existing copper communications network with a modern fiber optic cable system to facilitate communications. The interface between the Greensboro and High Point signal systems needs to be improved to better service traffic at the city borders. To provide this interface, the two systems will be connected to share, at a minimum, traffic volumes. As the hardware and software in each city is updated, the link between the two cities will be capable of sharing timing plans and other information to ensure a regionally coordinated signal system. These three improvements are anticipated to save more than 1,000,000 vehicle-hours per year, with a 9% decrease in travel time. The anticipated cost for these improvements is $5,250,000.

The signals along major corridors in Greensboro will be retimed at an anticipated cost of $750,000.

As part of the improvements in Greensboro for traffic control along major arterials, 56 CCTV cameras are planned. The cost of the CCTV hardware, including cameras and control/monitoring equipment is estimated to cost $1,500,000. This improvement requires the communications network identified above.

Greensboro Arterial Corridor ITS. As part of the City of Greensboro congestion management program, the Greensboro Department of Transportation (GDOT) has identified several congested corridors where traditional street widening will be difficult to implement. ITS improvements such as reversible lanes, DMS, detection and surveillance may be the only feasible congestion improvements along these corridors. The following arterials have been identified for early deployment of these ITS solutions:

- Wendover Avenue – Bridford Parkway to Yanceville Street.
- Battleground Avenue – Wendover Avenue to Cotswold Terrace.
- Bryan Boulevard – Benjamin Parkway to NC-68
- Elm Street – Wendover Avenue to Cone Boulevard.

The anticipated cost for ITS components to be deployed along these primary corridors is $5,000,000.

Signal System for Kernersville. Currently, there is no citywide coordinated signal system in Kernersville that permits upload and download capabilities or advanced abilities such as traffic adaptive and responsive capabilities, although some signals are on a closed loop system. The City of Kernersville will install a citywide signal system, which features a fiber optic communications network. The development of this system will include a provision for sharing data and control with both Winston-Salem and Greensboro to limit the potential for traffic problems at city borders. This system is anticipated to provide travel time savings of more than 63,000 vehicle-hours per year and a 20% decrease in travel times. The anticipated cost for these improvements is $4,000,000.

Signal Timing Optimization in Winston-Salem. Winston-Salem has undergone tremendous growth in the past few years. To accommodate this growth, approximately 20% of the signals in the area were retimed. The City of Winston-Salem will embark on a retiming project to update the timing on the remaining signals. This project will reduce travel time by 250,000 vehicle-hours per year, which represents a 5% decrease in travel times. The anticipated cost for these improvements is estimated at $750,000.

Formal Communications Plan. A formal communication plan is needed in the Triad Region to integrate communications throughout the region. 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. First, it will determine the exact bandwidth necessary between centers and from individual devices to hubs or concentration points. Second, it will fully document the fiber availability along corridors. Third, it will make recommendations as to how best to use this fiber, including technology choices. Lastly, it will provide an overall, consistent design standard that all of the agencies throughout the region can use as the system expands. For instance, the two NCDOT divisions that make up the Triad Region currently have some level of communication. If, however, the City of Winston-Salem desires to share data and video with NCDOT, the lack of a standard communication network may make this impossible. 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. With the continued deployment of ITS throughout the region, a formal Operations and Maintenance plan needs to be developed. This plan will provide guidelines for coordinated operation through the region. It is not meant to replace any incident management plans that have been developed. It is a supplement, designed to foster coordination and cooperation, as well as provide operational guidelines for DMS messages, camera use and other issues.

A formal maintenance plan will be required to document the maintenance needs of the system. The maintenance plan will include a database of devices, with their failure rates and other critical issues. From the maintenance plan, all of the entities in the region will have the opportunity to pool resources to provide for ongoing maintenance of highly specialized ITS devices. Issues that need to be evaluated in the development of the plan include the following:

- How to deal with repairs. One option is to remove and replace failed devices and ship the failed device to a repair center. This is the least cost in manpower, but requires a significant dept of spare parts. A second option is to repair on the spot or at a specified state/city-owned facility. This requires more manpower and expertise/training, but very few spare parts.
- Determining if outsourcing of all operations and maintenance issues a possibility. Many states, including Michigan, Florida and Colorado are beginning to outsource all of their maintenance. This may come at a higher cost than doing it all in house, but outsourcing does not require any new personnel.
- Develop guidelines for design that facilitate maintenance. This includes guidelines for protection for maintenance personnel working on a specific device. It also includes setting standards to facilitate maintenance, such as using a lowering device for all CCTV cameras regardless of height.

The development of the operations and maintenance plan can be done in-house to all of the agencies. However, it is recommended that an outside source be brought in to assist in the plan development and coordination of all of the agencies. The development of the Operations and Maintenance plan is anticipated to cost $200,000.

Transit

Bus AVL System. The buses in the region will be outfitted with AVL systems to permit tracking and enhanced data collection. In addition, an automatic vehicle identification (AVI) system will be implemented to work with the AVL for more comprehensive tracking and scheduling system. Finally, these two systems will be tied into on-bus systems that permit automatic passengers counters. The anticipated cost to outfit the buses with this system and provide central software in the Triad is $650.000.

Transit Dispatching, Demand Forecasting, and Automatic Passenger Counting. A CAD system will be developed and deployed for each transit system in the region. This system will involve an automatic passenger counting system that works in concert with the AVL system to obtain boarding/alighting data for future route planning purposes. This system is anticipated to cost $750,000.

Rideshare System. A region-wide database of work and home locations, cross-referenced with work schedules will be developed. This system will be voluntary. By using this system, ride-matching can be more easily accomplished for carpools and vanpools. This system is expected to cost $50,000 to implement. There will be costs for the annual operations and maintenance of this system.

Regional Transit Priority. There is an important need to provide a time savings for transit passengers along key transit corridors and throughout the Triad Region. A transit priority system for buses throughout the region will be deployed. This system will use the same equipment as the emergency vehicle preemption system, but will be on a lower priority level. This hardware for the system will cost approximately $1,500,000. Implementation will be the responsibility of each agency.

In addition to the hardware, a regional study is required identifying key corridors and intersections where transit priority would provide the greatest benefit. At the locations where it is identified that transit priority will provide a benefit, the signals need to be reviewed for timing and operations to determine the appropriate priority treatment. Additionally, the timing modifications need to be prepared for each location to ensure each agency implements transit priority according to plan. This study and all of the signal modification plans is anticipated to cost $800,000.

Smart Card Technology. There are numerous existing or planned regional bus systems within the region. Once transfer hubs for the regional bus systems are developed, a regional electronic payment system (Smart Card) will be implemented 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 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 $850,000.

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 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 CVO. Part of the site is already operational; however, the preparation of 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 violators. 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. This is an on-going effort by NCDOT and the costs will be borne internally to NCDOT.

Long-Term Projects

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

Traveler Information Systems

Value Added Information from ETRTMC and WTRTMC. There are many private companies that are beginning to repackage ITS data to provide to customers, as described later in this report. 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.

VRAS – Voice Remote Access System. En-route traveler information was identified as one of the key needs within the region. One of the more effective methods of en-route traveler information is via a voice activated system using standard cellular phones. This system will include a 511 number and the computer support to allow the entire system to be voice activated without the need for operators. This system would potentially be combined with a statewide effort and/or a public/private venture, and tied into existing systems. This system is anticipated to cost $1,000,000.

This project will also be undertaken on a statewide level to provide travel information throughout the state via telephone. The design of the 511 systems in the Triad Region will include hooks and other tie-ins to a larger statewide system.

Internet Traveler Information System. The internet system, both existing and that being developed in the short-term projects, will be expanded from a static system to a dynamic system with constant updates from the various detection stations in the region. In addition, as more bandwidth becomes available, more options for the CCTV video feeds will be available for streaming video to the internet from the various CCTV cameras in use. This expansion is anticipated to cost $1,500,000.

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

Traffic Control Systems

Continue to Expand the FMS. The short-term project was to increase the detection and DMS coverage in the region. In the long-term, this system will be expanded to fill in the gaps and extend throughout the entire region. Fourteen additional DMS sites have been identified. The anticipated cost for these improvements is $6,000,000.

A series of plans will be prepared to deploy ITS along some of the key corridors in the region. These corridors include I-85, I-85B, US-220 and US-52. It is anticipated that the cost of the ITS elements along these corridors will be approximately $20,000,000.

It is the desire of NCDOT to collocate the ITS operations in this region by consolidating the ETRTMC and WTRTMC. The study and recommendation to consolidate these centers, as well as the plans for the unified facility have been identified as a short-term project. It is anticipated that the cost to consolidate these centers, including relocating, development of a node facility for communications, and other expenses will cost approximately $3,000,000.

The total for these three FMS projects will cost approximately $29,000,000.

Develop a Regional Traffic Control Network. A regional traffic control network allows shared traffic data and video throughout the region. The network will feature data and video transmission to and from each city in the region to a central location. This central location will redistribute this information to all of the surrounding control centers. In addition, this central location will serve as a point on a larger statewide network that will connect the Triad Region to the Triangle and Metrolina Regions, as well as the rest of the state. The regional network is discussed in more detail in the next section. The statewide network is discussed in the statewide report. The anticipated cost for the regional traffic control network, including communications, is $11,450,000.

Additional CCTV Cameras on Arterials. The cities of Greensboro and Winston-Salem have identified the need for additional CCTV cameras at high traffic intersections. Greensboro will be implementing a communications network as part of a short-term project. Winston-Salem will require new communications for their cameras. The anticipated cost for the Greensboro project for 56 new cameras is $1,250,000 (This is for camera hardware and control only. The cost of communications is shown elsewhere). The anticipated cost for Winston-Salem, for 30 cameras and communications, is $4,000,000.

Freeway Lane Control Signals. An effective means of reducing secondary accidents in the event of an incident is the use of freeway lane control signals to alert motorists of closed lanes. These signals consist of a small box, placed over each lane, that displays a green arrow when all is clear, a red "X" when the lane is closed immediately ahead, and a yellow arrow that alerts the motorist of either slow traffic or advanced warning of a lane closure. These lane control signals can also be used to permit travel on freeway shoulders during peak periods where this is a save option. These signals are small, and can be installed on sign bridges and standard bridges, or on new structures intended solely for the lane control signals. The anticipated cost for deploying lane control signals on existing DMS structures throughout the Triad Region is $5,000,000.

Replace the Greensboro Signal System. One of the short-term projects is to upgrade their current traffic signal system by increasing the number of signals with communication. The long-term goal of this project is to replace the entire signal system with a new system, including cabinets and controllers, as well as increased system detection. This system will reduce travel times by 22% and save more than 2,700,000 vehicle-hours per year. This project is anticipated to cost $9,000,000.

Regional Emergency Vehicle Preemption. 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 the hospital or emergency room. Many local agencies have already installed 3M Opticom® equipment in the area, and all new emergency vehicle preemption equipment will be the same. Emergency vehicle preemption equipment will be installed at 500 intersections throughout the region, with 250 additional emitters being purchased and installed. The anticipated cost of this project is $875,000.

Transit Systems

Regional Transit Management System. The short-term project list identified the deployment of ITS elements for transit, including AVL and automatic dispatching. Following the deployment of these elements, the development of a regional transit management system will occur. This system will perform the following tasks:

- Automatic location system for para-transit calls similar to the 911 system
- Implement AVL in para-transit vehicles
- Integrate the transit dispatching system with the regional signal systems, real-time traffic information and other ITS elements
- Fully integrate the bus priority system with the various signal systems within the region
- Include smart bus stops at certain key locations where real-time bus information is provided
- Integrate real-time transit information into the kiosk-system

The system will use AVL to monitor the location of fleet vehicles, including para-transit and public transit buses. The AVL system will provide real-time location, latitude and longitude coordinates as well as travel direction to the system operator. By using CAD, para-transit riders can make reservations and operators can choose the most efficient routes to meet demands. The combination of AVL and CAD can be used to develop smart bus stops where arrival and departure times are updated on a real-time basis.

A study of the Winston-Salem Transit Authority (WSTA) recently evaluated the advantages of using CAD and AVL on a 17-bus fleet. Over a six-month period, ridership increased from 1,000 to 2,000 people, vehicle miles per passenger increased by 5%, operating expenses decreased by 2% per passenger trip and 9% per vehicle mile, and passenger wait time decreased by 50%[4]. Similarly, the Kansas City Transportation Authority (KCTA) improved on-time performance by 12% after using AVL for one year. Additionally, the AVL system permitted KCTA to monitor routes more effectively and refine schedules which resulted in the elimination of seven buses from the system at an annual savings of $400,000 in operating expenses[5].

The development of the software necessary for this regional integration of transit is anticipated to cost $2,250,000. Each smart bus stop is anticipated to cost $100,000 for the hardware and communications required. A total of 10 stops are planned.

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

Operations and Maintenance

One of the short-term projects is the development of a formal Operations and Maintenance pan. The funds shown for the Operations and Maintenance plan are for the plan development, not implementation. Operations and Maintenance costs are typically approximately 8% of the capital cost of any new project for a very basic level. This is a cost that is borne each year for power, spare parts, part replacement and labor. This assumes that all of the actual repair activities are performed by the part manufacturer and that failed or damaged items are removed and replaced with very little diagnostics performed by the owning agency.

ITS deployments require very specialized training that many signal technicians do not have. This typically includes fiber optic cable troubleshooting and repair, network diagnostics and configuration, CCTV and video image detection (VID) camera maintenance and repair, and other issues.

Project Summary

A summary of the aforementioned projects and their estimated costs 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)**
ATIS Projects			**ATIS Projects**		
S-1	Web-based alternative route data base	$81.5	L-1	Voice Remote System	$1,000.0
S-2	Enhancement to Local Cable Access	$12.5	L-2	Internet Traveler Information System (Phase 2)	$350.0
S-3	Internet Traveler Information System	$95.0	L-3	Regional Architecture Data Warehouse (Clearinghouse Phase 2)	$100.0
S-4	CCTV link to web	$37.5			
S-5	Kiosks at major public venues	$775.0			
S-6	Traveler Information Clearinghouse	$250.0			
	Subtotal	$1,251.5		**Subtotal**	$1,450.0
ATMS Projects			**ATMS Projects**		
S-7	Expand FMS	$3,000.0	L-4	Expand FMS (Phase 2)	$6,000.0
S-8	Portable VMS	$250.0	L-5	Regional Traffic Control Network	$6,000.0
S-9	Greensboro Signal System Upgrade	$5,250.0	L-6	Additional CCTV Camera on Arterials	$5,250.0
S-10	Kernersville Signal System	$4,000.0	L-7	Freeway Lane Control	$5,000.0
S-11	Winston-Salem Signal Timings	$550.0	L-8	Greensboro Signal	$9,000.0
	Subtotal	$13,050.0		**Subtotal**	$31,250.0
APTS Projects			**APTS Projects**		
S-12	Bus AVL System	$650.0	L-9	Smart Card Technology	$850.0
S-13	Transit Dispatching, Demand Forecasting, Automated Passenger Counting	$750.0			
S-14		$50.0			
	Subtotal	$1,450.0		**Subtotal**	$850.0
	Total Short-Term	$15,751.5		**Total Long-Term**	$33,550.0
Total 20-year Estimated Costs			**$49,301.5**		

Operational Concepts

A primary objective with ITS deployments is to provide operational coordination across jurisdictional lines. The proposed Triad 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 onto the entire region. During these major events, regional control and traffic management is of a primary concern. The operators within the ETRTMC and WTRTMC 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 Triad Region, and their primary responsibilities are:

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

State Highway Patrol
- Incident management
- Emergency management
- Enforcement

Forsyth County
- Forsyth County traffic signal control/systems

Forsyth County EMS
- Forsyth County emergency management

Forsyth County Sheriff
- Forsyth County incident management
- Forsyth County emergency management
- Forsyth County enforcement

City of Winston-Salem
- City of Winston-Salem traveler information – local issues and attractions, local traffic information, etc.
- City of Winston-Salem traffic signal control/systems
- City of Winston-Salem transit system

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

Guilford County Sheriff
- Guilford County emergency management
- Guilford County incident management
- Guilford County enforcement

Guilford County EMS
- Guilford County emergency management

NCDOT Division 9- Triad Region
- Incident management in Winston-Salem
- Traveler information in Winston-Salem
- Operate WTRTMC
- Highway Advisory Radio (HAR)

City of High Point
- City of High Point traffic signal control/systems

City of High Point PD
- City of High Point emergency management
- City of High Point incident management
- City of High Point enforcement

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

City of Greensboro
- City of Greensboro traffic signal control/systems
- City of Greensboro incident management
- City of Greensboro traveler information – local issues and attractions, local traffic information, cable channel, etc.

City of Greensboro Transit Agency
- City of Greensboro transit systems for Greensboro

NCDOT Division 7- Triad Region
- Incident management in Greensboro
- Traveler information in Greensboro
- Operate ETRTMC
- HAR

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

Alamance County EMS
- Alamance County emergency management

Randolph County
- Randolph County traffic signal control/systems

Randolph County Sheriff
- Randolph County emergency management
- Randolph County incident management
- Randolph County enforcement

Randolph County EMS
- Randolph County emergency 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 Triad 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 Triad 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 DMS, updated web sites and HAR 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.

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[6]. 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 FMS deployments refer to the *Off-Model Air Quality Analysis: A Compendium of Practice*, Federal Highway Administration Southern Resource Center, August 1999 included in the appendix of this report.

[6]"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.

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 back to a shop computer. The system has resulted in benefits shown below with an estimated benefit/cost ratio of 62:1.[7]

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%.[8]

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.

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

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

Regional 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 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%.[9]

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

[9] Stone, J., “Winston-Salem Mobility Management: An Example of APTS Benefits, “NC State University, 1995.

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.[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.

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.

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.[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.

[10] Giugno, M., Milwaukee County Transit System, July 1995 Status Report.
[11] Bus Rapid Transit Web Site, brt.volpe.dot.gov/guide/signal.html, February 14, 2001.

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[12].

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

Other ITS Benefits

Arterial Management Systems

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

[12] Tech Environmental, Inc., Air Quality Benefit Study of the SmarTraveler Advanced Traveler Information Service, July 1993.

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.[13]

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[14].

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[13] City of Los Angeles Department of Transportation, "Automated Traffic Surveillance and Control (ATSAC) Evaluation Study," June 1994.

[14] 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[15].

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 Triad 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 industry to develop standards for use within the ITS community. The most common standard that has been deployed to date is 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 Triad Region have been identified through the use of Turbo Architecture[16]. 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

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

AASHTO	NTCIP - Applications Profile for Common Object Request Broker Architecture (CORBA)	2305
ASTM	Standard Specification for DSRC - Physical Layer 902-928 MHz	PS 111-98
ASTM	Standard Specification for DSRC - Data Link Layer	Draft Z7633Z
EIA/CEA	Data Radio Channel (DARC) System	EIA-794
EIA/CEA	Subcarrier Traffic Information Channel (STIC) System	EIA-795
ANSI	Commercial Vehicle Safety Reports	TS284
ANSI	Commercial Vehicle Safety and Credentials Information Exchange	TS285
ANSI	Commercial Vehicle Credentials	TS286
IEEE	Standard for Common Incident Management Message Sets (IMMS) for use by EMSs	P1512
ITE	Advanced Traffic Controller (ATC) Application Program Interface (API)	9603-1
ITE	ATC Cabinet	9603-2
ITE	Advanced Transportation Controller (ATC)	9603-3
ITE	Message Set for External TMC Communication (MS/ETMCC)	TM 2.01
ITE	Standard for Functional Level Traffic Management Data Dictionary (TMDD)	TM 1.03
IEEE	Survey of Communications Technologies	ITSPP#5
IEEE	ITS Data Dictionaries Guidelines	ITSPP#6A
AASHTO	NTCIP - Simple Transportation Management Framework (STMF)	1101
AASHTO	NTCIP - Class B Profile	2001
AASHTO	NTCIP - Global Object Definitions	1201
AASHTO	NTCIP - Object Definitions for Actuated Traffic Signal Controller Units	1202
AASHTO	NTCIP - Object Definitions for DMS	1203
AASHTO	NTCIP - Point to Multi-Point Protocol Using RS-232 Subnetwork Profile	2101
IEEE	Guide for Microwave Communications System Development	1404
IEEE	Recommended Practice for the Selection and Installation of Fiber Optic Cable	P1454
IEEE	Message Sets for DSRC ETTM & CVO	1455
IEEE	Standard for Message Set Template for ITS	P1488
IEEE	Standard for Data Dictionaries for ITS	1489
AASHTO	NTCIP - Transportation System Sensor Objects	1209
AASHTO	NTCIP - Data Collection & Monitoring Devices	1206
AASHTO	NTCIP - Application Profile for Simple Transportation Management Framework (STMF)	2301
AASHTO	NTCIP - Internet (TCP/IP and UDP/IP) Transport Profile	2202
SAE	Truth-in-Labeling Standard for Navigation Map Databases	J1663
SAE	Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications	J1708
SAE	Information Report on ITS Terms and Definitions	J1761
SAE	A Conceptual ITS Architecture: An ATIS Perspective	J1763
SAE	ISP-Vehicle Location Referencing Message Profiles	J1746
SAE	In-Vehicle Navigation System Communication Device Message Set Information Report	J2256
SAE	On-Board Land Vehicle Mayday Reporting Interface	J2313
SAE	Mayday Industry Survey Information Report	J2352
SAE	Information System (ATIS) Data Dictionary	J2353
SAE	Advanced Traveler Information System (ATIS) Message Set	J2354
SAE	ITS Data Bus Architecture Reference Model Information Report	J2355
SAE	Standard for Navigation and Route Guidance Function Accessibility While Driving	J2364

SAE	ITS Data Bus Protocol - Link Layer Recommended Practice	J2366-2
SAE	ITS Data Bus Gateway Recommended Practice	J2367
SAE	ITS Data Bus Conformance Test Procedure	J2368
SAE	Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media	J2369
SAE	Field Test Analysis Information Report	J2372
SAE	Stakeholders Workshop Information Report	J2373
SAE	National Location Referencing Information Report	J2374
SAE	ITS In-Vehicle Message Priority	J2395
SAE	Measurement of Driver Visual Behavior Using Video Based Methods (Def. & Meas.)	J2396
SAE	Adaptive Cruise Control: Operating Characteristics and User Interface	J2399
SAE	Forward Collision Warning: Operating Characteristics and User Interface	J2400
SAE	ITS Data Bus Data Security Services Recommended Practice	J1760
SAE	ITS Data Bus Protocol - Physical Layer Recommended Practice	J2366-1
SAE	ITS Data Bus Protocol - Thin Transport Layer Recommended Practice	J2366-4
SAE	ITS Data Bus Protocol - Application Layer Recommended Practice	J2366-7
ITE	TCIP - Control Center (CC) Business Area Standard	1407
ITE	TCIP - Common Public Transportation (CPT) Business Area Standard	1401
ITE	TCIP - Fare Collection (FC) Business Area Standard	1408
ITE	TCIP - Framework Document	1400
ITE	TCIP - Incident Management (IM) Business Area Standard	1402
ITE	TCIP - Onboard (OB) Business Area Standard	1406
ITE	TCIP - Passenger Information (PI) Business Area Standard	1403
ITE	TCIP - Scheduling/Runcutting (SCH) Business Area Standard	1404
ITE	TCIP - Spatial Representation (SP) Business Area Standard	1405
ITE	TCIP - Traffic Management (TM) Business Area Standard	TS 3.TM

The first priority with the continued deployment in the Triad Region is to comply with national standards. However, a number of choices were made in the development and deployment of the ETRTMC and the WTRTMC 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 be either replaced or upgraded (if possible). This is not feasible. In instances such as this, the existing system will be maintained.

Regional Communication Architecture

Based on the short- and long-term projects, the key component of the Triad Region's ITS deployment plan is a dynamic traveler information system that will enable travelers to access road conditions both before leaving and while on the road. 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 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.

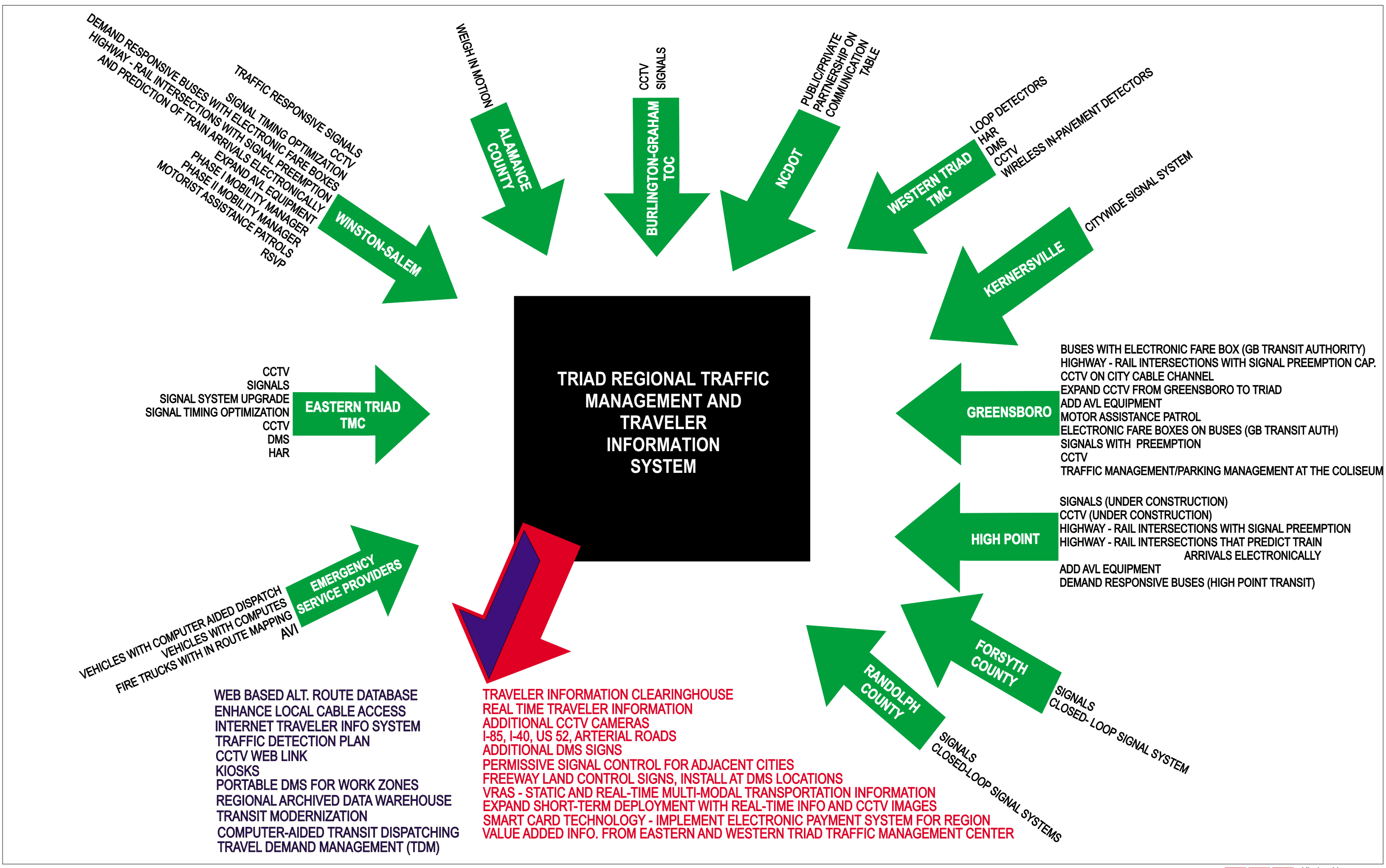


FIGURE 11. GENERIC REGIONAL ARCHITECTURE

Kimley-Horn and Associates, Inc.

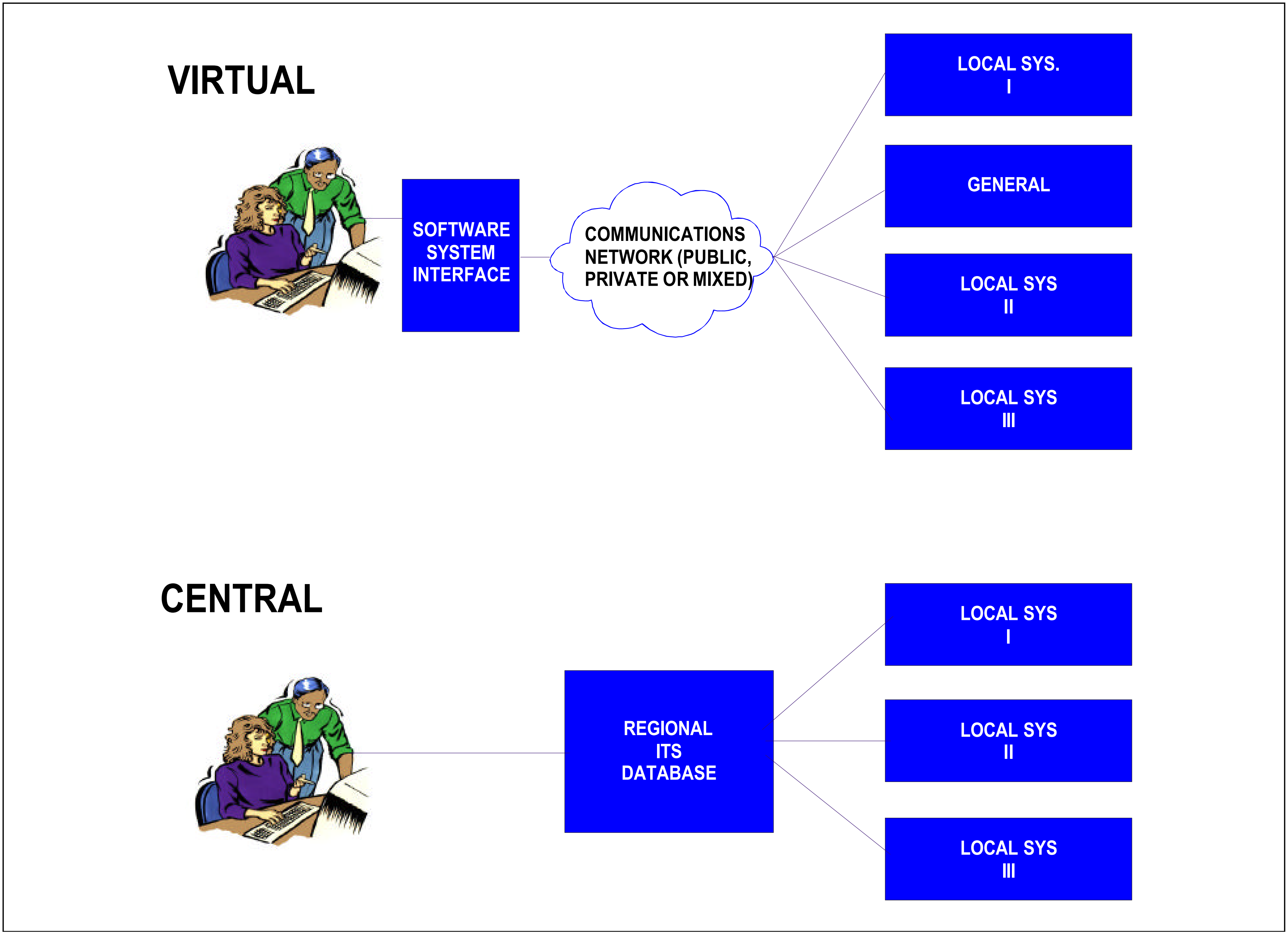


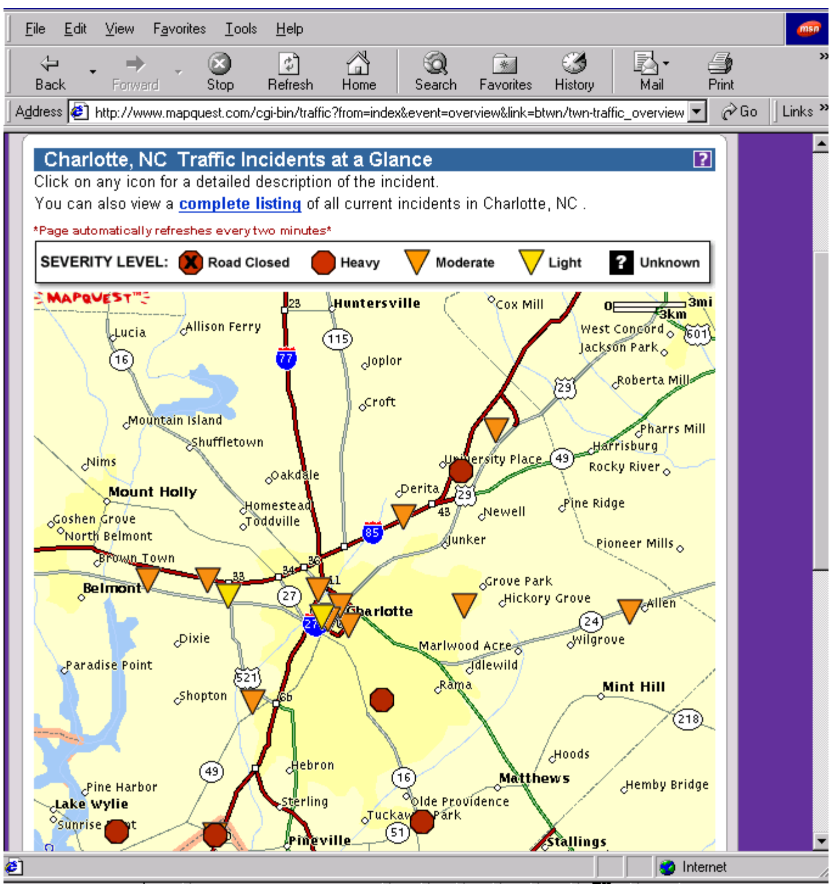
Figure 12 Central vs. Virtual Information System

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 of the data, video, and other information be brought to one central location for dissemination. For instance, the ETRTMC and/or WTRTMC 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 display data obtained from the DOT and provide it on the MapQuest. A sample image from MapQuest is provided for the Charlotte area (Triad area in development) in **Figure 13**[17].

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.[18]



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17 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).

18 Image from www.mapquest.com at approximately 6:15 p.m. on May 9, 2000.

The advantage of a central system is that is provides consistency to the end user not only in look and feel, but also in the data and video provided. A central system provides greater control over the information in that one agency, organization, or 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 it also has compatibility and consistency issues. A virtual system provides a front-end for the user from which he or she can select the desired information. 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 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 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 controls of the look of a site, a virtual system has different groups of people responsible for each of the local sites, which can confuse a user. Standardizing the front ends of the various systems can eliminate this problem.

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

Regional Architecture Recommendation

In a number of aspects, the Triad Region is a mature region with respect to ITS and traveler information systems. Because of the maturity associated with parts of the ITS deployment, a full central system is not appropriate. Likewise, due to the negative aspects associated with the virtual system, a virtual system is not recommended. Rather, a hybrid system is proposed. This recommendation not only covers the traveler information system elements, but also the day-to-day control and monitoring.

A hybrid system is proposed because the necessities of day-to-day operation will require that a significant portion of the infrastructure necessary be in place, namely a communication ring around the Triad Region. The hybrid system will maintain the independence of the existing TMCs within the region, however will provide links to and from each of the centers to promote information sharing. In addition, data of regional importance will be stored and disseminated in a regional traveler information clearinghouse.

The hybrid system will include a central Triad TMC. However, this center will only have primary responsibility for the NCDOT deployed and maintained elements. Each municipality within the region will have responsibility for their own individual elements, such as signal systems and the regional transit system. All of the centers responsible for controlling the various elements will be tied together through a regional system as described below. This regional system will permit the sharing of data and video to all of the connected agencies.

Communication System

The Triad Regional communication system requires that data and video be shared amongst several municipalities and two NCDOT divisions (7 and 9). The two options for this system are a Star type topology and a full ring network. A star topology would involve a connection between the two NCDOT facilities, with the two facilities serving as hubs for the local agencies. The ring topology would require that each major facility, both city and state, be connected on a ring through the entire region.

A star topology is recommended, as shown in **Figure 14**. A large bandwidth connection between the ETRTMC and the WTRTMC is necessary. This connection will serve as the backbone for all data and video to be transmitted through the region. Each of the local agencies would have a smaller connection, as it is necessary to transmit the required information.

The primary advantage of this type of a system for the Triad Region is its ability to conform to the needs of each agency as well as to grow over time. This provides for the most economical solution for the region in terms of initial cost. Where the ring network would require a direct connection of the same size bandwidth to each agency, the star network allows each link to be sized according to need.

As the ITS infrastructure continues to grow with new development and highway construction throughout the region, it may be possible to convert the star topology into a fully redundant ring network. Since it is unlikely that the infrastructure will be ready within the 10 year deployment timeframe, the star topology is defined and described in this report.

Communications Assessment

The primary communication link is between the WTRTMC and ETRTMC. This link needs to be able to transmit video and data from both centers. The primary component for regional communications is regional information or information that has a regional impact. Therefore, while Winston-Salem may have 77 CCTV cameras, the eastern side of the region will rarely have a reason to view most of these images on a regular basis. The same is true concerning the cameras in Greensboro and High Point.

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."

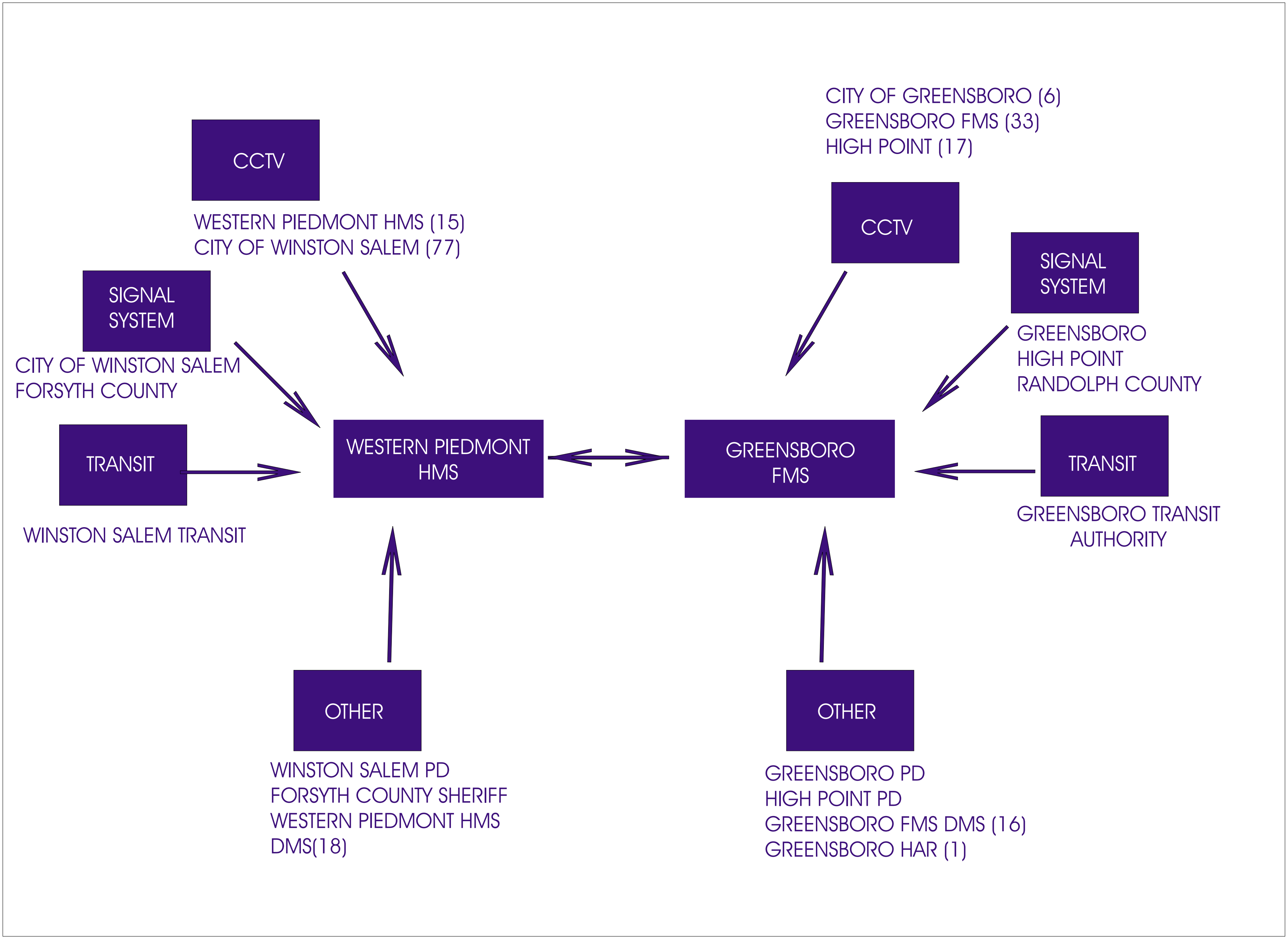

FIGURE 14. - Proposed Communication Topology

Video between the WTRTMC and WTRTMC and other agencies may 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 will be in the software to convert the data rate and in the network interface to change connection types.

Data transmission of traffic information requires substantially less bandwidth than 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 Kilobytes per second (Kbs). Data from other sources, such as traffic data count stations, DMS, and HAR does not require continuous communications; rather, the data (or voice for HAR) is sent in a burst. The more bandwidth available, the shorter the burst.

Data transmission between local agencies and the NCDOT WTRTMC and ETRTMC can be accommodated either by a direct connection or through leased communications using Digital Subscriber Line (DSL), Integrated Services Digital Network (ISDN), or a leased T-1. This type of continuous communication will permit information to be shared with the central control centers and these centers sharing the information with other users, as necessary.

Communications Plan

The proposed communications plan for the Triad 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 required already exist, have been designed, or are under construction. There are two proposed fiber connections that are needed to complete the connection between the WTRTMC and the ETRTMC. A connection from the ETRTMC and the City of High Point is also needed.

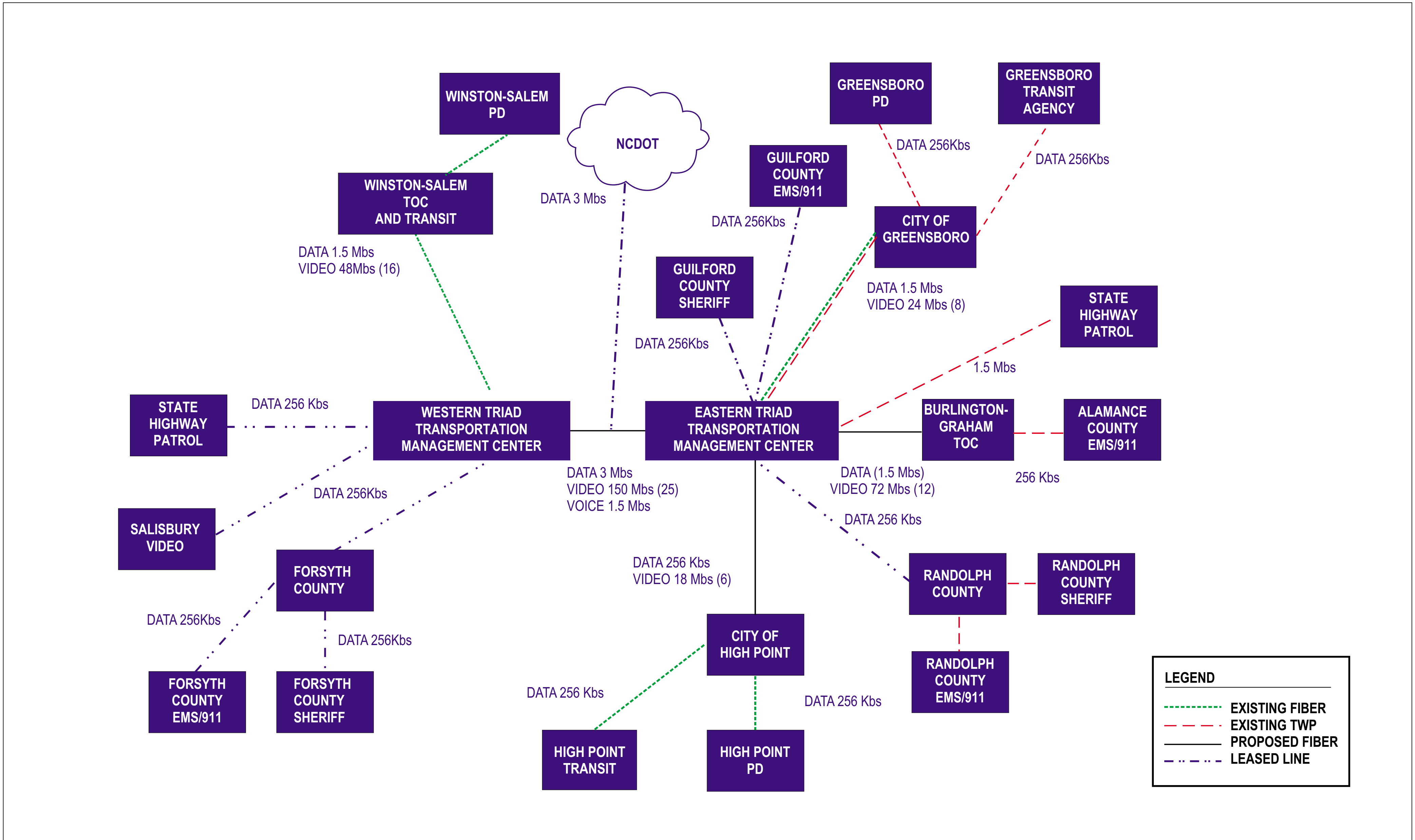

FIGURE 15. TRIAD REGION COMMUNICATIONS PLAN

Kimley-Horn and Associates, Inc.

Formal Communication Plan

The purpose of this document is to outline an overall ITS plan for the Triad 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 in which the entire region can 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 very little training or experience.

The regional communications plan will also identify communications requirements along corridors within the region, including I-40, I-85, and others. The plan will identify field elements, concentration points, and other items of importance to communications within the region. The plan will also identify technologies that can and should be used to reduce the fiber count necessary along each corridor.

East to West Trunk Link

The WTRTMC to ETRTMC connection will require approximately 14 miles of new fiber optic cable along interstate right-of-way. At an approximate construction cost of $50.00 per linear foot for conduit, cable, and installation, this connection will cost approximately $3.7 million. In addition, end equipment capable of OC-3 data rates (155 Mbs) is required at each end. Each of these boxes will cost approximately $100,000. Annual maintenance and operating costs of the fiber system will cost approximately $50,000.

The cost to lease the bandwidth required to connect these two centers would be approximately $120,000 per year, in addition to a one-time setup and installation cost of approximately $50,000. A wireless connection would require towers at both ends, a one-time construction cost of approximately $500,000 and annual operating and maintenance costs of between $50,000 and $100,000.

Figure 14 and **Figure 15** show the connection between the WTRTMC and ETRTMC's shows 25 video images being simultaneously transmitted and received between the two centers. Once a direct fiber optic cable connection between these two centers is established, NCDOT will have the ability to transmit nearly an unlimited number of simultaneous video images. The recommended OC-3 circuit, if dedicated only to video, would permit between 20 to 50 simultaneous images to be transmitted, depending on the bandwidth selected (television quality, full frame, full motion images). An OC-12 circuit would permit between 80 to 200 images. An OC-48 circuit would permit 320 to 800 simultaneous images. Since OC-3 networking equipment is significantly less expensive than OC-12 and OC-48 equipment, and since the cost of the OC-12 and OC-48 equipment continues to fall, it is recommended that the initial deployment use an OC-3 circuit.

One of the future goals in the Triad Region is the consolidation of the ETRTMC and WTRTMC. In the event this occurs, a communications hub or node type facility will be required at the closed facility. This facility is an unmanned facility that houses communications equipment, such as data and video transceivers and multiplexers, hubs, routers and other gear. This will serve as a concentration and distribution point for all of the ITS elements in the area.

Eastern Triad Region Communications

The Eastern Triad Region currently has communication infrastructures to most of the agencies and local traffic management and operations centers. This infrastructure includes both twisted pair copper and fiber optic cable. For those agencies that do not have communications to the ETRTMC, Randolph County and Guilford County Sheriff and EMS/911 facilities can be served by a leased line for data. This leased line can be either a DSL connection, a dual ISDN, or a partial T-1 operating at 256 Kbs. This leased line will cost approximately $10,000 per year with an initial setup of $2,000.

Burlington-Graham is in the process of installing a citywide signal system in addition to a number of CCTV surveillance cameras. It is their intent to provide pre-trip travel information in the form of a local access cable television channel to commuters traveling to both Burlington-Graham and the Triad Region. Although the new CCTV cameras will show video in the Burlington-Graham area, video images from the surrounding area would be beneficial. The bandwidth identified to provide this service is approximately 74 Mbs, or the equivalent of half an OC-3. The fiber option would require approximately 16 miles of cable and conduit at an average cost of $50.00 per linear foot for conduit, cable and installation. The infrastructure cost for fiber optics is approximately $4.25 million with an additional $100,000 for end equipment at each end. A leased solution would require a minimum of 12 T-1 circuits, however, 25 T-1 circuits would provide better video quality. This leased line (25 circuits) will cost approximately $400,000 per year with an initial set up cost of $200,000.

The other necessary communication in the Eastern Triad Region is between the proposed central TMC and High Point. A data rate of approximately 18 Mbs is required for video and data applications. This can be adequately served by a partial OC-1 or T-3. The fiber option would require approximately 10 miles of cable and conduit at an average cost of $50.00 per linear foot for conduit, cable and installation. The infrastructure cost for fiber optics is approximately $2.64 million, with an additional $100,000 for end equipment at each end. Annual maintenance and operating costs of the fiber system would be approximately $50,000.

Very low bandwidth information can be transmitted on the Criminal Justice Information Network (CJIN) of 800 MHz radios. This system is insufficient to support full motion video, however traffic and incident data can be shared using this system. It is recommended that CJIN be used as a supplement for a wired communications system, not a substitute.

The cost to lease the bandwidth required to connect these two centers would be approximately $40,000 per year, in addition to a one-time setup and installation cost of approximately $40,000. A wireless connection would require towers at both ends, a one-time construction cost of approximately $450,000, and annual operating and maintenance costs of between $50,000 and $100,000.

Western Triad Region Communications

The Western Triad Region does not require significant infrastructure improvements. A fiber optic connection already exists between the WTRTMC and the Winston-Salem facilities. Additional communication for data is required to the State Highway Patrol and Forsyth County Emergency Management Agency. Both links can be accomplished through a leased connection operating at 256Kbs.

Either DSL, ISDN or partial T-1 technology can be used. Each link will cost approximately $10,000 per year, with an initial setup charge of $2,000.

Statewide Link

The statewide link is necessary for numerous reasons, most notably to view traffic in the Triangle and Metrolina Regions, and for those regions to view traffic in the Triad Region. Traffic monitoring and control is a local issue, with regional and statewide impacts. For this 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 Triad 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 (2-5 frames per second) until a high speed statewide link can be established. A higher frame rate can be established at this bandwidth, but image quality will degrade.

The statewide link is recommended to be a leased network at this time. Several states are 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 Triad Region to NCDOT headquarters in Raleigh. The cost to lease the bandwidth required to connect these two centers would be approximately $90,000 per year, in addition to a one-time setup and installation cost of approximately $25,000.

APPENDIX

Meetings

Summits

NIA Compliance

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

Turbo Architecture Output

Triad Region Sausage Diagram

Triad Turbo Architecture Interconnect Diagram

Triad Turbo Architecture Flow Diagram

Triad Inventory to Market Package Comparison

Triad Market Packages Report

Triad Relevant Standards Activities

Triad Stakeholders Report

Triad Regional Architecture (Sample)

- Complete architecture is 330 pages long and included in a separate appendix.