Charlotte IVHS Area-Wide Plan

An IVHS Early Deployment Study
Submitted to
Federal Highway Administration

March 1993

CHARLOTTE IVHS
AREA-WIDE PLAN

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Prepared by the

Division of Highways
North Carolina Department of Transportation

In cooperation with the

Charlotte MPO
Kanlacon MPO
Gastonia MPO
and the
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North Carolina Department of Transportation

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CHARLOTTE IVHS AREA-WIDE PLAN

EXECUTIVE SUMMARY

This report serves as the first Intelligent Vehicle Highway System (IVHS) Area-Wide Plan for North Carolina. The purpose of this report is to outline short-term and long-term plans for the implementation and evaluation of IVHS technologies in the state. Further research and development needs to support IVHS deployment are also identified. The overall, nationwide agenda for the IVHS program is to optimize the use of the existing highway system through traffic operations and safety improvements, and to promote the use of public transportation.

The primary goals of this IVHS Area-Wide Plan will be achieved through the deployment of IVHS technologies to help maximize the safety and efficiency of the Charlotte Region's existing and future transportation facilities. There are four major IVHS deployment goals :

- **Optimal safety and congestion relief**
- **Improved environmental conditions**
- **Economic growth**
- **Improved technology transfer**

This Plan defines the Charlotte Region to be ten counties in North Carolina and two adjoining counties in South Carolina. The Plan provides a framework for the development of Congestion Management System and Incident Management System plans in other metropolitan regions and rural areas of the state. In 1993, the Department of Transportation plans to complete a Statewide IVHS Strategic Plan.

It will be imperative for planned IVHS improvements for freeways and arterials to be coordinated with specific action plans for busway and/or other transit systems. Improvements in safety, environmental protection, congestion reduction, mobility, and economic productivity can be achieved through the use of rail and public transportation. In turn, future public transportation improvements will be aided by certain technologies being promoted by the IVHS program.

Approximately 40 separate roadway segments are identified in the ten North Carolina counties in the Charlotte Region as potential IVHS deployment projects. These projects are recommended for implementation over more than a 20-year period by phase: the Phase I implementation period is from the present through 1997; Phase II for 1997 through 2002; Phase III for 2002 through 2012; and Phase IV beyond 2012. The Plan recommends an on-going review process that will incorporate IVHS projects in the 3-C planning process and the TIP program.

IVHS technologies in urban areas are defined by the Federal Highway Administration and IVHS-America in five broad categories:

- **Advanced Traffic Management Systems (ATMS)**
- **Advanced Traveler Information Systems (ATIS)**
- **Advanced Public Transportation Systems (APTS)**
- **Commercial Vehicle Operations (CVO)**
- **Advanced Vehicle Control Systems (AVCS)**

These five categories are interrelated and often share the application of specific IVHS technologies. For all five categories, as innovative IVHS technologies are developed and modified in coming years, those technologies will be appropriately adapted for existing freeways and arterials, and incorporated in the planning and design of new roadways. The Plan identifies approximately 100 separate technologies.

In order to direct the focus of applicable and cost-effective IVHS technologies for the Charlotte Region, the NCDOT and the Charlotte MPO have defined a number of specific "Initiatives" or broad program areas for IVHS deployment. These initiatives were prioritized by six separate focus groups from within the NCDOT, the Charlotte MPO, and from outside advisory panels. Priority IVHS Initiatives are:

* Real-time surveillance, detection, and data collection for freeways
* Incident management
* Accident/injury severity reduction
* Coordination with enforcement and emergency responders
* Congestion avoidance
* One-stop servicing for the trucking industry

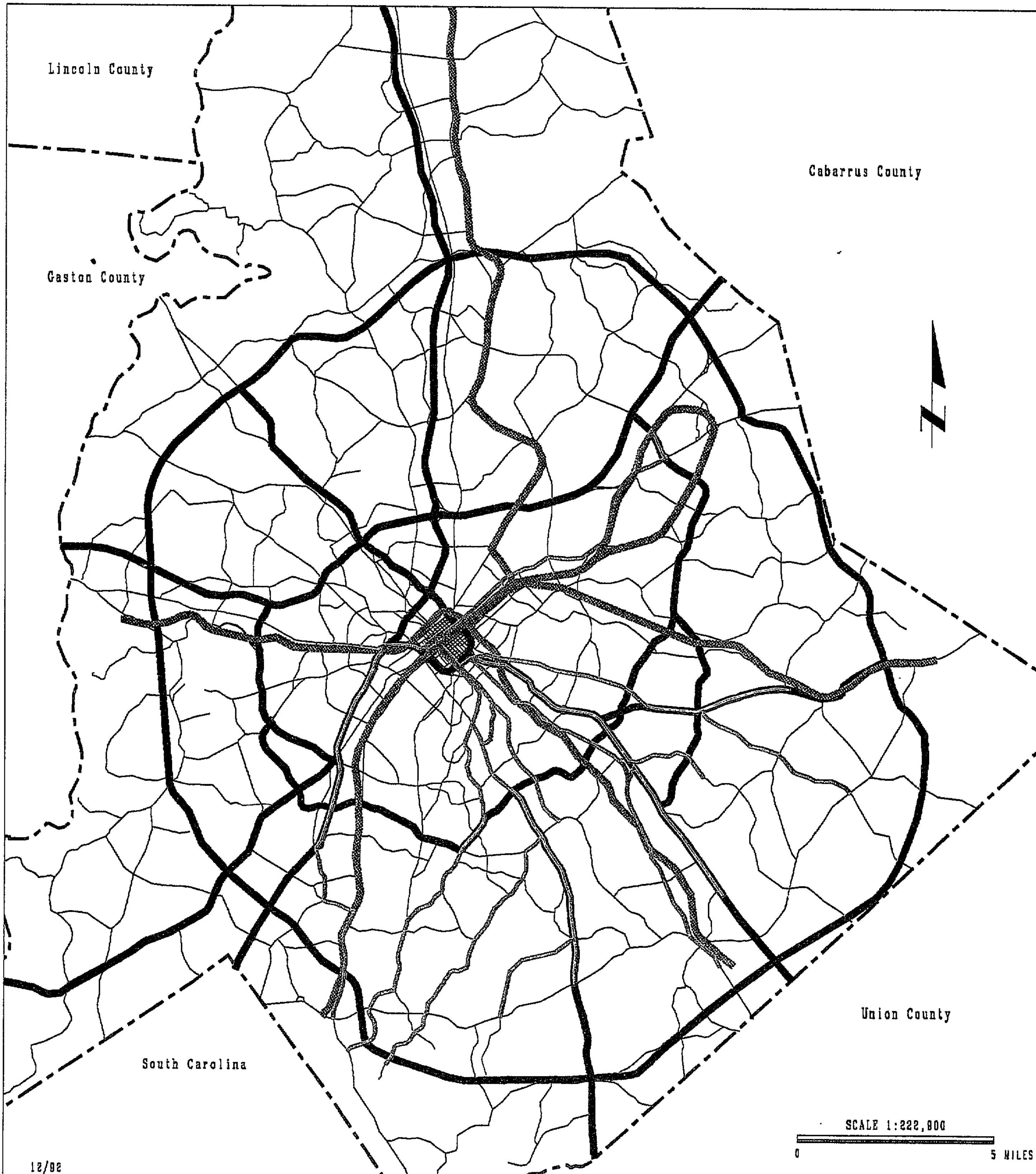
Costs for implementing the long-range (20-year) IVHS Area-Wide Plan for the Charlotte Region range between a low estimate of $164 million to a high estimate of $270 million, in 1992 dollars. These public sector investments are for ATMS, ATIS, and CVO components. Private sector (industry) investments for these three components may range up to an additional $30 to $100 million.

The NCDOT is dedicated to using the latest and most efficient IVHS technologies available, within budgetary constraints. Since the costs of new technologies tend to decrease as additional units are produced, such costs are expected to change as systems are upgraded. Therefore, the applicable technologies and the cost estimates for implementing the Plan should be updated on a biennial basis. Other elements of the Plan such as the Priority Road Segments and Transit Routes should be updated every three years.

In order to implement the plans and designs for deploying IVHS technologies in Charlotte and in other areas of the state, both urban and rural, it will be necessary to integrate funding for IVHS technologies into regular Federal Aid and State programs.

State highway program funding priorities will need to be examined by the Administration and the Board of Transportation in order to determine if a more cost effective expenditure of all public monies from all sources would warrant a redistribution of currently planned expenditures.

Scheduling of projects proposed in this Plan will depend on several factors. The first key to success is the continued documentation and approval of the concept of IVHS technology deployment as an effective strategy to address Traffic Congestion Management. The second key to success will be the continued understanding and acceptance of such technologies by the NCDOT administration, the Board of Transportation, the General Assembly, the MPO's in the Charlotte Region, the City of Charlotte DOT, and other involved parties.



MAP EX
MECKLENBURG COUNTY
PROPOSED TRANSPORTATION PROJECTS

IVHS

Express Bus Routes

Proposed Light Rail Transit

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CHARLOTTE IVHS AREA-WIDE PLAN

LIST OF ACRONYMS/ABBREVIATIONS

A	Total Number of Accidents on a Specific Category of Roadway Under Study
AASHTO	American Association of State Highway and Transportation Officials
ABS	Automatic Braking System
ADT	Annual Average Daily Traffic
AEI	Automatic Equipment Identification
AHAR	Automatic Highway Advisory Radio
ANSI	American National Standards Institute
APTS	Advanced Public Transportation System
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
ATC	Automated (electronic) Toll Collection
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVCS	Advanced Vehicle Control System
AVC	Automated Vehicle Classification
AVI	Automated Vehicle Identification
AVL	Automated Vehicle Location system
AVM	Automatic Vehicle Monitoring
B/C	Benefit/Cost Ratio
BOT	North Carolina State Board of Transportation
3-c	Three "C" Planning Process (Continuing, Comprehensive, Coordinated)
CAAA	Clean Air Act Amendments of 1990
CAD	Comp . -Aided Dispatching
CADD	Camp.-Aided Draftings and Design
CARAT	The NCDOT 1992 Congestion Avoidance and Reduction for Autos and Trucks Proposal
CIP	Charlotte Capital Improvement Program
CMAQ	Congestion Mitigation for Air Quality
CMS	Congestion Management System
c o	Carbon Monoxide
CTS	Charlotte Transit System
c v o	Commercial Vehicle Operations
DIME	Dual Incidence Matrix Encoded files
DMV	North Carolina Division of Motor Vehicles
DRS	Dead Reckoning System

ECPA	Electronic Communications Privacy Act
ENTERPRISE	Evaluating New TEchnologies for Roads PRogram - Initiative in Safety and Efficiency, a multi-state IVHS research consortium
EPDO	Equivalent Property-Damage-Only (Accidents)
ERGS	Electronic Route Guidance System
ETC	Elec. Toll Collection
ETTM	Electronic Toll and Traffic Management
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FMS	Freeway Management System
FTA	Federal Transit Administration (formerly UMTA)
GDF	Geographic Data Format
GIS	Geographic Information System
GPS	Global Positioning System/Global Positioning Satellite
HAR	Highway Advisory Radio
HAZMAT	HAZardous MATerial(s)
HOV	High Occupancy Vehicle
HP&R	Highway Planning and Research
HUD	Head-Up Display
HUFSAM	Highway Users Federation for Safety And Mobility
I	Interstate Highway
IA	Number of Class A Injury Accidents at Location Under Study
IB	Number of Class B Injury Accidents at Location Under Study
IBTTA	International Bridge, Tunnel and Turnpike Association
IC	Number of Class C Injury Accidents at Location Under Study
IEEE	Institute of Electrical and Electronics Engineers
I/M	Inspection and Maintenance Program (for motor vehicles)
IMS	Incident Management System
IR	Infrared
IRP	International Registration Plan
IS0	International Standards Organization
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991 (PL102-240)
ITE	Institute of Transportation Engineers
IVHS	Intelligent Vehicle Highway System
K	Number of Fatal Accidents at Location Under Study
KIOSK	An information center (for traffic) located in shopping malls, parking lots, hotels, businesses, etc. , usually with interactive computer ability.

L	Length of Section
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LOS	Level of Service
LRT	Light Rail Transit
LTL	Less Than Truck Load
MMI	Man-Machine Interface/Man-Machine Interaction
MPO	Metropolitan Planning Organization
MVMA	Motor Vehicle Manufacturers Association
NCDOH	North Carolina Division of Highways of the NCDOT
NCDOT	North Carolina Department of Transportation
NCPTRD	North Carolina Public Transportation and Rail Division, NCDOT
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
NHTSA	National Highway Traffic Safety Administration
NIMC	National Incident Management Coalition
NTIA	National Telecommunications and Information Administration
OBC	On-Board Computer
P	Number of Property-Damage-Only Accidents at Location Under Study
PDF	Predictive Data Fusion
Plan	The Charlotte IVHS Area-Wide Plan
RDS	Radio Data Systems
Region	The Twelve-County Charlotte Region, including the counties of Anson, Cabarrus, Cleveland, Gaston, Iredell, Lincoln, Mecklenburg , Rowan, Stanly and Union Counties in North Carolina, plus Lancaster and York Counties in South Carolina
RGD	Route Guidance Database
Rmvm	Accidents Per Million Vehicle-Miles
RNS	Radio Navigation System
RSPA	Research and Special Programs Administration
RTA	Regional Transit Authority
SAE	Society of Automotive Engineers
SHP	North Carolina State Highway Patrol
SI	Severity Index
STP	Surface Transportation Program
T	Total Number of Accidents at Location Under Study
TAC	Transportation Advisory Committee (of a MPO)

TAR	Travel Advisory Radio
TCC	1. Traffic Control Center 2. Technical Coordinating Committee (of a MPO)
TDM	Travel Demand Management
TIGER	Topologically Integrated Geographic Encoding & Referencing
TIP	Transportation Improvement Plan
TL	Truck Load
TMA	1. Transportation Management Areas 2. Transportation Management Association
TMC	Traffic Message Channel
TOC	Traffic Operations Center
TRB	Transportation Research Board
TSM	Transportation System Management
USGS	United States Geological Survey
v/c	Volume- to-Capacity Ratio
VMS	Variable Message Signs
VMT	Vehicle Miles Traveled
VORAD	Vehicle On-board RADar
VRC	Vehicle/Roadside Communications
WAVM	Wide-Area Vehicle Monitoring
WIM	Weigh-In-Motion

1. INTRODUCTION

Charlotte, the "Queen City," is the largest city in the Carolinas and serves as the major business hub for the two states. Although "less massive than other urban complexes", Charlotte (and its surrounding area) are "the essence of North Carolina.. . . (and) what much of the nation will be like by the Twenty-First Century." This view of North Carolina's urban regions has been voiced by Dr. John Kasarda of the University of North Carolina, as quoted in John Herbers, The New Heartland, (Times Books, New York, 1986, p. 29).

If this vision of the future becomes a reality, then it is imperative that short-term and long-term solutions be found to growing conditions such as traffic congestion and highway safety concerns. This IVHS Area-Wide Plan addresses such solutions for the Charlotte Region, as a prototype for other areas into North Carolina.

1.1 SCOPE AND PURPOSE

This report serves as the first Intelligent Vehicle Highway System (IVHS) Area-Wide Plan for North Carolina. The purpose of this report is to outline short-term and long-term plans for the further research and development, as well as implementation and evaluation of IVHS technologies in the state. This Plan outlines elements of a continuing planning process for incorporating IVHS technologies in the North Carolina Transportation Program.

The Charlotte IVHS Area-Wide Plan compiles and analyzes IVHS elements in the field of Advanced Traffic Management Systems, Advanced Traveler Information Systems, Advanced Public Transportation Systems, Commercial Vehicle Operations, and Advanced Vehicle Control Systems. This plan identifies the most appropriate IVHS technologies for deployment in the Charlotte Urban Area, and the prioritized list of roadways that would be improved by the use of those technologies. This plan includes time schedules for IVHS deployment, development and operating cost/benefit analyses, sources of IVHS funding, and IVHS technology assessments.

1.2 PROBLEM STATEMENT

On a national scale, Charlotte is a mid-sized urban area, with distinctively increasing congestion and safety problems. The greater Charlotte/ Mecklenburg area is unique in that it has many of the major traffic generating features found only in larger cities. For example, along the I-77 corridor alone, there is currently a 25,000-seat professional basketball arena, the eighth busiest international airport in the country, and a regional theme park. A planned NFL football stadium is scheduled to open in early 1994. The Charlotte Region also has the following features located in the northeastern quadrant of Mecklenburg County: two major interstate routes (I-77 and I-85), the University of North Carolina at Charlotte (UNC-C), the University Research Park, the University Medical Center, and the Charlotte Motor Speedway. Charlotte's downtown is the employment center for approximately 50,000 people, with several office towers of up to 60 stories dotting the skyline. The Charlotte Convention and Visitors Bureau boasts of

Charlotte as one of America's fastest growing metro regions, with 417,000 people in the city limits and 1.2 million in the metro area. Over 5 million people live within a 100-mile radius of Charlotte, making it the center of the nation's 5th largest urban region.

The NCDOT Traffic Survey Unit found that in 1992 sections of I-77 carried over 130,000 vehicles a day. Of the I-77 traffic, truck traffic constituted approximately 22%. According to the North Carolina Department of Transportation (NCDOT) Division 10 Office, as many as 50 to 60 major and minor traffic incidents occurred daily in 1992 on Charlotte's freeways. Freeway incidents typically create serious congestion and safety problems, in some cases reducing roadway capacity by 40 percent.

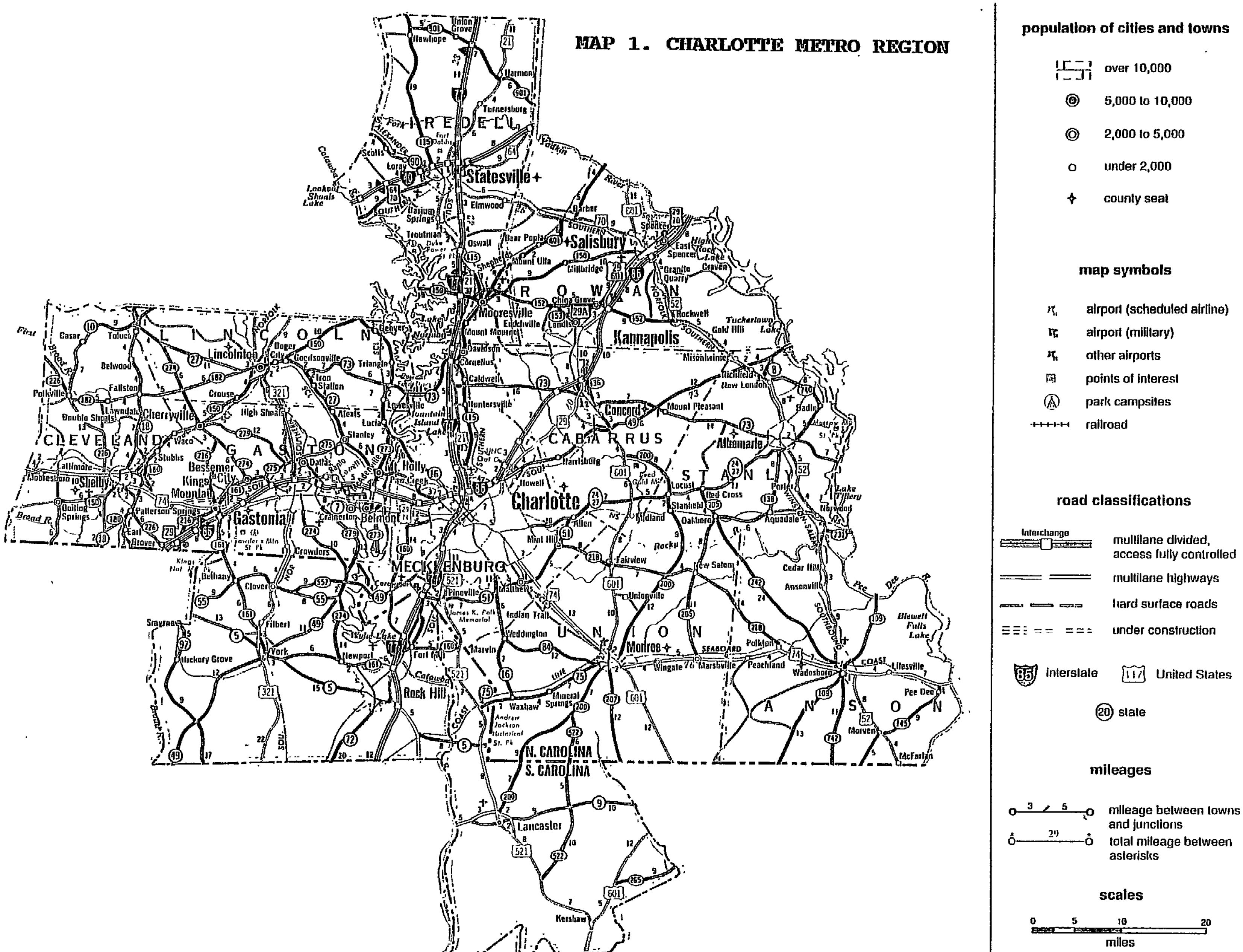
The Charlotte Region's current and projected population and economic growth rates have caused local and state planners and engineers to predict greatly increased transportation problems in the upcoming decades. According to the 1990 U.S. Census, Charlotte has experienced a population growth rate of 32.8% over the last ten years, while the Charlotte Region's growth rate was 29 .9% over the same time frame. The Charlotte Region consists of 12 counties, which include Anson, Cabarrus, Cleveland, Gaston, Iredell, Lincoln, Mecklenburg , Rowan, Stanly, and Union Counties in North Carolina; Lancaster and York Counties in South Carolina. Map 1 depicts the 12 county region. Mecklenburg County, which includes the City of Charlotte, is predicted to have a significant increase in population, reaching an estimated level of 686,200 in the year 2005 and 743,500 in the year 2010. These population estimates were obtained from the NCDOT Statewide Planning Branch.

According to the December 1992 "Charlotte Metro Region," between 1970 and 1987 the Charlotte Region added a net of 8,000 factory jobs (up 4%), 80,000 wholesale and retail trade sector jobs (up 96%), and 76,000 service jobs (up 179%). The Charlotte "2005 Transportation Plan" states that the high density work areas inside the city of Charlotte are attracting growing numbers of motorists to commute from the surrounding counties.

NCDOT's Statewide Planning Branch has predicted that total vehicle travel on the Charlotte Freeway System will grow by 58% from 1985 to 2005. Even with the currently planned transportation improvements, the I-77 level of service will not be able to exceed a "d" level of service rating. With existing budget constraints affecting the cost of purchasing right-of-way in developed areas, along with present and future environmental concerns, the concept of adding new lanes to Charlotte's freeways is not the most cost-effective option.

Even with the current state-of-practice in freeway management efforts in North Carolina, the NCDOT cannot keep pace with Charlotte's rapid growth. The introduction of Intelligent Vehicle Highway Systems (IVHS) has the potential to respond to Charlotte's growing transportation problems. Through the deployment of IVHS technologies in projects such as CARAT, ("Congestion Avoidance and Reduction for Autos and Trucks, ") the most cost-effective, state-of-the-art systems can be put to work for Charlotte and the Region.

MAP 1. CHARLOTTE METRO REGION



SOURCE: Clay, James W. and Alfred W. Stuart, Eds., "Charlotte Metro Region: Hub of the Carolinas", Charlotte, December 1992.

2. IVHS DESCRIPTION IN RELATION TO CARAT

The North Carolina Department of Transportation's July 1992 proposal entitled, "Congestion Avoidance and Reduction for Autos and Trucks" (CARAT), is a proposal for an Intelligent Vehicle Highway System (IVHS) Operational Test for Charlotte, North Carolina. CARAT provides the most efficient use of innovative technologies to improve the overall Freeway Management System and the essential evaluations for the advancement of the IVHS knowledge base. Throughout this Plan, this proposal for an IVHS Operational Test is referred to as "CARAT" or the "CARAT Project."

The NCDOT has overall responsibility for CARAT project management and is coordinating the efforts of other State agencies, the City of Charlotte, the University of North Carolina system, and private sector contractors and vendors during project development. Figure 1 illustrates the CARAT developmental organization. Once the CARAT project is operational, overall responsibility will change. The CARAT operational organization is identified in Figure 2.

CARAT proposes the implementation of IVHS technologies for Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), and Commercial Vehicle Operations (CVO) . Through the CARAT project, the NCDOT will continue to track and evaluate the status of IVHS advancements in areas such as ATMS, ATIS, CVO, as well as Advanced Vehicle Control Systems (AVCS) , and Advanced Public Transportation Systems (APTS) , to determine the appropriate time for their deployment in the Charlotte Region. IVHS technologies will affect Charlotte's freeways and arterials by reducing congestion and increasing convenience for travelers. Map 2 illustrates the CARAT Phase I proposal. Table 1 shows the Phase I, CARAT/IVHS Roadway System that includes the description of the Phase I Main Route, Southbound Alternate Route segments, Northbound Alternate Route segments, and other roadways which intersect I-77. Northbound and Southbound alternate routes are currently being used as part of the NCDOT Incident Management System (IMS) in the Charlotte area.

C.A.R.A.T. DEVELOPMENTAL ORGANIZATION CHART

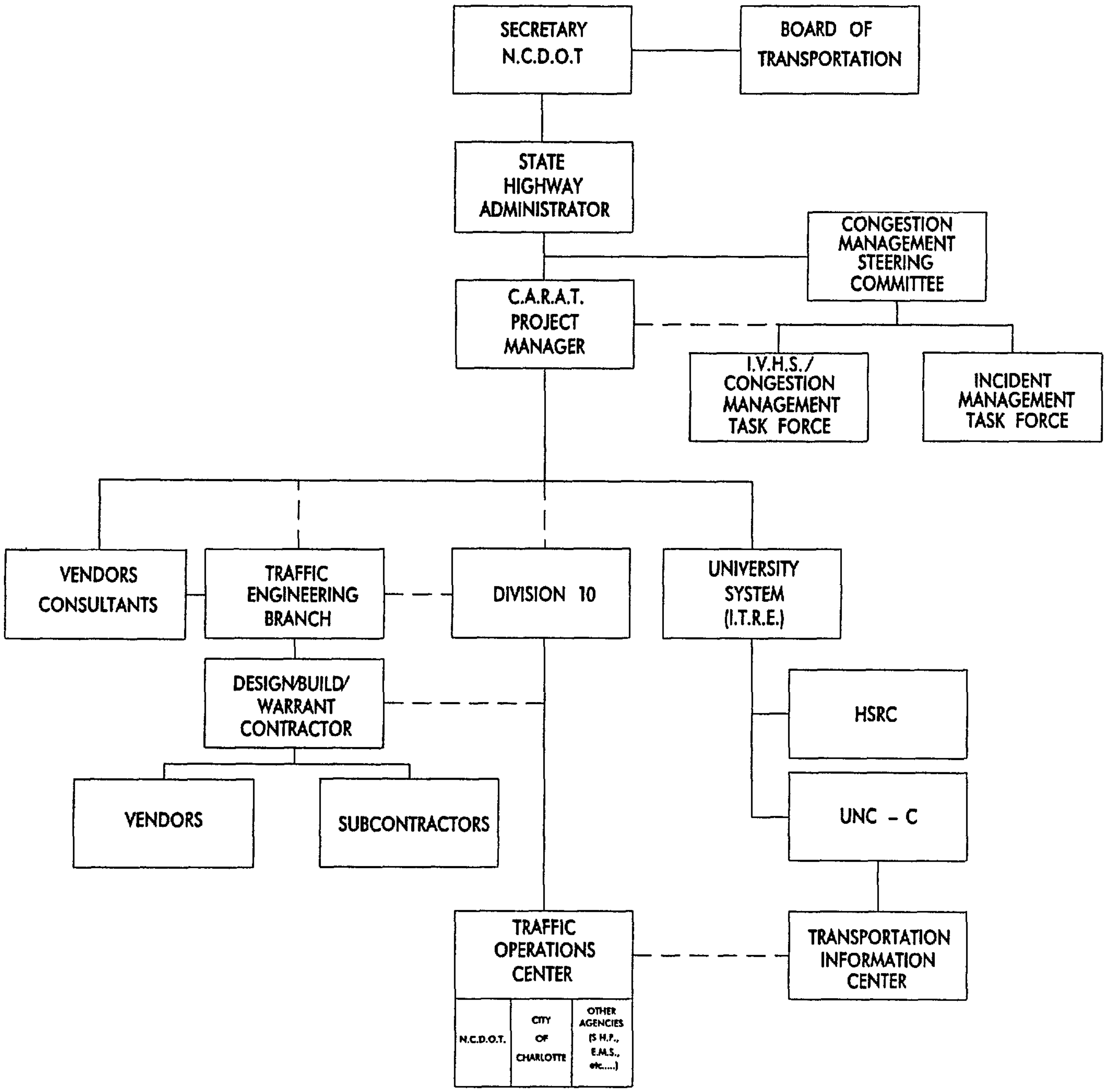


FIGURE I

C.A.R.A.T. OPERATION ORGANIZATION CHART

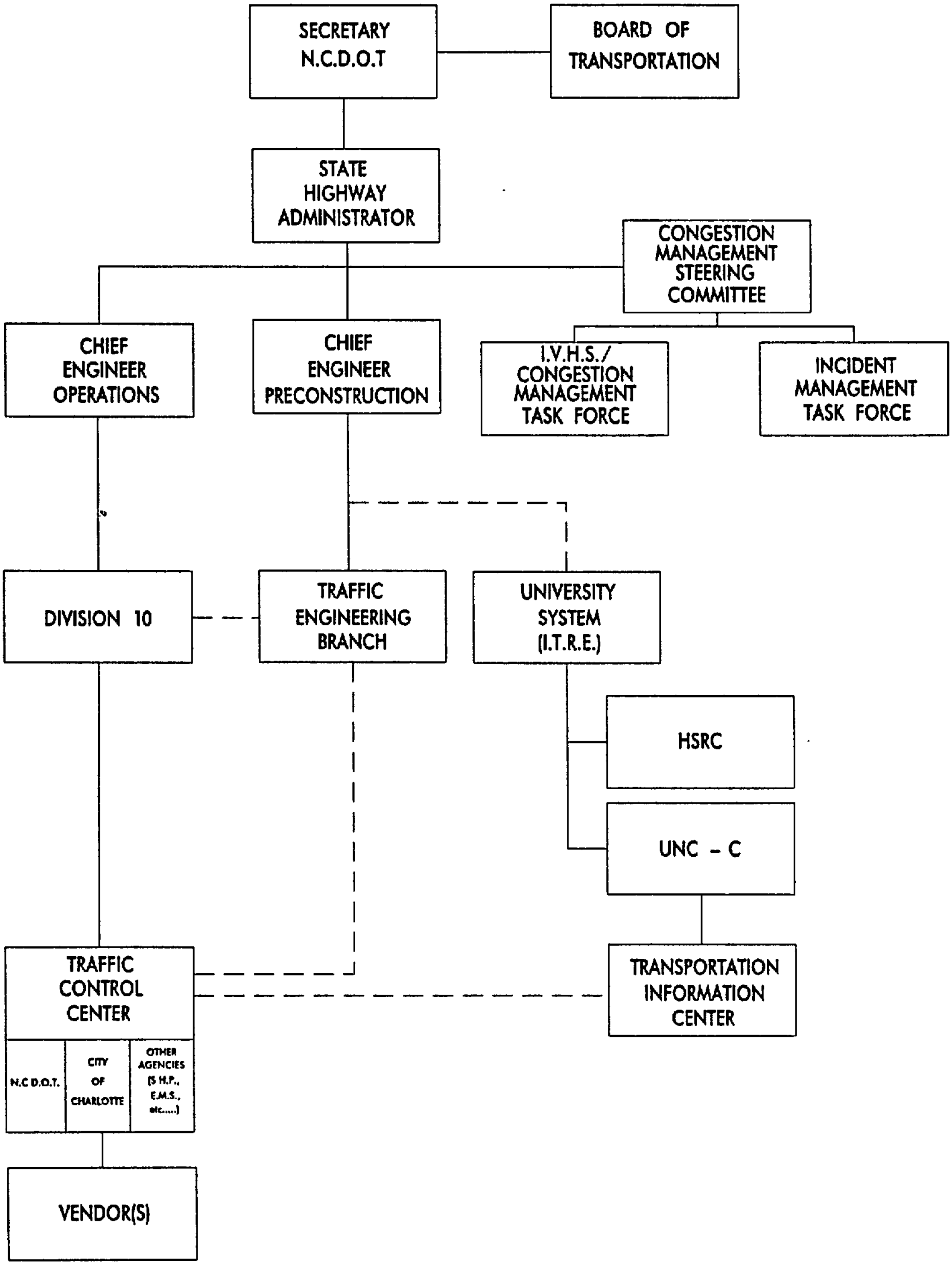
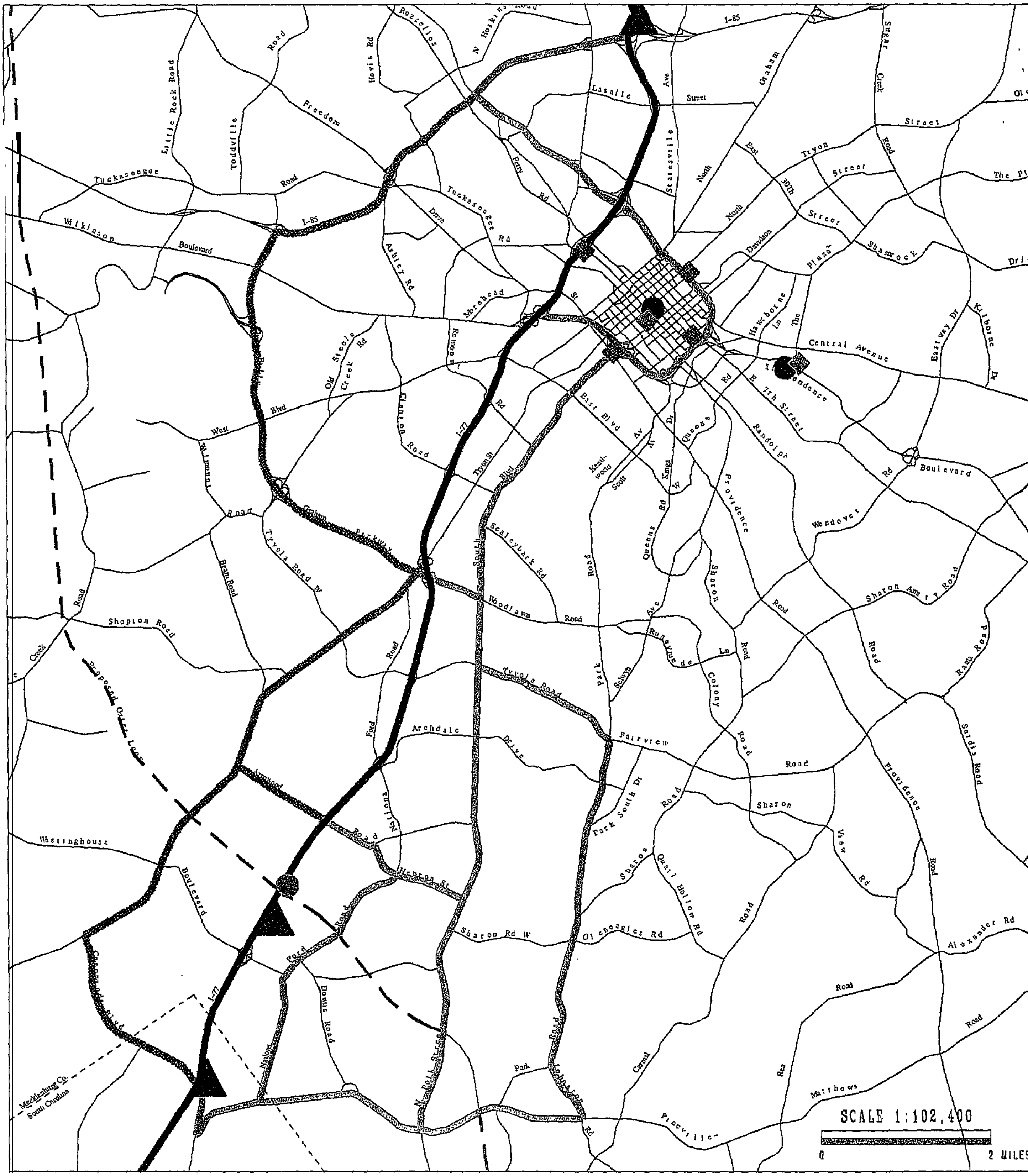


FIGURE II



MAP 2
CARAT PHASE I

Charlotte, N.C.

Interstate 77

Northbound Alternate

Southbound Alternate

Southbound and Northbound Alternate

Tower Mounted Cameras - Current

Proposed

Traffic Control Centers - Current

Proposed

Highway Advisory Radio Toners

TABLE 1

CARAT/IVHS ROADWAY SYSTEM
PHASE I

MAIN ROUTE:

NAME	DESCRIPTION
I-77	I-77 FROM THE INTERSECTION OF I-77 AND CAROWINDS BLVD IN SOUTH CAROLINA TO THE INTERSECTION OF I-77 AND I-85 IN NORTH CAROLINA

SOUTHBOUND ALTERNATE ROUTE SEGMENTS

	NAME	DESCRIPTION
1.	I-851	I-85 FROM THE INTERSECTION WITH I-77 TO THE INTERSECTION WITH US-521/BILLY GRAHAM PKWY
2.	us-521 BILLY GRAHAM PKWY	US-521/BILLY GRAHAM PKWY FROM THE INTERSECTION WITH I-85 TO THE INTERSECTION WITH YORK ROAD
3.	YORK ROAD NC-49	YORK RD/NC-49 FROM THE INTERSECTION WITH I-77 TO THE INTERSECTION WITH CAROWINDS BLVD
4.	ARROWOOD ROAD	ARROWOOD RD FROM THE INTERSECTION WITH YORK ROAD/NC-49 TO THE INTERSECTION WITH I-77
5.	CAROWINDS BLVD	CAROWINDS BLVD FROM THE INTERSECTION WITH NC-49 TO THE INTERSECTION WITH I-77

TABLE 1, CONTINUED

CARAT/IVHS ROADWAY SYSTEM
PHASE I

NORTHBOUND ALTERNATE ROUTE SEGMENTS:

NAME	DESCRIPTION
1. NC-51 (also SC 51)	NC-51 FROM THE INTERSECTION WITH I-77 TO THE INTERSECTION WITH JOHNSTON RD/PARK RD
2. NATIONS FORD ROAD	NATIONS FORD RD FROM THE INTERSECTION WITH NC-51 TO THE INTERSECTION WITH ARROWOOD RD
3. SOUTH BOULEVARD	SOUTH BLVD FROM THE INTERSECTION WITH NC-51 TO THE INTERSECTION WITH THE BELK FREEWAY/I-277
4. ARROWOOD ROAD	ARROWOOD RD FROM THE INTERSECTION WITH SOUTH BLVD TO THE INTERSECTION WITH I-77
5. JOHNSTON/PARK ROAD	JOHNSTON RD/PARK RD FROM THE INTERSECTION WITH NC-51 TO THE INTERSECTION WITH TYVOLA RD
6. TYVOLA ROAD	TYVOLA RD FROM THE INTERSECTION WITH PARK RD TO THE INTERSECTION WITH SOUTH BLVD
7. WOODLAWN ROAD	WOODLAWN RD FROM THE INTERSECTION WITH SOUTH BLVD TO THE INTERSECTION WITH I-77
8. I-85, (also Southbound)	I-85 FROM THE INTERSECTION WITH I-77 TO THE INTERSECTION WITH BROOKSHIRE FREEWAY
9. BROOKSHIRE FREEWAY	BROOKSHIRE FREEWAY FROM THE INTERSECTION WITH I-85 TO THE INTERSECTION WITH INDEPENDENCE BLVD
10. BELK FREEWAY	BELK FREEWAY FROM THE INTERSECTION WITH INDEPENDENCE BLVD TO THE INTERSECTION WITH I-77

TABLE 1, CONTINUED

CARAT/IVHS ROADWAY SYSTEM
PHASE I

OTHER ROADWAYS WHICH INTERCHANGE WITH I-77:

NAME	DESCRIPTION
1. HARRIS BOULEVARD	HARRIS BLVD FROM THE INTERSECTION WITH REAMES RD TO THE INTERSECTION WITH LAKEVIEW
2. SUNSET ROAD	SUNSET RD FROM THE INTERSECTION WITH BEATTIES FORD RD TO THE INTERSECTION WITH STATESVILLE RD
3. LASALLE STREET	LASALLE ST FROM THE INTERSECTION WITH I-77 TO THE INTERSECTION WITH STATESVILLE AVE
4. FIFTH STREET	FIFTH ST FROM THE INTERSECTION WITH TRADE ST TO THE INTERSECTION WITH IRWIN AVE
5. TRADE STREET	TRADE ST FROM THE INTERSECTION WITH FIFTH ST TO THE INTERSECTION WITH IRWIN AVE
6. MOREHEAD STREET	MOREHEAD ST FROM THE INTERSECTION WITH FREEDOM DR TO THE INTERSECTION WITH CEDAR ST
7. WEST BOULEVARD	WEST BLVD FROM THE INTERSECTION WITH REMOUNT RD TO THE INTERSECTION WITH TRYON ST
8. REMOUNT ROAD	REMOUNT RD FROM THE INTERSECTION WITH WEST BLVD TO THE INTERSECTION WITH TRYON ST
9. CLANTON ROAD	CLANTON RD FROM THE INTERSECTION WITH WEST BLVD TO THE INTERSECTION WITH TRYON ST/NC 49
10. TYVOLA ROAD	TYVOLA RD FROM THE INTERSECTION WITH TRYON ST/NC-49 TO THE INTERSECTION WITH SOUTH BLVD
11. WESTINGHOUSE BLVD	WESTINGHOUSE BLVD FROM THE INTERSECTION WITH YORK RD/NC-49 TO THE INTERSECTION WITH NATIONS FORD RD

3. GOALS AND OBJECTIVES

The primary goals of this IVHS Area-Wide Plan (Plan) will be achieved through implementing IVHS technologies to help maximize the safety and efficiency of Charlotte's existing and future transportation facilities. There are four major IVHS Deployment Goals :

* Optimal Safety & Congestion Relief
* Improved Environmental Conditions
* Economic Growth
* Improved Technology Transfer

This IVHS Area-Wide Plan, if fully implemented, is expected to achieve the following statewide and regional transportation improvement objectives :

3.1 SAFETY & CONGESTION OBJECTIVES

- IVHS technologies will improve overall system performance for North Carolina's Surface Transportation System.

- IVHS technologies will enhance transportation safety, reduce congestion, improve mobility, and provide for better driver/highway interaction.

- IVHS technologies will help minimize the effects of non-recurring incidents.

- IVHS technologies will support and enhance transit operations and other modes of mass transportation.

- IVHS technologies will positively influence travellers' choice of routes and modes by providing accurate real-time travel information and alternate route signing.

- The Plan supports the coordination efforts of IVHS with ramp metering, transit operations, HOV facilities, incident management programs, interconnected signal systems, and other existing and future traffic management and travel demand measures.

- The Plan coordinates traffic flow on the Charlotte Region's freeways and principal arterials while optimizing the efficiency of roadway facilities.

3.2 ENVIRONMENTAL OBJECTIVES

- The Plan supports the achievement of operational improvements through technological methods rather than only depending on the addition of more traffic lanes.

- The Plan contributes to regional air quality enhancement goals and helps to reduce environmental impacts from vehicle emissions.

- IVHS technologies help mitigate the impacts of roadway hazardous spills through IVHS activities such as a coordinated incident management program.

- The Plan makes optimum use of existing energy resources and transportation facilities.

3.3 ECONOMIC GROWTH OBJECTIVES

- The Plan develops an IVHS program that takes advantage of Federal Funding available through the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).
- The Plan helps to establish North Carolina as a high technology leader.
- The use of IVHS technologies will expand North Carolina's job market.
- The Plan calls for the maximum use of existing technologies while researching and testing the most innovative state-of-the-art technologies for the highest benefit/cost ratios.
- The Plan minimizes new construction and maintenance costs through IVHS applications.
- The Plan facilitates private sector financial participation in areas of mutual benefit to both public and private interests, and supports competitive markets.

3.4 TECHNOLOGY TRANSFER OBJECTIVES

- The Plan includes provisions for an operational test area for the deployment of IVHS technologies, in accordance with the Federal Highway Administration Guidelines and the provisions of the Intermodal Surface Transportation Efficiency Act of 1991.
- Through the Plan, the Charlotte Region will provide a building block for IVHS Freeway Management Systems for both urban and rural areas of North Carolina, as well as other states.
- Through local, state, and federal government; university; and private sector cooperation and coordination, IVHS technologies will be continuously compiled, analyzed, and shared.
- The Plan supports and actively solicits private sector participation and commercial involvement in experimenting with new technologies.
- The Plan encourages and provides opportunities for academic research and participation.
- The Plan provides -a framework for development of IVHS as an integral part of Congestion Management System and Incident Management System Plans in metropolitan regions and rural areas of the state.

4. RELATED PLANS AND PROGRAMS

The following plans and programs are related to this Plan in one of two ways : They either provide guidelines for the preparation of this IVHS Area-Wide Plan, or they will be affected by the implementation of this Plan.

4.1 FEDERAL HIGHWAY ADMINISTRATION GUIDELINES

The Charlotte Region is one of the first ten Metropolitan Planning Organizations (MPO's) throughout the country to develop an IVHS Area-Wide Plan since the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Denver is the only urban area which completed a plan under pre- ISTEA guidance. The Denver report has been reviewed by the NCDOT in the preparation of this study and report. In addition, the NCDOT reviewed project documentation for the Portland, Oregon study that is currently underway.

Specific guidelines governing the scope of this study are contained in the Cooperative Agreement between the FHWA and the NCDOT. A copy of this document is included in Appendix A.

4.2 IVHS STRATEGIC PLAN

The Strategic Plan for Intelligent Vehicle-Highwav Systems in the United States, May 20, 1992, sets out various elements for state transportation agencies and MPO's to guide their preparation of Area-Wide Plans. In many respects, the Charlotte IVHS Area-Wide Plan functions as a metropolitan area Strategic Plan, since this plan includes the following elements: goals and objectives, potential benefits, organizational structure for implementation, IVHS technologies, integration of systems and components, institutional issues, and a phased Action Plan. These are the elements of the IVHS-America/FHWA Strategic Plan. The Charlotte Area-Wide Plan incorporates the guidelines provided by the National Strategic Plan. Rather than parody that document, however, the NCDOT and the Charlotte MPO have structured a free-standing document that reflects the specific plans and programs that have been determined to fit a growing, mid-sized urban area in the Carolinas. The Charlotte IVHS Area-Wide Plan also incorporates guidance from the Federal IVHS Program Recommendations, October 15, 1992. As IVHS-America and the FHWA formulate various Tactical Plans, the plans will also be incorporated into the 3-C ("Comprehensive, Coordinated, and Continuing") planning process for Charlotte and other North Carolina urban areas.

4.3 CONGESTION MITIGATION FOR AIR QUALITY

Section 1008 of the ISTEA requires a Congestion Mitigation and Air Quality Improvement Program that provides federal aid for transportation projects in Clean Air Act non-attainment areas for ozone and carbon monoxide as designated by the Clean Air Act. In previous years, Mecklenburg County has been a non-attainment area for both pollutants. It is currently listed as a non-attainment area for ozone.

Mecklenburg County has had an inspection/maintenance (I/M) program for motor vehicles over the past decade. This program, which assures that automotive exhaust emissions are within acceptable limits, has been successful in improving the air quality in Mecklenburg County. For the past two years, there have been no readings that would classify the area as non-attainment for ozone. The state will make a decision in mid-1993 on whether to apply for Mecklenburg County to be removed from the ozone non-attainment list.

Charlotte is labelled as "unclassified" for Carbon Monoxide (CO) and has not had a violation for several years. The implementation of traffic control strategies, such as IVHS, is seen as an important action to control CO in the Charlotte area. IVHS is anticipated to play an important role in reducing environmental impacts from vehicle emissions and maintaining air quality through enhancing the free flow of traffic.

4.4 STATEWIDE PLANNING

Section 1025 of the 1991 ISTEA requires the states to implement a statewide planning process, a statewide transportation plan, and a statewide transportation program. As a state requirement, North Carolina for many years has required and adopted an annually updated Transportation Improvement Program (TIP). The current TIP is for the 1993-1999, seven-year development program.

Projects that are a part of the current TIP are reflected in the pages of this Charlotte IVHS Area-Wide Plan. The completion dates of programmed projects over the next seven years in Charlotte, Mecklenburg and surrounding counties have been considered in the overall analysis of roadway and transit improvements. While in coordination with TIP projects, IVHS implementation projects are the primary strategy for further alleviating congestion and improving safety and air quality in the region. IVHS will enhance current highway and transit improvement projects in the Charlotte Region.

4.5 METROPOLITAN PLANNING

ISTEA Sections 1024 and 1025(f)(1) (as a part of the Statewide Planning Process), require each state to develop its TIP in cooperation with their designated Metropolitan Planning Organizations. The NCDOT, through its Statewide Planning Branch, and in collaboration with the Traffic Engineering Branch and the Public Transportation and Rail Division, conducts a 3-C planning process with 17 MPO's. A transportation planning engineer and an area traffic engineer work regularly with the three MPO's in the Charlotte Region, and with all other MPO's throughout the state.

The process of continuing, comprehensive and coordinated transportation planning has taken on several new dimensions at the state and MPO level. In several national meetings during calendar year 1992, such descriptors as "consistent" (from year to year), "consultative" (with the public), "cross-cutting" (with various transportation modes), "constrained" (by available funding), and in "conformance with the Clean Air Act," have been commonly used in reference to the planning process.

Although not an edict of a specific section of ISTEA, such descriptors are expected to be part of FHWA's Guidelines to be issued and subject to public comment in the development of statewide Congestion Management System Plans. The NCDOT and Charlotte MPO have considered such factors in the development of this IVHS Area-Wide Plan.

4.6 TRANSPORTATION MANAGEMENT AREAS

Section 1024(i) (1, 2, 4, 5) requires the Secretary of the USDOT to designate every urban area over 200,000 population as Transportation Management Areas (TMA's), upon request of the Governor and the appropriate MPO. The Charlotte MPO has been so designated. A further provision for TMA's is that transportation plans and programs be carried out in the 3-C process in cooperation with the State and transit operators. As the planning staff for Charlotte Transit, the Charlotte DOT has been an integral part of preparing this IVHS Area-Wide Plan.

4.7 CONGESTION MANAGEMENT SYSTEM PLAN

Section 1024(i) (3) and Section 1034 of ISTEA require each state to develop, establish and implement a Congestion Management System to effectively manage new and existing Federal Aid facilities that are eligible for funding under the Federal Highway Act or the Federal Transit Act. Specific strategies identified by ISTEA as meeting this requirement are travel demand reduction and operational management strategies. IVHS technologies and programs will meet the criteria for both strategies, particularly operational management.

NCDOT is presently in the developmental stages of the following systems : Congestion Management, Safety Management, Pavement Management, Bridge Management, Public Transportation Facility Management, and Intermodal Management, as required by ISTEA. The Safety, Pavement, and Bridge Management Systems are nearly complete. At this time, it is expected that the planning process outlined in this report will be incorporated into the Statewide Congestion Management System Plan. This plan will be completed under the policy guidance of the NCDOH Congestion Management Steering Committee.

Under this committee's guidance, the Statewide Planning Branch is working with the states MPO's in developing a Congestion Management System Plan for each of the 17 urbanized areas in North Carolina. ISTEA policy guidelines will also be considered in developing these plans. Once developed, this overall system will adequately monitor and report congestion in each of these areas. It will also serve as a tool for developing Congestion Mitigation Measures (such as IVHS) to solve both short range and long range congestion problems.

4.8 INCIDENT MANAGEMENT PLAN

The State Highway Administrator has appointed an Incident Management Task Force to oversee the implementation of Incident Management Plans for needed areas of the state. The first Incident Management Plan, like the first IVHS Area-Wide Plan, is being developed in the Charlotte Urban Area. Several components of this plan are in place:

- an Inter-agency Agreement for the removal of vehicles from the roadway, signed by the Division of Highways and the State Highway Patrol

- Motorist Assistance Patrols, which have been in operation under Division 10 of the NCDOT on Charlotte's freeways since early 1992

- Alternate Routing Plans for freeway construction zones, which have included the upgrading of some alternate routes with intersection widening improvements, closed loop signal systems on selected alternate routes, and other improvements

- Interagency Incident Management Team monthly meetings and training sessions, where all emergency responders in the Charlotte urban area are working together to coordinate incident response

- The opening of a Traffic Operations Center in October 1992, located on Independence Blvd., in order to more effectively coordinate and to serve as the focal point for the Incident Management Team

Other components of the Incident Management Plan will be added periodically.

4.9 STATEWIDE STRATEGIC PLAN

As a member and active participant in IVHS-America, and a member of the multi-state Pooled Fund study called Project ENTERPRISE, the NCDOT is in the process of developing a Strategic Plan for IVHS Deployment on a statewide basis. This Charlotte IVHS Area-Wide Plan will serve as a model for the development of IVHS deployment plans in other areas. It is expected that the set of plans that are developed for each MPO, and for all other "rural" areas of the state, will collectively become a part of the Statewide IVHS Implementation Plan. In 1993, The Department plans to complete a Statewide IVHS Strategic Plan.

5. TRAVEL DEMAND MANAGEMENT

Improved transit service plays an important role in Travel Demand Management for the City of Charlotte. Charlotte is committed to a high level of service for its public transportation system. Charlotte's transit, vanpools, Carpools, and other modes of transportation offer economic and environmental benefits to users and non-users. Multi-occupancy travel helps to reduce congestion, increase mobility, save fuel, reduce pollution, and reduce travel costs to system users. This Plan discusses travel demand management for the City of Charlotte only. Other cities in the Region will be added to this Plan in future updates.

5.1 TRANSIT

Charlotte Transit System (CTS) has more than 300 employees responsible for 136 peak period buses operating daily along 40 routes. Approximately 11 million passengers use the CTS yearly. Table 2 gives detailed CTS operating data for the past fiscal year. Over the next five years, 50 buses and related equipment will be purchased to meet projected service demands.

The CTS provides express buses, such as the Albemarle and the Pineville Express Routes that will be enhanced by CARAT/IVHS deployment and the introduction of APTS technologies. The City of Charlotte operates a traffic signal preemption system for express buses that includes 17 intersections along 10th Street and Central Avenue. Currently, the preemption system improves travel time for passengers on 12 express buses (two express routes) during peak hours. Additional signal preemption capability is available for Albemarle Road from the intersection with Independence Boulevard to the intersection with East Harris Boulevard, and will be used to “feed” the future HOV lane on US 74.

5.2 RIDESHARING

The City of Charlotte's Rideshare Program supports vanpooling and carpooling efforts throughout Mccklenburg County. The City provides free computer matching services for individuals interested in sharing a common mode of transportation. The City currently provides 16 late model vans to groups of approximately 15 passengers per van that commute in the same vicinity. The Charlotte Department of Transportation calculates that involvement in their Vanpooling Program can save the average commuter approximately 50% in monthly driving expenses for a 10 mile round trip commute, with proportionately increased savings for commuters traveling greater distances.

The City of Charlotte has arranged for the use of parking lots where commuters may park free and board express buses or carpools and meet vanpools. The City has currently secured 35 privately owned Park-and-Ride facilities located throughout the Charlotte area. Two publicly-owned Park-and-Ride lots are located near East Harris Boulevard & Lawyer Road and on Providence Road near the intersection with Sardis Road. Express passengers that need to return to their cars or home on weekdays between 9:00 a.m. and 4:00 p.m. may benefit by using Charlotte's Guaranteed Ride Home Program. This program provides midday emergency transportation through a taxi company, for express passengers, to their Park-and-Ride lots.

TABLE 2

**CHARLOTTE PUBLIC TRANSIT OPERATING STATISTICS
FOR THE FISCAL YEAR 1992**

PASSENGERS, MILES, AND HOURS	EXPENSES AND REVENUES	PERFORMANCE INDICATORS
# OF PASSENGERS 11,146,373	TOTAL EXPENSES $14,480,882	PASSENGERS/ROUTE MILE 2.55
PERCENT CHANGE IN # OF PASSENGERS (1991-1992) -0.32%	TOTAL REVENUE $5,406,835	PASSENGERS/ROUTE HOUR 33 .56
PERCENT TRANSFER RIDERS 20.22%	FAREBOX REVENUE $5,406,835	FAREBOX REVENUE/ PASSENGER $0.49
REGULAR ROUTE MILES 4,366,296	NET COST $9,074,047	RECOVERY RATIO 37%
PERCENT CHANGE IN # OF ROUTE MILES (1991-1992) +1.85%	PERCENT CHANGE IN NET COST FROM (1991-1992) -3.19%	NET COST/ PASSENGER $0.81
REGULAR ROUTE HOURS 332,094		FAREBOX REVENUE/ TOTAL EXPENSE 37%
PERCENT CHANGE IN # OF ROUTE HOURS +3.01%		

Information for Table 2 was provided by the Public Transportation & Rail Division of the North Carolina Department of Transportation, and the Charlotte Department of Transportation.

5.3 FUTURE HOV LANES

Passengers of transit, Carpools, and vanpools will benefit greatly by the availability of a barrier-separated, reversible High Occupancy Vehicle (HOV) Facility along US 74 (Independence Boulevard) between Brookshire Freeway and Albcmarle Road. The HOV Facility is being constructed in the median of the widened Independence Boulevard. When completed in March of 1998 the HOV Facility will enhance traffic flow by only permitting buses and other occupancy vehicles that carry three or more passengers to use the HOV lane.

5.4 OTHER TRAVEL DEMAND MANAGEMENT ACTIVITIES

Long-term Travel Demand Management (TDM) may include Bicycle Programs, Busway Facilities, and/or a Light Rail Transit System.

Although the Charlotte Urban Area does not currently have a bicycle program, the City has requested development of a Bicycle Suitability Map by the NCDOT's Bicycle Program. NCDOT's Bicycle Program encourages transportation improvements that enhance safety to riders and the motoring public. In addition, the Bicycle Program encourages innovations, such as accommodating bicycles on bus mounted racks, in support of cooperative efforts between the use of bicycles and public transportation.

A future Busway/HOV system could combine the use of express bus routes, Busway/HOV lanes, busway preemptions, and/or special freeway ramps. Such a system may include routes connecting Uptown Charlotte with the Airport, UNC-Charlotte, Matthews, and Pineville. This system would require the addition of 136 buses to the current fleet at a cost of $23.12 million. According to the Transit Corridors Study, prepared as part of Charlotte's "2005 Transportation Plan," transit travel in the region could increase by 59% between 1985 and 2005 if the busway/HOV system was implemented.

Light Rail Transit (LRT) consists of trains comprising one to six vehicles that are electrically propelled from an overhead wire. A future LRT System may include routes connecting Uptown Charlotte with the Airport/Gastonia, UNC-Charlotte/Concord/Kannapolis, North Mecklenburg/Mooresville, Matthews/Monroe, and Pineville/Rock Hill.

In September 1992, the City of Charlotte and a consultant team headed by Parsons Brinckerhoff Quade and Douglas, Inc., began work on a Transitional System Planning study to prioritize radial corridors from Uptown Charlotte for LRT implementation. The study also will include preparation of financial and corridor development plans for the corridor where LRT improvements would be begun first.

In the Transitional System Planning Study, the consultant team has analyzed LRT implementation in seven corridors. Capital costs for system construction range from $197 million for a 10-mile UNC-Charlotte line to $327 million for the 15-mile Park Road corridor. Parsons Brinckerhoff regards the Providence Road, Park Road, and Albemarle corridors as the lowest priority for LRT implementation.

5.5 TRAVEL DEMAND MANAGEMENT SUMMARY

It will be imperative for planned IVHS improvements to be coordinated with specific Action Plans for Busway and/or LRT systems. Improvements in safety, environmental protection, congestion reduction, mobility, and economic productivity are achieved through the use of public transportation. Future public transportation will be aided by the innovations of Intelligent Vehicle Highway System (IVHS) technologies. Busway corridors are analyzed as part of the I-77 corridor's Traffic Management in Section 6, Map 7. For specific IVHS initiatives relating to Advanced Public Transportation Systems, please refer to Section 8, Table 4.

6. METHODS & PROCEDURES FOR IVHS AREA-WIDE PLANNING

Components of system planning and preliminary engineering are necessary elements in the development of an IVHS area-wide plan. These principles help identify current and future congestion, as well as help to determine the feasibility of IVHS deployment. These components include land use patterns, highway functional classification, corridor analysis, safety analysis, air quality analysis, and future capacity analysis. Geographic Information Systems (GIS) can be used to help identify and analyze these elements.

6.1 APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEMS

The Geographical Information Systems (G>I S.) Unit of the NCDOT has compiled data from the City of Charlotte and Mecklenburg County to form the digital transportation data base for the I-77/277 Corridor through Charlotte. G. I. S. has created several maps to aid in the initial analysis of the Charlotte Transportation System's I-77/277 freeways and connecting arterials. While G. I. S. data banks are completed for the City of Charlotte and Mecklenburg County, the remaining eleven counties included in the Charlotte Region are not projected to have completed G. I. S . data banks until the year 2000.

6.2 LAND USE PATTERNS

The generation of traffic on a particular street is very closely related to the use of adjacent land areas. Some types of land use generate much more traffic than others. For example, a commercial or retail area such as a shopping center will generate (or attract) much larger volumes of traffic than a residential area. The attraction between different land uses varies with the intensity of development and the distance between those developed areas. Therefore, it becomes necessary to designate land uses by type for transportation planning. An analysis of the distribution of existing land use serves as a basis for forecasting future land use needs and the resulting travel patterns. Knowledge of future travel patterns helps make sound decisions on the implementation of IVHS technologies.

In November of 1985, the Charlotte City Council and Mecklenburg Board of Commissioners adopted the **General Land Plan 2005" for Charlotte and Mecklenburg . This Plan serves as the general land use policy for the Charlotte-Mecklenburg area. In developing this plan, forecasts were made relating to population, number and types of households, number and mix of jobs, and location of new dwellings and employment centers. Making decisions on these variables, and projecting future trends, allows land-use and transportation planners to make decisions on how land might develop. Land development corresponds to the amount and type of traffic that will be generated in particular areas.

In the *'Generalized Land Use Plan", Mecklenburg County was divided into seven areas for analysis. These areas include the north, northeast, northwest, central, south, southwest, and east. Each area was analyzed based on past and future trends in population, employment, households, and housing. Strategies for redirecting growth were developed for each of these areas to encourage a distribution of growth among various parts of the county. Identifying these patterns is necessary as a means of determining where growth is likely to occur and enabling the deployment of IVHS technologies in areas that will be most responsive. Land use patterns for CARAT Phase I are shown in Map 3.

MAP 3
CARAT PHASE I
LAND USE PATTERNS
Charlotte, N.C.

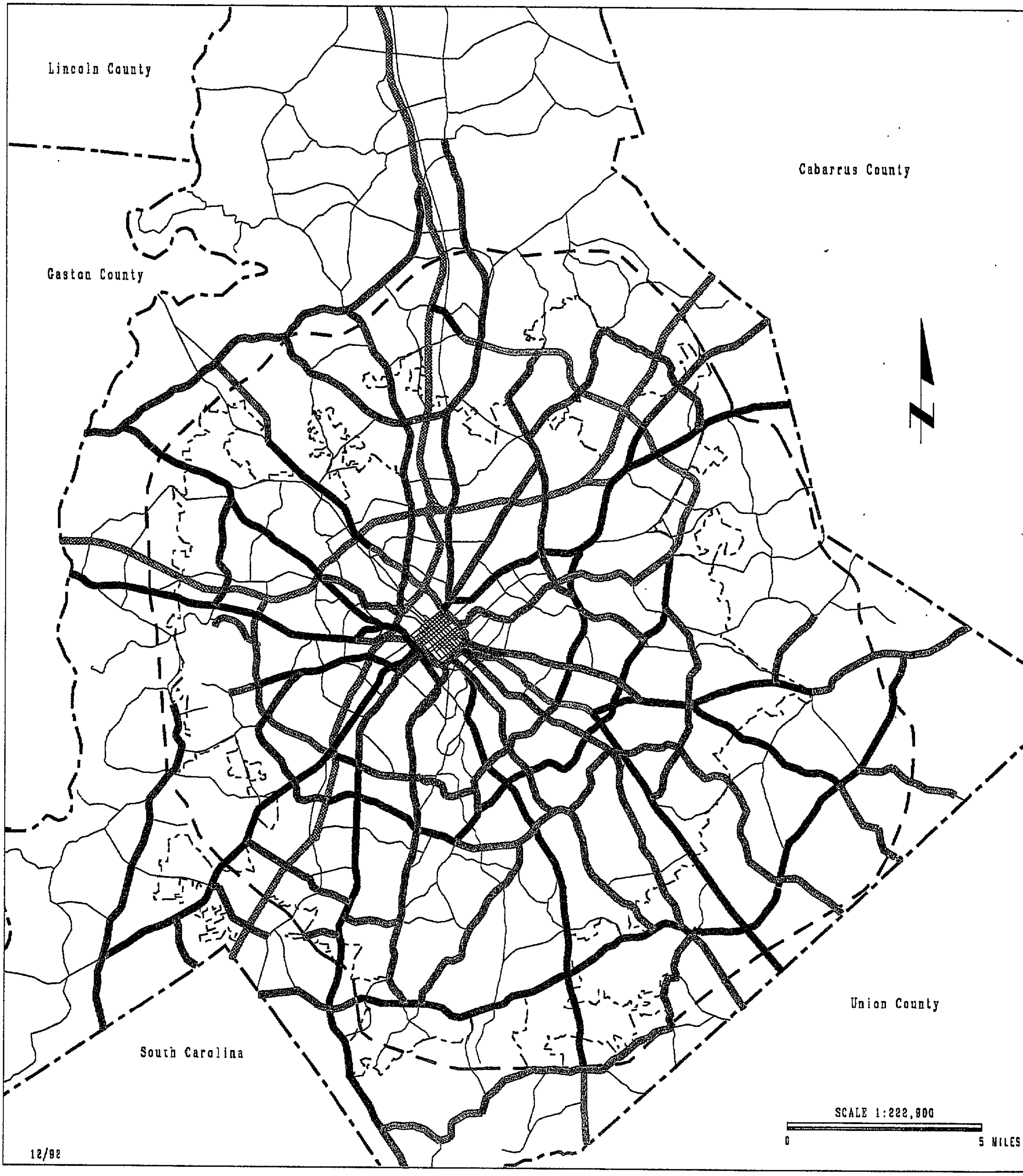
- Interstate 77
- Northbound Alternate
- Southbound Alternate
- Water
- Existing Residential
- Developing Residential
- Rural Residential
- Existing Employment
- Annexation Sphere of Influence
- Developing Employment
- Community Commercial Center
- Major Mixed Use Center
- Major Institutional
- Major Parks & Open Space
- Farm Preservation Area
- Treatment Plant
- Municipality-Not Charlotte

6.3 FUNCTIONAL CLASSIFICATION

Classification of the roadway system defines the function that the roadway is designated to serve. With a knowledge of the existing classification, alternate routes can be chosen that function in a manner conducive to the increased demands that might be placed on these facilities as a result of IVHS technologies. Functional classification is the process by which streets and highways are grouped into classes or systems, according to the character of service they are intended to provide. In developing a system of functionally classified roadways, decisions are made on how to direct travel within the network in a logical and efficient manner.

The highway network performs two primary functions, travel mobility and land access. An objective of IVHS implementation is to improve the travel mobility along routes that function primarily for traffic service. Facilities classified as "1ocal" emphasize the provision of land access. The classification of "arterial routes" is reserved for those routes with an emphasis on providing a high level of mobility. "Collector routes" offer a combination of both functions.

Charlotte-Mecklenburg is an urbanized area as designated by the Bureau of the Census. Facilities within this area are designated as interstates, freeways, urban principal arterials, minor arterials, collector streets, and local streets. The urban principal arterial system is significant to the area in terms of the nature and composition of travel it serves. The urban minor arterial system is used to interconnect with and augment the urban principal arterial system and to provide service to trips of moderate length at a somewhat lower level of travel mobility than principal arterials. Urban collector streets provide both land access and traffic circulation within commercial and industrial areas, and residential neighborhoods. The functional classification system for the Charlotte-Mecklenburg roadway system, excluding collectors and local streets, is shown on Map 4. Streets shown but not classified are collectors and, in a few cases, local streets.



MAP 4
CHARLOTTE/MECKLENBURG FUNCTIONAL CLASSIFICATION

Interstate Classification
Freeway Classification
Principal Arterial
Minor Arterial
County Boundary
City Boundary
Proposed Outer Loop

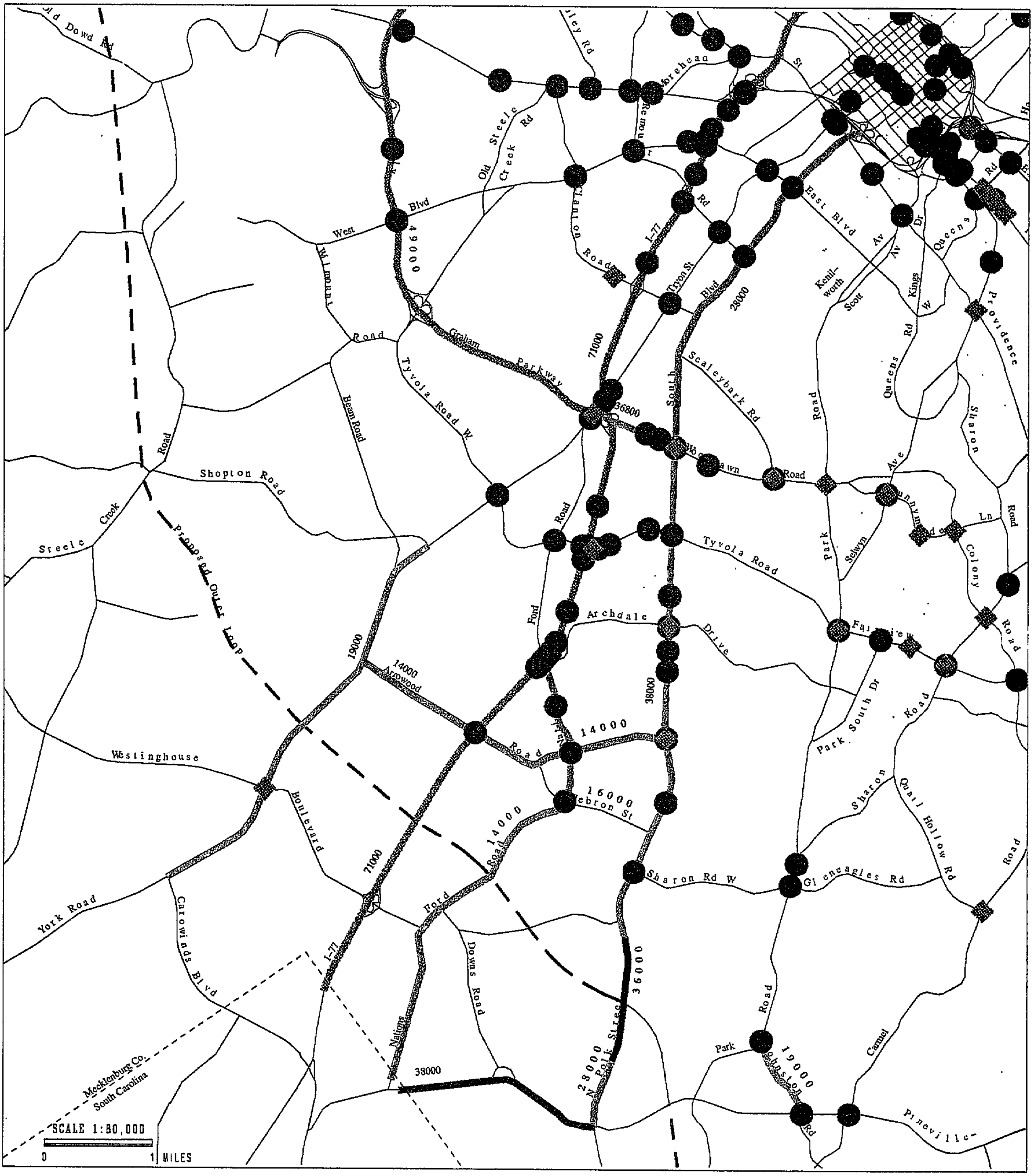
6.4 CORRIDOR ANALYSIS

Ideally, a corridor analysis with assessments of congestion (level of service) and safety (accident rates, etc.) would be done for all potentially impacted travel corridors. As an illustration of the use of the GIS capability, level of service and accident locations have been depicted for the I-77/277 corridor through Charlotte, which is the proposed CARAT Phase I project.

6.41 LEVEL OF SERVICE

A good indication of the adequacy of a street system is a comparison of the traffic volumes with the ability of the streets to move traffic at a desirable speed. The ability of a facility to move traffic is referred to as "capacity". Capacity is defined as the maximum number of vehicles that have a reasonable expectation of passing over a given section of a roadway in one direction, or in both directions, during a given time period under prevailing roadway and traffic conditions ("Highway Capacity Manual", TRB Special Report 209, 1985, p. l-3). The relationship of traffic volumes to the capacity of the roadway (v/c ratio) is a measure of determining the level of service being provided.

Travel demand is generally reported in the form of annual average daily traffic (ADT) counts. Traffic counts are taken regularly at several locations around the Charlotte area. These counts were obatined for the roadways included in Phase I of the CARAT Project. Using the 1991 traffic volumes and the existing capacity of the roads in Phase I, the level of service for each facility was calculated. The 1991 traffic volumes and the corresponding v/c ratios and levels of service for CARAT Phase I are shown on Map 5.



MAP 5
CARAT PHASE I
CORRIDOR ANALYSIS
Charlotte, N.C.

Volume/Capacity Ratio, 1991
> 0.00 <= 1.00
> 1.00 <= 1.25
> 1.25 <= 1.50
> 1.50 <= 1.75
> 1.75 <= 2.00
> 2.00

High Accident Locations, 1992

High Congestion Locations, 1992

Average Annual Weekday Traffic Volumes 14000

6.42 SAFETY ANALYSIS

Severity index, exposure, and accident rates are the essential features of a safety analysis. The 1990 NCDOT "Traffic Accident Analysis Manual" defines severity index with a formula that is used to measure the mix of accident severity in a group of accidents, at a specific location. That formula is as follows :

$$SI = \frac{64.0\ (K + IA) + 19.1\ (IB + IC) + I'}{T}$$

The formula weighs the different classes of accident severity as follows :

1. Fatal accidents (K) and Class A (IA) injury accidents are given 64 .O times the weight given to property-damage-only accidents. (This system of weighing is based on accident cost estimates used by the Accident Studies Unit for each injury class).

2. Class B and Class C (IB and IC) accidents are added together and given a weight of 19.1.

3. Property-damage-only (P) accidents are given a weight of 1.

The Severity Index (SI), as computed for an intersection, is a number which is unique to that particular intersection; (T is the total number of Accidents at the intersection). The EPDO Index, "Equivalent Property-Damage-Only Index, " is the numerator of the Severity Index formula. The EPDO Index compares intersections to one another. The EPDO Rate, as defined by the 1990 NCDOT "Traffic Accident Analysis Manual," is the EPDO Index divided by a measure of exposure, as calculated in the following formula:

$$\text{EPDO Rate} = \frac{\text{EPDO Index}}{\text{Entering Volume x Time}}$$

Exposure is the number of times vehicles are exposed, or open to the paths of other vehicles. Since the EPDO Rate reflects severity and the normal accident rate does not, the EPDO Rate is considered to be a more valuable tool. According to the 1990 NCDOT "Traffic Accident Analysis Manual, " accident rates are calculated in terms of accidents per million vehicle-miles, as follows :

$$Rmvm = \frac{A\ (1,000,000}{ADT \text{ x } \underset{(Days)}{Time} \text{ x } L}$$

Map 5 also illustrates Charlotte's high traffic accident locations in the I-771277 corridor. The Transportation Planning Division of the Charlotte Department of Transportation "1992 Traffic Operations Plan" defines high accident locations as locations with an EPDO Rate greater than 7 .OO accidents per million entering vehicles and an EPDO Index greater than 360 in the three year period, or intersections where an unusually high number of pedestrian accidents have occurred. Map 5 is for illustration only and does not depict the complete safety analysis for this corridor. The 1992 analysis is based on accident data for 1989 - 1991.

6.5 NETWORK ANALYSIS

An accurate measure of the effectiveness of IVHS technologies is obtained by measuring the improvements to the entire network rather than an analysis of exclusive facilities. IVHS technologies can be designed to assist drivers on the most congested routes, which in turn improves operations on alternate routes. The success of IVHS relies on the ability to improve routes with existing congestion without having an adverse impact on other less congested routes. Although a detailed network analysis was not conducted for this Area-Wide Plan, it should be incorporated in future updates.

6.6 SITE IMPACT TRAFFIC EVALUATION

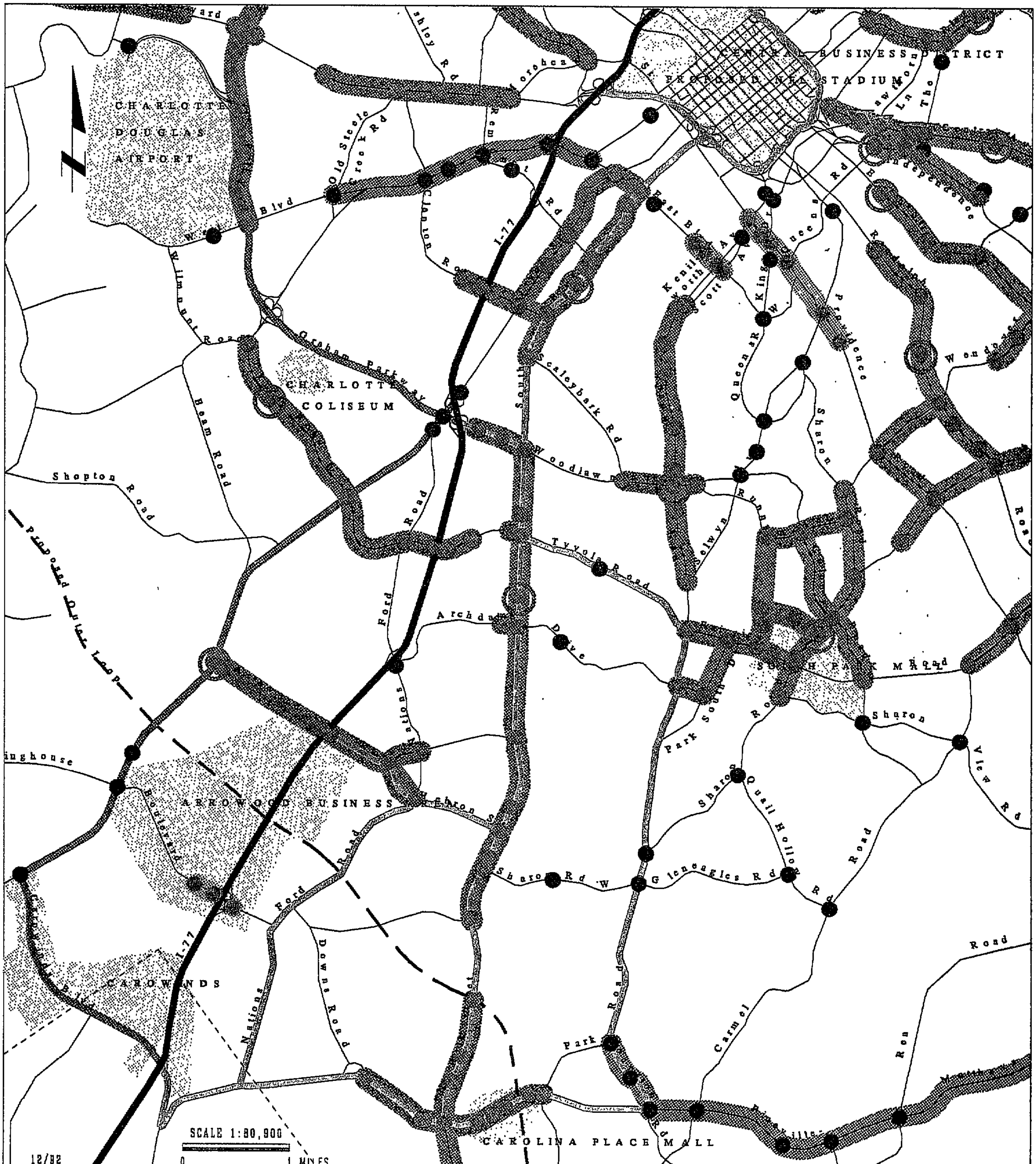
The development of areas that will generate or attract high volumes of traffic such as industrial parks, business parks, regional malls, regional entertainment facilities, or high density residential development can have a major impact on the existing roadway network. Several techniques exist for managing the high volumes of traffic generated by these types of developments.

Signal systems are designed to move traffic through a series of signalized intersections without stopping. Minimizing the number of stops has many benefits including reduced delay, conservation of energy, preservation of the environment, travel time savings, reduced headway, and a better use of storage space resulting from fewer stops. The City of Charlotte operates several signal systems that operate primarily under on-line controllers, and some time-based controllers. On-line controllers have the ability to perform calculations as a "background" task offering the advantage of tailoring the control plan to the specific traffic data; therefore, providing a better response to traffic demand. The NCDOT refers to such on-line systems as "closed loop" signal systems, and is currently implementing these types of signal system improvements throughout the state.

Under time-based control, each local intersection is programmed to implement a different timing plan at different times during the day. For locations that experience random, sudden increases in demand, it is best to choose a system utilizing on-line controllers. The closed loop and time-based signal systems pertaining to CARAT Phase I are shown on Map 6. Other techniques for managing traffic, at locations with high level traffic generators, include HOV lanes, reversible lanes, and grade separated intersections. Map 7 shows the location of these features, as well as some of the major traffic generators.

The location of major traffic generators can be helpful in determining where high levels of demand can be expected. Major generators located in the CARAT Phase I corridor include Carowinds theme park, Charlotte Coliseum, Carolina Place Mall, and Heritage USA theme park. Several new and growing areas within the Charlotte-Mecklenburg region have also been identified. These areas include industrial development along I-77 in North Mecklenburg, the Arrowood development, the Westinghouse Blvd. development, and IBM located north on I-85. Other areas attractive to development include the outskirts of the Outer Loop, and the US 74 corridor.

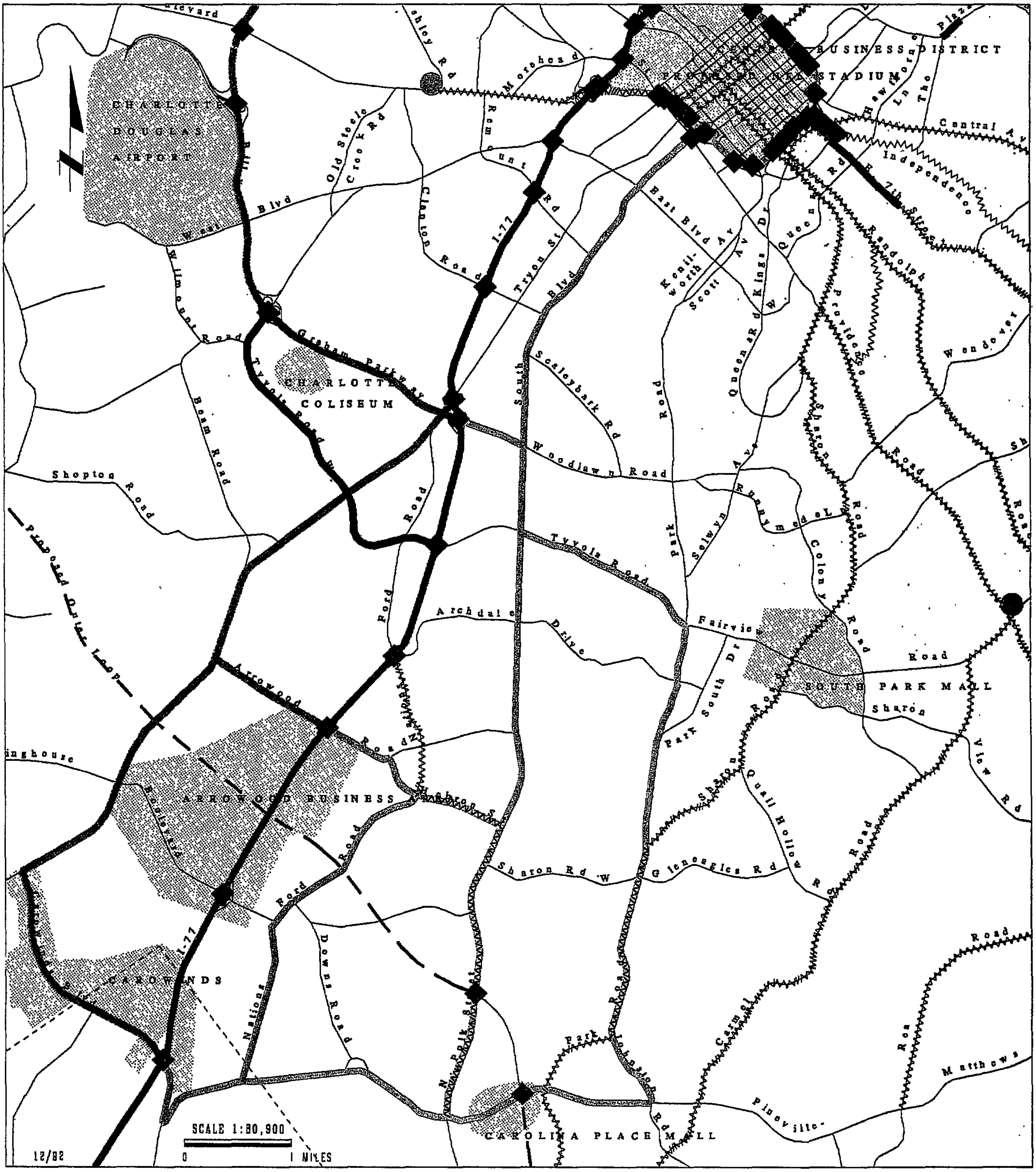
Other features included in Map 7 include current and proposed Express Bus System routes and major Park and Ride lots in the CARAT Phase I corridor.



MAP 6
CARAT PHASE I
SIGNAL LOCATIONS
Charlotte, N.C.

- Interstate 77
- Northbound Alternate
- Southbound Alternate
- Bus Preempted Signals
- On-Line Intersection Controller
- On-Line Master Controller
- Timebased Intersection Controller
- Isolated Intersection Controller
- Major Traffic Generators

- On-Line (Closed Loop) System
- Timebased (Closed Loop) System
- Proposed On-Line (Closed Loop) System



MAP 7
CARAT PHASE I
TRAFFIC MANAGEMENT FEATURES
Charlotte, N.C.

- Interstate 77
- Northbound Alternate
- Southbound Alternate
- Express Bus System
- Park and Ride Lots
- High Occupance Vehicle Lanes
- Grade Separated Intersections
- Major Traffic Generators
- Reversible Lanes

7. IVHS PROJECT PHASING

This section identifies specific freeway and arterial segments in the Charlotte Region that should be considered part of the IVHS network of roadways. All freeway sections, both current and planned and a significant proportion of the arterial system is included. The segments, and recommended phasing, was developed through a series of staff meetings with the Charlotte, Gastonia and XANLACON MPO's, plus staff from the NCDOT Statewide Planning Branch, Traffic Engineering Branch, Operations Office (for Incident Management coordination), and Division 10.

7.1 EXISTING TRANSPORTATION SYSTEM

There are currently four separate documents that guide development of roadway and transit improvements in Charlotte: the "Thoroughfare Plan," the "State Transportation Improvement Program," the "Charlotte Capital Improvement Program," and the "2005 Transportation Plan."

(1) The document that is required for all incorporated cities, towns, and villages in North Carolina is the mutually adopted "Thoroughfare Plan". The current Thoroughfare Plan for Charlotte was adopted in November of 1990. Such plans are in effect for eight counties out of the ten in the North Carolina study area, and for approximately forty municipalities that include Gastonia, the Kannapolis-Concord (KANLACON) area, Monroe and Statesville.

(2) The "State Transportation Improvement Program" (TIP) is an annually-updated, seven-year plan, that is reviewed at a series of public meetings each year. The current TIP includes projects for fiscal 1993 through 1999. This plan applies to the upgrading and expansion of the 77,000~mile State Highway System. It includes, in addition to highway improvements, the Governor's Highway Safety Program, the Aeronautics Program, the Bicycle and Pedestrian Program, and the Public Transportation and Rail Programs. The State TIP applies to all cities, towns, and rural areas within the state.

(3) The "Charlotte Capital Improvement Program" (CIP) is an annually-updated, five-year plan. This program includes improvements and expansion 'of both State System highways within the City of Charlotte and municipal maintained streets. The municipal maintained streets form an additional 16,000~mile system, the largest city-maintained street system in North Carolina The CIP includes capital improvements that are funded strictly with local or Powell Bill funds, over and above TIP-funded projects.

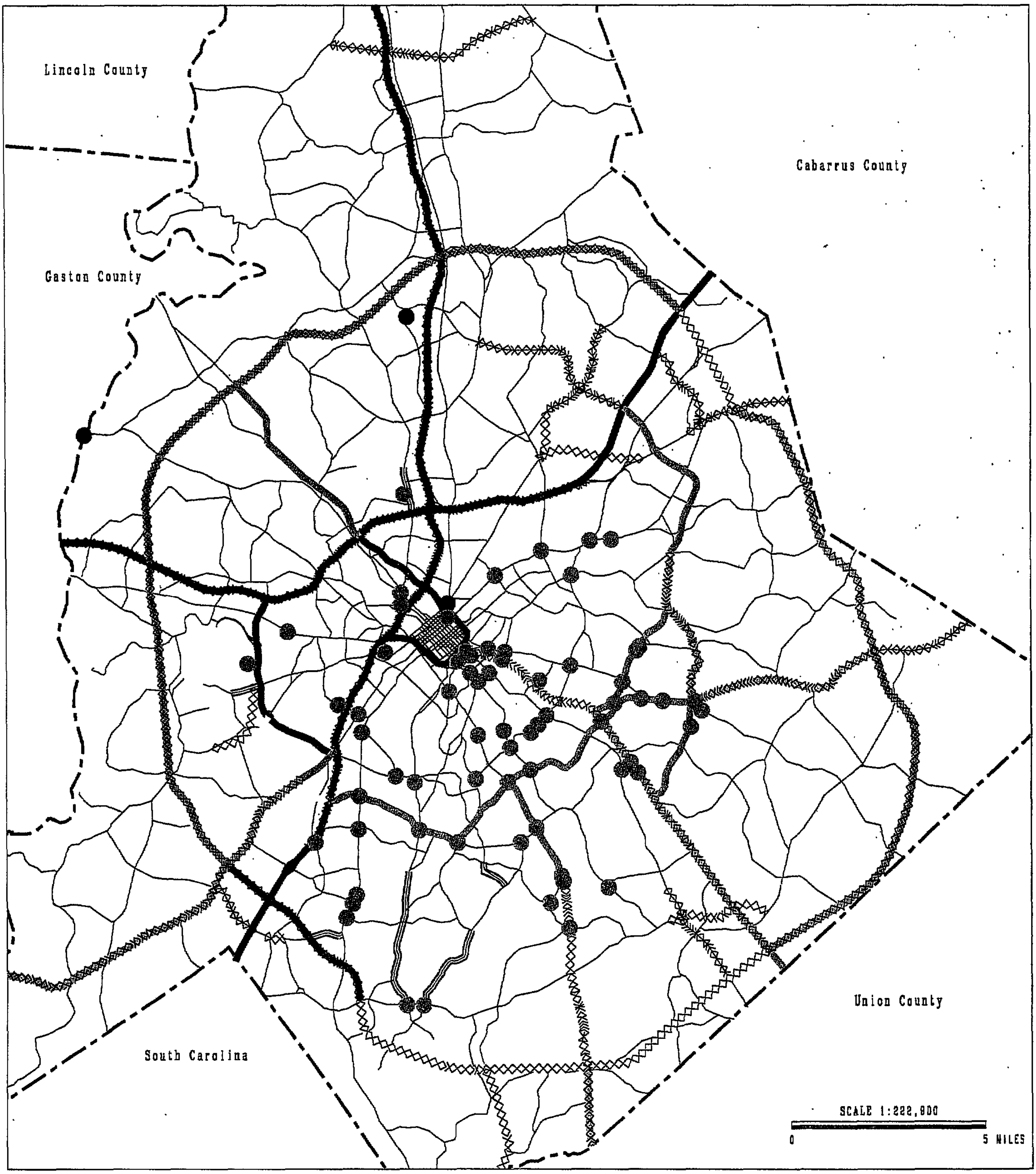
(4) The City of Charlotte's "2005 Transportation Plan", is based on the adopted Thoroughfare Plan, and incorporates both funded projects from the TIP and CIP, and also identifies other needs that are unfunded. The City of Charlotte is currently updating its 2005 Plan and will be presenting its "2015 Transportation Plan" to the public in October of 1993.

Since each of these planning efforts undergoes continual update and review through the 3-C planning process, specific projects that may be considered to be "critical" or priority projects are not listed in this study. However, all programmed and unprogrammed projects have been considered in the development of the "CARAT system" for state and municipal facilities. Mecklenburg County's currently programmed projects from the TIP and CIP are shown in Map 8.

7.2 FUTURE CARAT SYSTEM

Currently, the future CARAT System consists of proposed IVHS projects for the Charlotte Region. Mecklenburg County's proposed IVHS projects are specifically illustrated in Map 8. Projects are identified as Phase I for 1992 through 1997 implementation , Phase II for 1197-2002, Phase III for 2002-2012, and Phase IV for beyond 2012. The complete list of proposed IVHS projects, for the entire Charlotte Region, is shown in Table 3. The intent is for this set of projects to be incorporated into the 3-C planning process for annual updates as specific Traffic Congestion/Traffic Management projects.

Except for CARAT Phase I projects, none of these projects as specific IVHS implementation projects are currently programmed in the TIP or CIP, but will be considered in future updates. The proposed program will be reviewed by the MPO as well as the State Board of Transportation. In 1993, as part of the 3-C process for Gastonia and KANLACON, the CARAT Early Deployment planning study will be reviewed with their MPO's prior to updating.



Phase I
Phase I Incident Management
Phase II
Phase III
Phase IV
Programmed TIP Projects, 93-97
Roadway Projects
Bridge Projects
Capital Improvement Plan, 1992
Roadway Projects
Intersection Projects

MAP 8
MECKLENBURG COUNTY
PROPOSED IVHS PROJECTS

TABLE 3

CHARLOTTE REGION PROPOSED IVHS PROJECT PHASING

Phase I Projects, 1992 - 1997

	Approximate Lengths	1992 Status
A. I-77 from the intersection with Carowinds Blvd. in S.C. to the intersection with I-85 in N.C.	15.2 miles (24.5 km)	CARAT Phase I Proposal (part); Incident Mgmt.
B. I-77 from the intersection with I-85 to the intersection with Iredell County Line	17.0 miles (27.4 km)	Incident Management
c. I-85 from the intersection with I-77 to the intersection with the new road at King's Grant	10.5 miles (17.0 km)	Incident Management
D. I-277 from the I-77 intersection with the Belk Freeway to the I-77 intersection with the Brookshire Freeway	4.4 miles (7.1 km)	Incident Management
E. I-85 fram the intersection with NC 161 at Kings Mountain to the intersection with I-77	10.6 miles (17.1 km)	Incident Management
F. Charlotte Outer Loop from the intersection with NC 49 to the intersection with NC 51	5.1 miles (8.2 km)	Under Construction (R-211 & R2248)
G. Billy Graham Parkway from the intersection with I-85 to the intersection with I-77	5.3 miles (8.5 km)	*
H. Brookshire Freeway from the intersection with I-77 to the intersection with I-85	2.2 miles (3.5 km)	*

Phase I Continued

		Approximate Lengths	1992 Status
I.	Traffic Control Center (TCC)	———	CARAT Phase I Proposal (part)
J.	Westside Kannapolis - Concord By-Pass, from intersection with I-85 to the intersection with Enochville Ave.	5.8 miles (9.3 km)	New planned for 1996 - '99 construction (U- 2009)
K.	U.S. 74 West from the intersection with I-77 in Mecklenburg County to the intersection with I-85 in Gaston County	24.3 miles (39.2 km)	Closed Loop Signal system under construction

TABLE 3, CONTINUED

CHARLOTTE REGION PROPOSED IVHS PROJECT PHASING

Phase **II** Projects, 1997 - 2002

	Approximate Lengths	**1992** Status
A. Independence Blvd. HOV Lanes from the intersection with I-277 to the intersection with Albemarle Rd.	4.0 miles . (6.4 km)	Part under construction (U-209)
B. I-85 from the Intersection with the new road at King's Grant to the Cabarrus/Rowan County line	13.1 miles (21.1 Km)	Planned Incident Management
C. Charlotte Southern Outer Loop from the intersection with NC 51 at Pineville to the intersection with U.S. 74 East (Independence Blvd.)	12.5 miles (20.2 km)	Part under construction (R - 211)
D. Charlotte Eastern Outer Loop from the intersection with I-85 North to the intersection with NC 49	8.3 miles (13.4 km)	Part under construction (R - 2123)
E. Harris Blvd. from the intersection with I-77 to the intersection with I-85 (to be included in Phase **II** if conduit can be added to current **TIP** project)	6.1 miles (9.8 km)	Widening underway (see note at left) (U - 609)
F, Tyvola Rd. from the intersection with the Billy Graham Parkway to the intersection with I-77	3.3 miles (5.3 km)	Tie - in Reversible Lanes control with T.C.C.
G. Providence Rd. from the intersection with International Drive (at end of current 4-lane section) to the intersection with the Outer Loop	4.8 miles (7.7 km)	Widening in TIP for FY 96 (part of U - 2510)

Phase II Continued

	Approximate Lengths	1992 Status
H. I-77 from the intersection with I-85 to the intersection with Iredell County Line	(same as project I.B)	Proposed addition of surveillance & control in 1997 to Incid. Management
I. I-85 from the intersection with I-77 to the intersection with the new road at King's Grant	(same as project I.C)	Proposed addition of surveillance & control in 1999
J. I-85 from the intersection with NC 161 at Kings Mountain to the intersection with I-77	(same as project I.E)	Proposed addition of surveillance & control in 2001
K. Westside Kannapolis-Concord By-Pass, from intersection with I-85 to intersection with NC 49	6.5 miles (10.5 km)	New facility planned for 1999 - ? construction (R-2246)

TABLE 3, CONTINUED

CHARLOTTE REGION PROPOSED IVHS PROJECT PHASING

Phase III Projects, 2002 - 2012

		Approximate Lengths	1992 Status
A.	U.S. 74 East of Charlotte (section to be improved with closed loop signal systems, plus by-pass projects at Monroe and Rockingham)	33.4 miles (53.9 km)	TIP projects (R-2559 and U-2583)
B.	NC 49 (York Rd.) from the intersection with I-77 to the Bridge at the S.C. state line	11.8 miles (19.0 km)	Widening planned for FY '98 (U-2512)
c.	Harris Blvd./East Harris Blvd. from the intersection with I-85 to the intersection with Independence Blvd.	11.7 miles (18.9 km)	*
D.	Brookshire Boulevard (NC 16) from the intersection with I-85 to the intersection with the Outer Loop	5.2 miles (8.4 km)	HOV lanes to be considered
E.	Albemarle Rd. (NC 24/27) from the intersection with Independence Blvd. to the intersection with the proposed Charlotte Outer Loop	7.8 miles (12.6 km)	*
F.	"Charlotte Route 6" (Tyvola from I-77 to Park Rd.; Fairview from Park Rd. to Sharon Rd.; Sharon Rd. from Fairview to Sharon Lane; Sharon Amity Rd. from Providence Rd. to Harris Blvd.)	miles 12.9 (20.8 km)	*

Phase III Continued

		Approximate Lengths	1992 Status
G.	Providence Rd. (NC 16) from Sharon Amity Rd. to end of 4-lane (near International Dr.)	2.9 miles (4.7 km)	*
H.	Providence Road (NC 16) from Outer Loop to NC 84 in Weddington	. 7.3 miles (11.8 km)	*
I.	Eastern Outer Loop from US 74 East to NC 49 North	7.6 miles (12.3 km)	Programmed (R-2123, part)
J.	US 521 (Relocation) from Outer Loop to S.C. State Line	6.6 miles (10.7 km)	Programmed (R-2242)
K.	I-277 from the I-77 intersection with the Belk Freeway to the I-77 intersection with the Brookshire Freeway	(same as project I.D)	Proposed tie-in of Downtown Control Center to TCC in 2002
L.	I-85 from the intersection with the new road at King's Grant to the Cabarrus/Rowan County line	(same as project II.B)	Proposed addition of surveillance & control in 2007 to Incident Mgt.

TABLE 3, CONTINUED

CHARLOTTE REGION PROPOSED IVHS PROJECT PHASING

Phase **IV** Projects, beyond 2012

		Approximate Lengths	**1992** Status
A.	Charlotte Eastern Outer Loop from intersection with US 74 east to intersection with Albemarle Rd.	. **19.4** miles (31.3 km)	TIP Project R-2123 (part)
B.	Charlotte Western Outer Loop from intersection with York Rd. to intersection with I-85 North	8.3 miles (13.4 km)	TIP Project R-2248 (part)
c.	Albemarle Road (NC 24/27) from the Charlotte Eastern Outer Loop to Albemarle	29.6 miles (47.7 km)	*
D.	NC 16 from the Charlotte Western Outer Loop to the intersection with NC 273 in Gaston County	4.6 miles (7.4 km)	*
E.	Proposed Gastonia By-Pass (relocated US 74) from Mecklenburg County to the intersection with I-85	17.5 miles (28.2 km)	In approved Thoroughfare Plan dated **July 30, 1991**

* These projects have been included in this list of proposed IVHS projects during the creation of this Charlotte IVHS Area-Wide Plan.

8. IVHS TECHNOLOGY DEPLOYMENT

The IVHS Technology Deployment Plan consists of an overview of the five major components of IVHS, and specific technologies in those components, a prioritized set of IVHS Program Initiatives for the state, and supporting activities.

8.1 INTRODUCTION TO IVHS TECHNOLOGIES

IVHS technologies are defined by five broad categories: Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Public Transportation Systems (APTS) , Commercial Vehicle Operations (CVO) , and Advanced Vehicle Control Systems (AVCS) . These five categories are interrelated and often share the application of specific IVHS technologies. For all five categories, as innovative IVHS technologies are developed and modified, those technologies will be appropriately adapted for current freeways and arterials, and incorporated in planning and design of new roadways.

The foundation of IVHS is ATMS. ATMS relies upon detection, communication, and control. A master traffic control center controls information obtained from a real-time traffic surveillance system as well as from ATIS, APTS, CVO, and AVCS efforts. Real-time control adjustments that account for the current transportation system and current traffic loads, then manage the overall system through incident management, congestion management, and travel demand management. Examples of real-time management efforts include, but are not limited to, ramp metering, variable message control, signal timing adjustments, motorist advisories, and overall system analyses.

ATIS technologies provide motorists with real-time information on traffic conditions, routes, and schedules. ATIS has the ability to provide visual and auditory presentations to inform motorists of their current locations, aid them in planning their routes, direct them through alternate routes, help guide them to their destinations, and provide various informational services. Informational services may include, but are not limited to, real-time reports on accident locations, weather updates, road conditions, optimal routes, -recommended speeds, lane restrictions, traffic conditions, and parking locations/vacancies. Information may be provided to and received from the motorists through such features as transceivers (in-vehicle, home, office, kiosks, and hand-held); travel advisory radio; and variable message signs.

APTS uses IVHS technologies to enhance safety and efficiency while increasing patronage and productivity of high occupancy vehicles which include conventional buses, shared-ride vehicles, rail transit, and the range of para-transit vehicles. APTS can automatically handle trip fees, real-time bus scheduling and ride-sharing; may utilize high occupancy vehicle (HOV) lanes and signal preemption; and will enhance passenger security. Additional APTS enhancements include, but are not limited to, improved fleet monitoring, customer information, and dispatching.

CVO technologies have the ability to increase operational safety and efficiency of fleet operations and commercial vehicles. Trucks, delivery vans, inter-city buses, and emergency vehicles are examples of vehicle operations that may be aided by CVO technologies. CVO systems can reduce time spent at weigh stations and enhance fleet productivity. Examples of specific CVO technologies include : Automated Vehicle Identification (AVI) , Automated Vehicle Classification (AVC), Automated Vehicle Location (AVL), and dynamic network routing and scheduling. CVO system efforts promote standardization among states and nations, which reduces the number of stops at weigh stations and ports of entry.

AVCS technologies have the ability to enhance vehicle control by aiding drivers' sensory perception and reaction, AVCS uses sensors, computers, warning systems, and control systems in vehicles and the roadway to augment human eyes and ears while facilitating driving tasks. Examples of AVCS technology applications include automated steering, braking, and acceleration. The AVCS application that reaches farthest into the future is totally automated highways, in which control of vehicles is given to AVCS technologies.

AVCS and the other four IVHS categories are not limited to the previously mentioned technologies. Rather, the specific technologies identified in this introduction are representative of approximately 200 individual technologies identified to date. A more complete listing of current IVHS technologies, (many of which have been reviewed in some detail by the NCDOT), are identified in Appendix E.

8.2 IVHS INITIATIVES

NCDOT and the Charlotte MPO have defined specific initiatives for ATMS, ATIS, AVCS, CVO, APTS, and AVCS applications, in order to direct the focus of IVHS technologies for the Charlotte Region. Table 4 displays the list of IVHS initiatives that are grouped according to their priority rating for application in the Charlotte Region. This rating was derived from the process described below and detailed in Appendix D. An emphasis will be shown on initiatives in priority categories 1 and 2 during IVHS implementation Phase I. This Phase covers the time frame of 1992-1997 and is discussed in Section 7.2 of this Plan.

Six focus groups were formed to create the priority listing of IVHS initiatives. These groups included: engineers from NCDOT's Traffic Engineering Branch, Statewide Planning Branch, and an AdHoc Group from several units of the NCDOT; staff members of the Charlotte MPO; members of the ENTERPRISE Consortium; and executives from trucking companies in the Charlotte Region. NCDOT's AdHoc Group consisted of engineers representing the Office of Policy & Emerging Issues, the Research Unit, the Program Development Branch, the Division of Motor Vehicles, and the Public Transportation Division. Each group's rating consensus for 1992, and their projected 1997 outlook, are shown in Table D . 1 and Table D .2 of Appendix D . These two appendix tables should be carefully considered when developing specific approaches to IVHS implementation on a project by project basis. For specific projects, the evaluation/ratings of one or a subset of the focus groups might predominate.

For example, the Trucking Focus Group was very positive to the concept of "one stop shopping" or servicing for the trucking industry, and to the concept of Weigh-in-Motion (WIM) . On the other hand, this focus group was much less enthusiastic to other "Regulatory Support" concept in the CVO area.

Ratings reflect the perceived needs that an IVHS initiative could fill, based on each individual's experience and expertise. Table 4 displays the final approximated average of all six focus groups combined. This "approximated average" represents a proxy of an overall consensus. An additional task for the NCDOT is to further refine this list.

All of the initiatives listed in Table 4 are important IVHS issues. Lower ratings do not suggest that initiatives are unimportant. Lower ratings merely state that application of those initiatives should be implemented sequentially, within budgetary constraints.

The specific technologies that address each IVHS initiative are listed in Table D .3 and D .4 of Appendix D . Additional IVHS details can be found in Appendix E, which contains a review of many current IVHS technologies. Information on technologies subjected to this review are included in files currently maintained by engineers and planners in various units of the NCDOT .

TABLE 4

1992 PRIORITY LISTING OF IVHS INITIATIVES

* PRIORITY 1 INITIATIVES	CATEGORY
Real Time Surveillance, Detection and Data Collection for Freeways	ATMS
Incident Management	ATMS
Accident/Injury Severity Reduction	ATMS
Coordination with Enforcement & Emergency Responders	ATMS
Congestion Avoidance	ATIS
One Stop Servicing for the Trucking Industry	CVO

* PRIORITY 2 INITIATIVES	
Real Time Surveillance, Detection and Data Collection for Arterials	ATMS
Freeway Traffic Flow Management	ATMS
Documentation and Analysis of Data	
Congestion Management	ATMS
Congestion & Incident Accident Verification	ATMS
Coordination with Roadway Construction & Maintenance Scheduling	ATMS
Safety Awareness	ATMS
Incident & Congestion Reporting	ATIS
Real Time Operational Safety & Efficiency Monitoring	CVO
Law Enforcement & Regulatory Support	CVO

* Initiatives have not been ranked within their particular Priority Group. The order of initiatives within a Priority is therefore random, but grouped by IVHS "Category".

TABLE 4, CONTINUED

* PRIORITY 3 INITIATIVES	CATEGORY
Arterial Traffic Flow Management	ATMS
Coordination of Arterials with Freeway Flow through Signal Control	ATMS
Focal Point for Area-Wide Congestion Management & Incident Management (Control Center)	ATMS
Coordination with Local Special Events	ATMS
Route Guidance	ATIS
Traveler Advisory/Information Services	ATIS
Warning/ "MAYDAY" Communications	ATIS
Human Factors Analysis	ATIS
Environmental Monitoring & Reporting	ATIS
Vehicle-to-Vehicle & Roadside-to-Vehicle Communications	ATIS
Vehicle & Cargo Monitoring	CVO
Interstate Cooperation & Standardization	CVO
Human Factors Enhancements	CVO
Route Scheduling/Arrival and Departure Information	APTS
Dynamic Ride Sharing	APTS
Signal Preemption Systems	APTS
Security Systems	APTS
Fleet Management Improvements	APTS
Human Factors Enhancements	APTS

* Initiatives have not been ranked within their particular Priority Group. The order of initiatives within a Priority is therefore random, but grouped by IVHS "Category".

TABLE 4, CONTINUED

* <u>PRIORITY 4 INITIATIVES</u>	<u>CATEGORY</u>
Technology Transfer for IVHS	ATMS
Integration of National Highway System & Statewide Traffic Control Plans	ATMS
Upgrading of Traffic Management Software.	ATMS
Trip Planning	ATIS
Two-way Comnunications	ATIS
In-vehicle Route Guidance	ATIS
Vehicle Control Enhancement	AVCS
Route Planning and Scheduling	cvo
Automatic Fare Collection	APTS

* <u>PRIORITY 5 INITIATIVES</u>	<u>CATEGORY</u>
Fully Automated Highways	AVCS

* Initiatives have not been ranked within their particular Priority Group. The order of initiatives within a Priority is therefore random, but grouped by IVHS "Category".

8.3 ACTIVITIES SUPPORTING THE IVHS PLAN

The preceding section outlines a priority implementation plan for deploying IVHS technologies through various technical initiatives. These initiatives are aimed at carefully placing various traffic control and operational improvements through the on-going 3-C planning process.

There are a number of supporting activities that are necessary in order to implement any of the recommendations of this plan. First is the task of plan approval and adoption by NCDOT and DOH management, and the Charlotte MPO. Following this approval, the plan will need the understanding and endorsement of the NCDOT Secretary and the State Board of Transportation.

It is expected that the responsibility of Plan review and recommendations to the Secretary will be assigned to the Board's "Safety and Emerging Issues" committee. The next step will be incorporating IVHS technologies as part of the set of techniques currently available in planning and preliminary engineering. The initial NCDOT branches and units utilizing IVHS technologies, and incorporating IVHS in design, include Statewide Planning, Traffic Engineering, and Geographic Information Systems. Roadway Design, the Feasibility Studies Unit, Planning and Environmental, Research, Public Transportation, the field Divisions, and other branches and units of the Department will in due course incorporate the use of IVHS technologies in their work.

Specific Program Management activities that are also an integral part of this overall IVHS Area-wide Plan include the following :

* Organizational assignment for Congestion Management and IVHS implementation, and coordination ;

* Research and Development, focused on unique needs for the state and coordinated with the national Research & Development, and Operational Test programs;

* Training and Technology Transfer for NCDOT and local governments in the state;

* Development of a Human Factors element in the Planning, Design, and Traffic Engineering tasks;

* Marketing Program, including a user acceptance survey, and assessment of socioeconomic impacts of IVHS deployment;

* Participation in the Nationwide effort to develop IVHS standardization and system architecture;

* Development of a Program Review, Evaluation, and Redirection component;

* Obtain private sector participation in IVHS research, operational tests, and deployment;

* Support regional air quality improvement objectives.

Each of these activities will be incorporated in the cost estimates for IVHS deployment (Section 9.1).

8.4 UPDATING THE IVHS AREA-WIDE PLAN

This IVHS Area-Wide Plan has several elements that will need to be updated periodically:

* Freeway and arterial road segments and transit routes (Section 7);
* IVHS Technologies (Section 8.2, Appendix E) ;
* Cost estimates (Section 9) ;
* G.I .S. Data base (Appendix C);
* IVHS projects in the TIP (to be developed as implementation of the Plan).

It is recommended that the elements of this plan be updated according to the following schedule:

(1) Freeway and Arterial road segments and transit routes that are part of the IVHS network - every three years, with the next update occurring in 1997;

(2) Applicable IVHS Technologies to be considered for deployment - every two years, as a minimum, or whenever major technological breakthroughs occur ;

(3) Cost estimates and projects included in the TIP - annually, as part of the continuing TIP review and update;

(4) G.I.S. data base - as needed.

It is also important that the Program Development Branch solicit input from the Statewide Planning Branch, Traffic Engineering Branch, the various field Divisions, as well as the appropriate MPO's and the general public on overall IVHS/Congestion Management/Incident Management projects to include in the annual update.

8.5 EXPANSION TO OTHER URBAN AREAS

As suggested in Section 4.9, this Charlotte IVHS Area-Wide Plan is designed to serve as a pilot project for other urban areas in the state. That is, the other major metropolitan areas throughout the state will over time have their own individual IVHS Area-Wide plans developed. The next area to receive an IVHS plan is the Greensboro/Winston-Salem/High Point region. That Planning process will be underway in calendar year 1993 with a Federal Aid Grant for Early Deployment Planning.

Some components of the Charlotte IVHS Area-Wide Plan also will serve as a resource document for IVHS deployment plans in rural areas of the state. Those elements of the Charlotte Plan that pertain to the review and analysis of IVHS technologies, and the methods used in this study, will be particularly useful for IVHS deployment plans for all areas of the state.

8.6 PRIVATE SECTOR PARTICIPATION

Several opportunities exist for involvement of the private sector in the deployment of IVHS technologies, in the Charlotte Region and elsewhere. First, it is anticipated that as Operational Tests are made of specific technologies, technology firms and vendors will participate in these tests in various ways. Initially, it is expected that some type of in-kind cost sharing or loans of equipment would supplement public monies committed to these tests.

During the short-range development stage, 1992 - 1997, it is projected that most of the effort in implementing IVHS in Charlotte will be applied in the Freeway Management System and development of the basic infrastructure, such as the Traffic Control Center and the communication system. In later stages, however, as technologies that apply to Advanced Vehicle Control Systems come on-line, it will be important to have closer coordination of the implementation plans with vehicle manufacturers and highway user groups. To begin planning for that stage of the program, technology forums with vehicle manufacturers and the NCDOT will be scheduled over the next year.

In both the short-range and longer range implementation periods, major employers, shopping malls, and major activity centers such as the Charlotte Motor Speedway and the Charlotte-Douglas International Airport will be incorporated in the planning and development process. One example of private sector participation is that kiosks located at shopping malls could provide travelers with convenient real-time information. Another would be to provide real-time links to major trucking firms in the Charlotte area from the Traffic Control Center, when built. This idea has been explored with several firms in the region.

9. DEVELOPMENT AND OPERATING COSTS/BENEFITS

9.1 ESTIMATED COSTS

Costs of implementing the long-range IVHS Area-Wide Plan for the Charlotte Region are based on 1992 estimates developed in-house by the Traffic Engineering Branch for the CARAT Phase I project. These "bottom up" cost estimates have been compared with "top down" estimates based on a proportion of the appraised nationwide calculations for implementing the various components of a comprehensive "smart highway" system.

The referenced nation-wide appraisals were derived from:

(1) Reports on Major Aspects of IVHS, prepared by Working Groups of MOBILITY 2000, Dallas, Texas, March 1990, section on "Advanced Traffic Management Systems", pages 10- 19.

(2) Strategic Plan for IVHS in the United States, prepared by IVHS-America, Washington, D.C., May 20, 1992, pages III. 144-111.152.

The estimates of funding potential for IVHS deployment shown in Table 5 are based on proportioning estimates made for Nationwide IVHS deployment to the scale of the Charlotte Region. The derivation of the low estimate and high estimate is explained in Table 5. Nationwide Public Sector Potential Funding are from the IVHS Strategic Plan, p. 111-147. These "funding potentials" are "top down" cost estimates and are related here only to show a comparison to the "bottom up" cost estimates shown in Table 6.

The cost estimates developed in Table 6 are based on "cost per mile estimates" for the CARAT Phase I proposal, extrapolated to apply to the entire 345.6~mile freeway and arterial system in the Charlotte Region. The significant point about the 20-year capital and operating costs shown in Table 6 is that, even at the high estimate level, the overall cost estimate is much less than even the low estimate of potential funding shown in Table 5. Therefore, the "bottom up" cost estimates are reasonable as related to the funding potential expected for the Charlotte Region.

The primary objective of developing cost estimates for the entire proposed long-range IVHS system of freeways and arterials in the Charlotte Region is to estimate the long-range impact on the TIP planning process. For example, in Fiscal Year 1993, the estimated Federal Aid Construction Program for the entire State of North Carolina is projected in the TIP to be $586.2 million, including $196.3 million in requested State Matching Funds. The total Federal Aid Program for the seven years in the TIP is $6.2 billion.

In Mecklenburg County, the current projected Federal Aid and North Carolina Highway Trust Fund construction program is estimated at $1.87 billion, excluding bridge, rail crossing, and other safety projects. This is the total estimated budget over the seven years included in the current seven year TIP (Fiscal 1993 - 1999). In order to achieve IVHS objectives, funds need to be allocated in TIP from Federal Aid and the North Carolina Highway Trust Fund for the deployment of IVHS technologies.

TABLE 5

CHARLOTTE REGION FUNDING POTENTIAL FOR IVHS DEPLOYMENT

(In Millions of 1992 Dollars)

	NATIONWIDE IVHS PUBLIC SECTOR POTENTIAL FUNDING	CHARLOTTE REGION POTENTIAL FUNDING	
		LOW ESTIMATE *	HIGH ESTIMATE **
ATMS	**$24,941**	**$182**	$302
ATIS	1,996	14	14
AVCS	4,320	32	32
cvo	4,986	36	36
APTS	2,855	21	21
SUBTOTAL	$39,098	$285	$405
PS & E @ 8%	3,128	23	32
TOTAL	$42,226	$308	$437

* NOTE 1: Low Estimate based on Charlotte Region Urban Freeway Mileage proportion of 0.73 percent of the 18,800 Nationwide Total.

** Note 2: High Estimate (ATMS only) made on assumption of $24,941 billion on ATMS Public Infrastructure Costs being distributed among 75 largest metro areas and that Charlotte would be at the mid-range of funding. Other element costs are estimated the same as the Low Estimate.

TABLE 6

CHARLOTTE REGION ESTIMATED COSTS OF IVHS PROJECTS

(In Millions of 1992 Dollars)

COMPONENTS *	LOW ESTIMATE	MID-RANGE ESTIMATE	HIGH ESTIMATE
A. Capital Costs			
1. Incident Management Start-up	$ .47	$ .47	$ --**
2. Bus Preemption/Closed Loops ***	9.19	9.19	9.19
3. Freeway Surveillance	71.18	81.79	124.22
4. Arterial Surveillance	31.78	54.25	54.25
5. HOV Control System	3.58	7.02	7.02
6. Traffic Control Center	2.00	5.70	5.70
SUBTOTAL	$118.20	$158.42	$200.38
B. PS&E, Construction Engineering, Training @ 20% of A.	23.64	31.68	40.08
SUBTOTAL	$141.84	$190.10	$240.46
C. Operating Cost (20 year totals in 1992 dollars)	$ 23.00	$ 29.80	$ 29.80
D. TOTAL ESTIMATED COSTS	$164.84	$219.90	$270.26

* NOTE 1: Costs estimated include only ATMS, ATIS & CVO elements

** NOTE 2: Incident Management Costs included in Surveillance Costs

*** NOTE 3: Although Bus Preemption Signal Systems are slightly less expensive than Closed Loop Signal Systems, costs are estimated as the same on a "per intersection" or "per mile" basis.

The current estimate (1992 dollars) of some 76 projects in the City of Charlotte's "2005 Transportation Plan" is $2 .32 billion, over a 15 year period. For purposes of this planning report, the total cost estimate of construction of road and street improvements for the next 20 years in Charlotte and Mecklenburg County will be assumed to be approximately $3 billion. Capital investment for the ten-county region would be somewhat higher. This is not an engineer's estimate but simply a straight line projection of 1992 costs included in the two referenced plans extrapolated over the next 20 years.

Current estimates for deploying IVHS technologies in Mccklenburg County and the entire 10 county, Charlotte Region are shown in Table 6. The $164 million to $270 million estimated for optimal deployment of IVHS technologies would therefore amount to approximately six to nine percent of the projected 20-year capital expenditures estimated for street and highway improvements over this period.

The North Carolina DOT's TIP is updated annually. For any construction project to be listed in the TIP, it will have previously been approved by the Board of Transportation as a budget item, after review and comment by the public and the FHWA. In some instances, particularly for large projects, several sub-lettings are made for specific project segments.

Such is the case, for example, for the 63.4 mile (102.1 km) Charlotte Outer Loop. This major long-range construction project is listed in the 1993-1999 TIP in three segments ranging in length from 16 to 28 miles. By the time individual projects are designed and let to contract, lengths of project segments will vary due to several factors. Estimates for specific construction lettings often change from year to year. This will also be the case for the proposed projects listed in this IVHS Area-Wide Plan.

The NCDOT is dedicated to use the latest and most efficient IVHS technologies available, within budgetary constraints. Since the costs of new technologies tend to decrease as additional units are produced, such costs are expected to change as systems are upgraded. Therefore, the cost estimates for implementing this Plan should be updated on a biennial basis, and correspond with the NCDOT's Biennial Budget Request to the General Assembly.

9.2 ESTIMATED BENEFITS

The NCDOT currently uses a Benefits Matrix Model to calculate the benefits of a particular project ("Technical Report #8: Transportation Project Evaluation Using the Benefits Matrix Model", January 1983). Benefits included in the model are user benefits (cost savings for vehicle operations, travel time, and accident reductions), plus factors that account for economic development potential and environmental impact. This model is extensively used by the Statewide Planning Branch in their analysis of project alternatives.

An optional analysis tool ("Economic Analysis and Potential Cost Savings Associated with System-wide TSM Analysis", NCDOT, February 1985) has also been developed by the NCDOT Office of Policy and Emerging Issues, and has been used in several cases to analyze alternative, multi-modal Transportation System Management (TSM) programs and projects.

While these two models are excellent tools to assist in identifying optimal choices among competing project alternatives, it was determined that a more general program evaluation approach would be more appropriate for analyzing benefits for this IVHS Area-Wide Plan. Therefore, a "taxonomy" similar to one originally developed by the IVHS-America Benefits, Evaluation and Costs Committee has been adapted for this study. Table 7 illustrates the range of benefits that would be expected to accrue from IVHS deployment, and the diverse groups that are benefited. The four major categories for benefits relate to the specific IVHS Program Objectives shown in Section 3 :

Safety and Congestion (traveler benefits), Economic growth, Environmental, and Information (technology transfer).

More specific benefits in each of these categories could be identified for each category of technology, or for each "initiative area" identified in Section 8.2. However, as an example of this type of analysis, a representative sample of tangible and intangible benefits of IVHS deployment is shown in Table 8. This listing of the benefits of representative IVHS technologies was included in a recent project report of the National Cooperative Highway Research Program (NCHRP) .

Since the major categories of benefits from IVHS deployment that will affect the traveling public are safety improvements and congestion reduction, estimates of projected nationwide benefits in these two categories are shown in Tables 9 and 10, respectively. These estimates are necessarily based on numerous assumptions and related projections that must be carefully reviewed and analyzed before drawing conclusions about benefits for the Charlotte Region. However, they portray a level of magnitude that could be realized over the coming decades if IVHS deployment is achieved at its optimal potential. Reduced levels of benefits, of course, would result from reduced deployment levels.

TABLE 7

TAXONOMY OF BENEFITS FROM IVHS

Categories of Benefits	Impacted Groups					
	Users	General Population		Other Groups		
	(eg. Urban, Rural, Elderly, Commuters	Other Transportation System Users	**Non-Users**	**Public Transp.**	Truckers	Other Industry
Safety & Congestion	X	X		**X**	X	
Economic Growth	X	X	**X**	**X**	X	X
Envi romnent			**X**			
Information-Technology Transfer	X	X		**X**	X	X

SOURCE: Final Report of the Working Group on IVHS Benefits", Mobility 2000 Workshop, Dallas, March 1990.

TABLE 8

EXAMPLE BENEFITS FOR SPECIFIC IVHS TECHNOLOGIES

TECHNOLOGY	TANGIBLE BENEFITS	INTANGIBLE BENEFITS
ATMS		
a. Optimized Vehicle Actuation	* Reduced travel time * Reduced travel cost * Reduced congestion	system efficiency
b. Fixed Time Coordination	* Reduced fuel consumption * Reduced stops and delays * Reduced congestion * Reduced travel cost * Decreased air pollution	* System efficiency * Improved transit operat i on * Vehicle & pedestrian safety * Improved data co1lection * Training
c. Partially Adaptive Coordination	* Save fuel cost * Save operating cost * Reduced congestion * Save time * Decreased air pollution	* System efficiency * Improved transit operation * Vehicle & pedestrian safety * Improved data collection * Training
d. Fully Adaptive Coordination	* Save fuel costs * Save operating costs * Reduced congestion * Save time * Decreased air pollution	* System efficiency * Improved transit operation * Vehicle & pedestrian safety * Improved data collection * Training
e. Ramp Metering	* Reduced delays * Reduced fuel consumption * Reduced air pollution	* Reduced congestion * Improved freeway operation

TABLE 8, CONTINUED

EXAMPLE BENEFITS FOR SPECIFIC IVHS TECHNOLOGIES

TECHNOLOGY	TANGIBLE BENEFITS	INTANGIBLE BENEFITS
ATIS		
a. Computerized Rationalization of Direction Signing	* Optimum route identification * Savings in travel time * Money saved	* Eliminate excess driving * Increased driver confidence * Intuitive savings
b. Traveler Advisory Radio	* Reduced delay from traffic incidents * More efficient detours * Reduce risk of secondary accidents	* Reduce accident risk * Increased driver confidence * Reduce driver anxiety * Improve police patrols * Improve access for emergency vehicles
c. Self-Contained Onboard Navigation Systems	* Reduced travel time * Reduced travel costs to drivers * Reduced congestion	* Improved routing advise * Better route planning to all drivers who purchase system
d. Electronic Route Guidance Systems	* Reduced travel time * Reduced travel cost * Better traffic data * Reduce pollutants * Reduce VMT	* More efficient route choice * Reduce recurring congestion for individual consumers and drivers in general * Better planning methods * Reduce driver stress
e. Automatic Vehicle Identification Technology	* No cash or ticket handling * Increase Toll Plaza capacity * Reduced vehicle delays * Reduced pollutants * Reduced construction needs (for Toll Plaza) * Staffing reduction	Increased motorist efficiency Improved administrative procedures

TABLE 8, CONTINUED

EXAMPLE BENEFITS FOR SPECIFIC IVHS TECHNOLOGIES.

TECHNOLOGY	TANGIBLE BENEFITS	INTANGIBLE BENEFITS
AVCS		
a. Anti lock Braking Systems	* Reduced number of accidents * Reduced accident cost * Reduced insurance costs	Reduced risk of accidents
b. Speed Control systems	* Vehicle operating costs	* Driver comfort * Economic efficiency
c. Variable Speed Control	* Improved safety * Improved fuel efficiency	* Optimize speeds * Optimize traffic flow
d. Radar - Assisted Braking	* Reduce accidents * Reduce congestion * Reduce rear end collisions	* Improve network flow
e. Automatic Headway Control	* Reduce accidents * Reduce congestion * Reduce fuel consumption * Increase highway capacity * Reduce vehicle operating costs	* Enhanced comfort and convenience
f. Automated Steering Committee	* Increase highway capacity * Reduced Accidents	* Better utilization of roadway space within existing ROW
g. Automated Highway System	* All Tangible Benefits	* All Intangible Benefits

SOURCE: NCHRP Report 340: "Assessment of Advanced Technologies for Relieving Urban Traffic Congestion", December 1991

TABLE 9

ESTIMATE OF NATIONWIDE IVHS SAFETY BENEFITS

A. LOWER RANGE ESTIMATE *

PHASE	YEAR	LIVES SAVED/YR.	INJURIES SAVED/YR.	$ SAVED/YR.
1	1995	1	50	$ 2,300,000
2	2000	46	1,780	$ 890,000,000
3	2010	2,200	84,000	$ 4,200,000,000

B. HIGHER RANGE ESTIMATE

PHASE	YEAR	LIVES SAVED/YR.	INJURIES SAVED/YR.	$ SAVED/YR.
1	1995	88	3,060	$ 167,000,000
2	2000	**927**	35,500	$ 1,800,000,000
3	2010	11,529	442,000	$22,200,000,000

* 5-Year Delay in Deployment Schedule and 50% Lower Safety Effectiveness of all IVHS Technologies

SOURCE: "Final Report of The Working Group on IVHS Benefits", Mobility 2000 Workshop, Dallas, March 1990, p. 13 & 14.

TABLE 10

ESTIMATE OF NATIONWIDE IVHS CONGESTION REDUCTION

SAVINGS	TECH.	for 2000			for 2010		
		Large Area Market Acceptance	Small Area Market Acceptance	Pct. Reduc.	Large Area Market Acceptance	Small Area Market Acceptance	Pct. Reduc.
Recurrent Delay Reduction	ATMS	20%	0%	15%	60%	40%	15%
	ATIS	10%	2%	10%	40%	20%	30%
	cvo	30%	30%	15%	60%	60%	30%
	AVCS	10%	10%		40%	30%	
Incident Delay Reduction	ATMS	20%	0%	15%	60%	40%	20%
	ATIS	10%	2%	3%	40%	20%	5%
	cvo,	30%	30%	5%	60%	60%	10%
	AVCS	10%	10%	10%	40%	30%	30%
Excess Mileage Reduction	ATMS	20%	0%		60%	40%	
	ATIS	10%	2%	30%	40%	20%	40%
	cvo	30%	30%	30%	60%	60%	40%
	AVCS	10%	10%	N/A	40%	30%	N/A

SOURCE: M. Cheslew, "Estimates for 2000 and 2010, "Proceedings of The IVHS-America 1992 Meeting, Newport Beach, May 1992, p. 408.

9.3 Benefit/Cost

Since a particular design of IVHS Deployment Projects is not the intent nor scope of this Plan for the Charlotte Region, a specific benefit/cost or cost effectiveness evaluation would be premature and at best speculative. Therefore, nationwide and selected IVHS project benefit/cost data are provided.

Table 11 shows annual estimated societal benefits of IVHS deployment nationwide compared to capital investment costs to the year 2012. Two levels of investment are shown for IVHS. The $89 billion level of investment was based on the early work of the Mobility 2000 working groups. The $129 billion level of investment was suggested. in the IVHS Strategic Plan, (page 111-147). The $129 billion represents cost estimates of public sector funding of $39.5 billion plus private sector cost estimates for participating in ATIS, AVCS , and CVO initiatives, (including vehicle manufacturing costs) of $89 .6 billion. Total 20-year benefits estimated in this study, result in a favorable benefit/cost ratio, particularly if the optimal safety benefits are realized.

Since overall societal benefits are often overstated or understated when applied to programs in a metropolitan area, or to a particular set of project alternatives, it is also useful to examine benefit/cost ratios for specific IVHS - related programs and projects. Table 12 documents reported benefits from a large sample of ATMS operational test projects that were underway during the decade of the 1980's. A growing body of literature addresses the impacts of IVHS deployment, as related in the "References" Section of this Plan. As more operational tests of IVIIS technologies are conducted, including the test for the Charlotte - CARAT Phase 1 activity, additional cost and benefit data will be obtained to verify and update the current state of knowledge on the effectiveness of IVHS deployment.

9.4 SOURCES OF FUNDING

Several sources of funding have been and are currently being used to initiate this IVHS Area-Wide Plan for the Charlotte Region. An initial feasibility study was carried out with Highway Planning and Research (HP&R) funds. The Plan itself is being funded under Federal Aid funding through the Early Deployment Program, at an 80/20, Federal/State matching ratio. Development of the Evaluation Plan and Final Performance Specifications for the Charlotte IVHS/Freeway Management System will be performed under Federal Aid funding through the IVHS Research Program. In the future, other IVHS feasibility studies, research and development, and operational tests are expected to be carried out with these sources of funding and perhaps with federal funds from the IVHS "Other Corridors" program.

TABLE 11

SOCIETAL BENEFITS AND IMPLEMENTATION COSTS OF IVHS

ANNUAL BENEFITS	LOW ESTIMATE	HIGH ESTIMATE
Productivity Improvements	$ 1.8 billion	$ 3.6 billion
Energy Savings	190 miilion	386 million
Accident/Injury Cost Reduction	3.4 billion	17.8 billion
Total Estimated Annual Benefits	$ 5.4 billion	$ 21.8 billion
PO-Year Estimated Benefits in 1992 dollars	$ 108 billion	$ 436 billion
PO-Year Estimated Costs in 1992 dollars	$ 89 billion	$ 129 billion

SOURCE: A. B. Boghan; "Comparing IVHS Benefits with Alternative National Transportation and Telecommunications Strategies", Proceedings of the IVHS-America 1992 Annual Meeting, Newport Beach, May 1992, page 402.

TABLE 12
REPORTED BENEFITS/COSTS FROM EARLY ATMS OPERATIONAL TESTS

NAME OF STUDY	AUTHOR	STUDY DATA	EVALUATION METHODOLOGY	TECHNOLOGY DEMONSTRATED	REPORT BENEFIT
National Signal Timing Optimization Project (11 cities nationwide)	FHWA	1982	Before-after Simulation model	Improving traffic signal timing plans	For each average intersection: 15.000 vehicle hours of delay saved; 455,000 vehicle stops eliminated; 10,000 gallons of fuel saved; $28,695 average annual benefit; 8.5% improvement in travel time; benefit-cost ratio of 63:1
Fuel-Efficient Traffic Signal Management (FETSIM) (61 cities & 1 county in Calif.)	ITS	1986	Before-after Simulation model; Field Test	Improving traffic signal timing plans	15% reduction in vehicle delays; 16% reduction in vehicle stops; 7% reduction in travel times 8.6% reduction in fuel use; $231 million savings over 3 years: benefit-cost ratio of 58:1; reduced emissions; increased safety: improved public transit operations; improved traffic operations data base
Automated Traffic Surveillance and Control (ATSAC) (Los Angeles Calif.)	L.A. Dept. of Trans.	1987	Before-after	Computer control of traffic signals	13% reduction in travel time; 35% reduction in vehicle stops; 14% increase in average speed; 20% decrease in intersection delay: 12.5% decrease in fuel consumption; 10% decrease in hydrocarbon emissions; 10% decrease in carbon monoxide emissions; benefit-cost ratio of 9.8:1
Chicago Area Expressway Surveillance and Control Project (Chicago, Ill.)	McDermott et al.	1979	Before-after	Freeway surveillance and control system	30% reduction in peak period congestion; 18% reduction in accidents; decreased travel times; increased average speeds; expedited emergency responses; benefit-cost ratio of 4.1 (ramp metering)

SOURCE: "Smart Highways: An Assessment of Their Potential to Improve Travel," General Accounting Office, Washington, DC, May 1991, p. 22.

However, in order to implement the plans and designs for deploying IVHS technologies in Charlotte and in other areas of the state, both urban and rural, it will be necessary to integrate funding for IVHS technologies into the regular Federal Aid and State Construction Programs. This effort will require reallocation of funds and a careful assessment of funding priorities by the management and administration of the NCDOT, including the State Board of Transportation, as well as the North Carolina General Assembly. IVHS solutions to congestion problems must hereafter be included in the project scoping process.

Included in Federal funding programs authorized by the 1991 ISTEA, the following offer potential funding sources for the projects included in this Plan: National Highway System (NHS) ; Surface Transportation Program (STP) ; Congestion Mitigation for Air Quality Improvements (CMAQ) , and perhaps some aspects of the Bridge Program and Highway Safety Program.

State funding priorities from the Highway Trust Fund and the Highway Fund, which match federal aid, will need to be examined in order to determine if a more cost effective expenditure of all public monies from all sources would warrant a redistribution of currently planned expenditures. This strategy and the implications of future reallocation of highway program resources will be explored with the State Board of Transportation, through the Committee on Safety and Congestion, and with the 1993 General Assembly.

As another initiative in incorporating IVHS technologies into the regular construction program, such projects will necessarily need to be included in plans submitted by the respective MPO's in the State. IVHS projects have been discussed with the Charlotte MPO, Policy Committee, and the Technical Coordinating Committee (TCC) . In the case of the other MPO's in the Charlotte Region, the IVHS program was discussed during the course of preparing this Plan with the technical staff of the KANLACON and Gastonia IWO'S . The plan preparation itself has received official status by the Charlotte MPO and is included in their current Fiscal Year work program.

In other areas of the state, WI-IS technologies have begun to receive recognition and support from various MPO's and from Divisions within the NCDOT . For example, in the series of public meetings held in the fall 1992, the Winston-Salem MPO included a project on erecting overhead variable message signs (VMS) as their number two priority project for inclusion in the update of the TIP.

9.5 STAGES OF FUNDING/SCHEDULING

In section 9.1 the overall 20-year IVHS deployment costs for the Charlotte Region are presented, in terms of 1992 dollars. Table 13 distributes these estimated costs over the four phases of the program. These costs again are shown in 1992 dollars. If the "low estimate" for ATMS, ATIS, and CVO costs ($164 million) are distributed over the next twenty years, at a compound amount factor of three percent, the total cost of the public investment would amount to $221 million. At a four percent compound amount factor, the total would be $245 million.

Scheduling of projects proposed in this IVHS Area-Wide Plan will depend on several factors. The first key to success is the continued acceptance and approval of the concept of IVHS technology deployment as effective techniques to address Traffic Congestion Management. Continued support will be required from the Administration of the Department, the State Board of Transportation, and the General Assembly. This support has been outstanding during the first two formative years of the program (1991 and 1992).

The second key to success will be the continued understanding and acceptance of such technologies by the MPO's in the Charlotte area, particularly the Charlotte MPO, the City of Charlotte DOT, and other involved parties. A high level of commitment to the program now exists among all the above parties. A strong base of support also exists with the private sector, particularly the trucking industry and the economic development interests, in the Charlotte Region. However, with a new administration in State government and changes that will inevitably occur over time at the state and local level, a focused effort of informing responsible policy-making bodies will be an important aspect of continuing this program.

It is assumed that since the IVHS program is authorized as Section VI of the ISTEA, it will receive funding and priority support from the Federal government, particularly the FHWA, FTA, and NHTSA. The ongoing support of the Congress for the IVHS program will of course be paramount to providing funding streams to deploy appropriate technologies in an optimal and cost-effective manner.

TABLE 13

IVHS DEPLOYMENT COSTS BY PHASE
(In millions of 1992 dollars)

COMPONENT	PHASE I 1992-97	PHASE II 1997-2002	PHASE III 2002-2012	PHASE IV BEYOND 2012	TOTAL *
System Miles/ Kilometers:	100.4 161.9	58.6 94.5.	107.2 172.9	79.4 128.1	345.6 557.5
A. Capital Costs					
1. Incident Mgt.	0.36	0.11			0.47
2. Bus Preemption/ Closed Loops	2.43		3.34	3.42	9.19
3. Freeway Surveillance	22.30	13.81	5.04	30.01	71.16
4. Arterial Surveillance		8.06	23.72		31.78
5. HOV Control system		1.56	2.02		3.58
6. Traffic Control Center	2.00				2.00
SUBTOTAL	27.09	23.54	34.54	33.43	118.18
B. PS&E, Construction Engineering, Training @ 20% of A	5.33	4.69	6.76	6.85	23.63
SUBTOTAL	32.42	28.23	40.88	40.28	141.81
C. Operating Costs	5.75	5.75	11.5	N/A	23.00
D. TOTAL ESTIMATED COSTS	38.17	33.98	52.38	40.28	164.81

* NOTE **1:** Low Estimates of costs (from Table 6) shown for illustration; other estimates would be similarly distributed; Table 13 shows ATMS, ATIS, CVO elements only.

10. CONCLUSIONS AND RECOMMENDATIONS

PROCESS CONCLUSIONS AND RECOMMENDATIONS

* The Area-Wide IVHS planning process outlined in this Plan for the Charlotte Region needs to be further refined. It should be developed in more detail in future NCDOT IVHS Area-Wide Plans.

* The use of GIS as a presentation and data analysis tool is an effective and relevant application for IVHS Area-Wide planning. Continual development of GIS will be useful in future IVHS Area-Wide Plans.

* A study should be conducted to determined whether IVHS technologies should be considered for highway systems that are classified below principal arterial .'

* The "level of service" and safety analysis processes identified in this Plan need further development and integration with the GIS data base. Level of service in itself may not adequately differentiate between current and future (planned) facility performance measures.

* Models for current network analysis and future capacity analysis need further development by the Statewide Planning Branch.

* The state-of-the-art in applying knowledge about the driver/user interface with new technology such as IVHS components is currently in its infancy. The NCDOT should become more involved in national IVHS Human Factors research efforts, and develop its own "niche" in the task of integrating Human Factors and Safety issues into the design of ATMS, ATIS and CVO components, as well as highway design in general. Two hundred, fifty thousand dollars annually should be budgeted for this task over the next four years. The first year budget will be a part of further Operational Test design work in the Charlotte/CARAT IVHS project.

* The Charlotte Region has recently been designated by the FHWA as an IVHS "Pipeline Project" area, but with no approved Federal Aid to test alternative/competing IVHS technologies. The NCDOT should budget one hundred, fifty thousand dollars annually over the next four years to test IVHS components. This task should be jointly funded with a similar level of effort from the private sector.

* As an integral part of the Evaluation Plan for any Operational Tests or Deployment of IVHS technologies in Charlotte or elsewhere in the state, the evaluation must include an assessment of each of the Objectives listed in Section 3.

FUNDING/IMPLEMENTATION CONCLUSIONS AND RECOMMENDATIONS

* IVHS Area-Wide Plans should be developed for all MPO's in North Carolina which contain a city of over 200,000. Currently, this would include the Raleigh-Durham and Fayetteville areas, in addition to the Charlotte and Piedmont Triad Regions.

* MPO's in all parts of the state should use the results of this first Area-Wide Plan to develop their own set of projects incorporating IVHS technologies for TIP project requests. The general application of TDM and TSM techniques as applied to Congestion Management, Incident Management, Safety Management, and Intermodal System Management programs and processes should be undertaken in all areas of the state as appropriate.

* The Charlotte Area-Wide IVHS Plan should be reviewed by the NCDOH Congestion Management Steering Committee, the BOT Committee on Congestion and Safety, and the Policy Committee (or TAC) and TCC of the three MPO's in the Charlotte Region. Modifications as appropriate should be made in the Plan before being presented to the BOT for adoption.

* An organizational analysis should be made by the DOH and the PTRD to assign implementation responsibility for IVHS Plans.

* The Area Wide Plan must be considered an overall "Strategic Plan" for the Charlotte Region. It does not detail which IVHS technologies should be deployed on a particular route segment. That task will be carried out in the scoping process and in the Project Planning and Design stages for each TIP/CIP project.

* The NCDOT's Congestion Management System Planning activities must include consideration of IVHS technologies as part of project Planws. IVHS deployment costs must become part of overall project costs.

* Finally, the NCDOT should complete as soon as possible a statewide Strategic Plan for IVHS deployment. This Plan should cover each metropolitan region and rural area of the state.

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APPENDICES

APPENDIX A

SCOPE OF WORK/COOPERATIVE AGREEMENT

Attachment 1

Project No. IVH-9237(601)

Charlotte, North Carolina

IVHS Early Deployment Study

Cooperative Agreement Between

The Federal Highway Administration

and

The North Carolina Department of Transportation

The Federal Highway Administration (FHWA) hereby approves the request of the State of North Carolina dated March 25, 1992 for Federal assistance funding for an IVHS Early Deployment project for an areawide study of potential IVHS deployment activities in the Charlotte metropolitan area pursuant to 23 USC 307.

1. Estimated Cost

   The State shall be reimbursed for allowable costs incurred in the performance of work under this award in an amount not to exceed $400,000. The maximum Federal share for this project shall not exceed 80 percent of the total cost, as agreed to by the State.

2. Responsibilities of the State

   The State shall perform, or cause to be performed, the **work** defined in Activities 1 through 7 of the attached proposal, "Congestion Avoidance and Reduction for Autos and Trucks (CARAT) - Early Deployment Planning Project", transmitted March 25, 1992. The attached proposal is hereby incorporated into this contract document.

3. Schedule

   The period of performance is expected to be 18 months from the date of execution of this contract.

4. FHWA Participation

FHWA shall-be considered as an oversight and guidance agent in this IVHS Early Deployment Project. The State will provide the FHWA Division Office with quarterly status reports and information on working group meetings and copies of correspondence. A designated staff person in the FHWA regional and headquarters offices will also be notified of meetings and receive copies of status reports.

5. Reporting Requirements

Each quarter the State shall submit to FHWA project progress report, which briefly summarizes work accomplished, work planned, problems encountered, recommended solutions, and any other pertinent information.

6. Documents

The product described in the attached proposal will be provided in draft for review by FHWA.

7. Promammatic Chances

The State must obtain prior approval from FHWA whenever any significant change is anticipated. These include, but are not limited to:

(1) Any revision of the scope or objectives of the project (regardless of whether there is an associated budget revision requiring prior approval).

(2) Need to extend the period of availability of funds,

(3) Changes in key personnel, program manager, or prime contractor.

8. Technology Transfer

FHWA shall have unlimited rights to the work developed in performance of this Agreement. Unlimited rights are defined as the right to use, disclose, reproduce, .prepare derivative works, distribute copies to the public, in any manner and for any purpose, and to have or permit others to do so. The State shall make available to FHWA three copies of all work developed in the performance of this Agreement. The State agrees to place the work developed in performance of this Agreement in the public domain.

9. Costs

The State shall limit its progress claims and final claims to those costs incurred in accordance with this Agreement and to submit its final claim within 90 days after the project is completed.

10. Additional Requirements

The State shall comply with all laws, regulations and FHWA requirements applicable to this Agreement and with the general provisions set forth in Appendix A hereto.

11. Certification Regarding Lobbying

By executing this Agreement, the State makes the Certification regarding lobbying which is attached hereto as Appendix B.

12. Termination

The State shall notify FHWA immediately of any intent to terminate this Agreement.

13. Effective Date

This Agreement is effective upon execution by both parties to this Agreement.

Federal Highway Administration

Nicholas L. Graf

Nicholas L. Graf
Division Administrator

Date 6/12/92

North Carolina Department of Transportation

W. G. Marley, Jr.

W.G. Marley, Jr.
State Highway Administrator

Date June 10, 1992

CARAT Early Deployment Planning Project, NCDOT

SCOPE

Over the past several months, the North Carolina Department of Transportation (NCDOT) has been developing the concept and plan for the long range deployment of IVHS technologies in several areas of the state. One of these IVHS deployment projects is being planned for the Charlotte Urban area, and eight county regions which include two counties in neighboring South Carolina.

The project in Charlotte is called CARAT, Congestion Avoidance and Reduction for Autos and Trucks. This project is primarily a Freeway Traffic Control project, and will focus on both congestion relief and incident management. The overall Goals and Objectives of the CARAT project are:

(1) Improve safety and overall system performance for the Charlotte Urban Area Transportation System;

(2) Decrease congestion on the freeway system and major arterials;

(3) Provide an operational test area for the deployment of IVI-IS technologies;

(4) Demonstrate the effectiveness of IVHS technologies in medium-sized urban areas;

(5) Test an innovative approach to implementing an advanced freeway management system with a Design-Build-Warrant contracting procedure; and

(6) Provide a mechanism to effectively evaluate the system as it is being installed and operated, and provide a means to conduct research and train transportation professionals in advanced Traffic Management Systems and Advanced Traveler Information Systems.

In order to develop a more comprehensive approach to the CARAT project, the NCDOT is requesting funds from the FBWA for an Early Deployment project, to be set up through a Cooperative Agreement. The details of the overall CARAT project have previously been reviewed by the FHWA in a draft "overview" report.

This document details the activities, anticipated products, schedule, funding requirements, and committments made to support a request to the FI-IWA for Early Deployment Funding.

ACTIVITIES

The primary intent of early deployment activities in the CARAT Project is to develop a component of the continuing, coordinated, comprehensive transportation planning process for the Charlotte Metropolitan area. This process has been underway for the past several months through the continuing joint planning program in the NCDOT's Statewide Planning Section and the Traffic Engineering Branch. In addition, a research and development project sponsored by the FHWA, the NCDOT, and the UNC Institute for Transportation Research and Education at UNC-Charlotte has developed an overall analysis of IVHS deployment needs for the region. The research project report, in draft form, has also been reviewed by the FHWA.

The following set of activities will be carried out by the NCDOT to further supplement these previously completed planning and research elements. These activities will be conducted in collaboration with the City of Charlotte, the University system, and other participants in the the CARAT project. Early Deployment activities include:

#l Review ATMS and ATIS system deployment and planning efforts in other state and local transportation departments.

#2 Conduct a series of "technology" transfer seminars" with potential private sector participants, including organizations with the following capabilities:

- System integration
- Traffic engineering
- Software development
- Communications systems
- Control systems/ hardware manufacturing
- Vehicle manufacturers
- Trucking industry
- Travel industry
- Bonding industry (for design-build-warrant contract)

#3 Review and synthesize IVHS technologies to assure the Department is considering all the latest available capabilities, and has a process in place to continue to track current technological developments in the field.

#4 Analyze the status of transportation planning data and processes in the Charlotte Urban Area (both state and local activities), and determine how best to assure continuing consideration of IVHS deployment in the following processes: .

- Network analysis
- Congestion management and travel demand management (TDM)
- Safety analysis and response (accidents, other incidents)
- Air quality analysis
- Future capacity analysis

#5 Refine goals and objectives for IVHS deployment based on the above analyses.

#6 Develop a deployment plan for implementing IVHS technologies in the Charlotte Urban Area:

- Preliminary performance, specifications
- ATMS technologies
- ATIS technologies
- CVO coordination
- R&D support
- Training and educational support

#7 Develop a schedule and budget for CARAT implemtation.

PRODUCTS

Early Devployment Funding would result in an overall areawide plan for IVHS Deployment in the Charlotte Urban Area. This would include a reviewing process of responsible agencies, organizatons, and companies, along with the detailed analysis of technologies, routes, and corridors. The funding would also create system plans for both Congestion Management and an Incident Management. The major output of the CARAT "Early Deployment Project" will provide answers to the following questions:

(1) What is the overall structure of the CARAT IVHS program, in terms of its components and activities and the way in which these interrelate?

(2) What is the time frame for the overall program, and for each individual project?

(3) What locations in the Charlotte Urban Area will be used to develope and evaluate IVHS technologies in the program?

(4) What public and private sector organizations will be involved in the activities?

(5) What technologies will be developed through the program, and what will be the benefits of their use?

(6) What criteria and environments will be used to assess the performance of technologies developed in the program?

(7) What will be the cost of the CARAT program, in terms of individual projects and activities and overall program mananagement?

(8) What sources of funding are available for the program?

(9) What is the ultimate goal of the program, and the future direction after completion of the work?

APPENDIX B

HUMAN FACTORS ANALYSIS

SCOPE OF WORK

For

HUMAN FACTORS COMPONENT OF THE CARAT EFFORT

Prepared by

UNC Highway Safety Research Center

Introduction

The following narrative describes the scope of work for the proposed human factors component of the NCDOT project entitled, *'Congestion Avoidance and Reduction for Autos and Trucks" (CARAT). As described in the proposal to FHWA, the purpose of this specific effort is to incorporate a much-needed human factors component into all phases of the CARAT effort. This human factors component will be aimed at ultimately effecting the operational efficiency and effectiveness of the IVHS efforts, and thus affecting the level of service, safety, and convenience for the user.

As described in the Appendix to that proposal, the human factors issues can be thought of as falling into two areas -- those issues related to the users of the IVHS system (the drivers), and those related to the traffic engineer/controllers of the IVHS system.

In terms of user-related human factor needs, the IVHS system being contemplated includes two basic types of systems that affect the users -- information systems that provide information to the user and allows the user to determine his/her own driver behavior (e.g., permanent and variable message signs, advisory radio, etc.), and operator control systems which "force" the user to take some action (e.g., ramp metering systems, ramp closure/detour systems). The human factors requirements for these systems are:

1. To provide information messages which can be easily interpreted and understood by the user such that proper behavior is facilitated. Here, the key is to design messages such that the user is convinced that the desired action is necessary to increase their own convenience and safety.

2. To design the "driver control systems" such that the driver is essentially forced to take the appropriate action.

3. To develop long-term public support for the IVHS system by designing both information and control systems which "convince" the user that what the system is providing is better than a non-system alternative. Thus, the user must be shown that control he/she gives up to the IVHS system provides them with more efficient and convenient travel. (The question, of course, is how to do this, since each individual driver can only be in one place at a time and thus will not be provided with visual feedback of the problems of the non-used alternative.)

With respect to human factors needs related to the controllers, the requirements are:

1. To design control center facilities which meet the human factors needs of the operating staff -- a suitable work environment.

2. To design the day-to-day work functions of the controllers and center staff in such a way to insure the optimum use of the massive amounts of data that are provided to them.

3. To continually upgrade and redesign the facilities and staff operations based on a continuing series of operational studies.

Project Objective

The basic objective of this effort is to divide and develop human factors expertise necessary to meet the above described requirements. These requirements include review of IVHS planning documents for both facilities and operational procedures, monitoring and study of both the engineer/controllers and the users after the system is in place, and providing feedback to the NCDOT, the City of Charlotte, UNCC and other IVHS users across the nation.

The human factors/safety team to be provided in this effort will be based at the UNC Highway Safety Research Center in Chapel Hill. It will be headed by Dr. Ronald G. Hughes, human factors specialist. Other safety research and engineering expertise will be provided by Dr. Forrest M. Council, Mr. Charles Zegeer, and Mr. William Hunter of the Highway Safety Research Center on an as needed basis. A full-time research assistant at UNC will provide support to the team leader. Finally, a Human Factors Technical Advisory Group, a small group of human-factors and engineering consultants from other UNC campuses and private agencies, will be identified to review and supplement the efforts of this core HSRC team. The budget includes funding for their efforts and for any necessary subcontracts with other vendors for specialized equipment, software or personnel.

Tasks

Specific tasks that will be involved in this effort are described in the following narrative. The ordering of the tasks may be modified, depending on the nature of available construction funding and thus the schedule for implementation. However, because the design of both the IVHS information and control systems must be ultimately based on user needs, the initial tasks will be related to studies of user needs. (It is also noted that it may well be the case that not all of the following tasks can be carried out under the available funding. We have provided the longer list for informational purposes, and to allow the project coordinator input into choice and scheduling of efforts. To some extent,the tasks are presented in a priority order. Again, this order may change based on construction and implementation of the CARAT system and on findings from higher priority tasks. The final choice of tasks will be made in cooperation with the Coordinator and will be limited by funding.)

Task 1. Conduct User Needs and Information Analvses. This task will include two separate components -- the definition of user requirements for use in preliminary design of the systems and facilities and a study of information display alternatives. Requirements definition will address specific, individualized information needs (and the estimated value of such information in terms of perceived contribution to CARAT/IVHS operational goals) for auto, public transportation, commercial transport/delivery, and specialized users (e.g., law enforcement, medical and emergency). The product of this effort will be a prioritized list of detailed information requirements for each specific user area as well as a prioritized list across all areas. This information will be used in making program design decisions as to where investments will producemaximum benefits.

The study of Information Display Alternatives will address the full range of "display" alternatives considered most appropriate to each user category, given unique requirements of each. The notion of display will not be limited to visual highway signing techniques, but shall include use of radio/TV broadcasts for real-time as well as pre-trip planning, visual as well as auditory in-vehicle displays, as well as summary data indicating "trends" having a direct bearing on user requirements. Initial work in this area will define the current state of understanding in this area based on a review of IVHS and driver-information/human factors research conducted to date. Based on this review, HSRC will provide specific design recommendations for the CARAT project.

Task 2. Determine Traffic Control Center (TCC) Information Requirements and Preliminarv User Interface Design This effort will address in detail the manpower/personnel/training and human engineering design issues/requirements for TCC operational personnel. Initial work will focus on the definition of the TCC operator role in traffic management, the information required to support the TCC operator (i.e., the data needed), an assessment of the information processing requirements (i.e., the form in which the massive amount of numeric data from the vehicle detection systems and the visual data from the monitors should be provide to the operator), the degree of automation involved as well as the potential for future areas of automation, an assessment of the knowledge, skills, and abilities required for effective operator performance, recommendations for operator training, recommendations for deployment of the four-person TCC staff, and the potential role of simulation for operator training. (See later discussion of simulation training in Tasks 7 and 8.)

Task 3. Review TCC Facility Desian Plans. Based on the definition of operator needs in Task 2, the proposed design of the Traffic Control Center facility will be reviewed. Based on this review, HSRC will provide specific design recommendations for the CARAT project to the Coordinator.

Task 4. Develop and Implement Studies of the Human Factors Components of the Control Center Operation. After the TCC is in operation, the team will conduct needed research studies related to the actual operation of the Center. The staff will prepare reports concerning the outcome of this research and provide/coordinate necessary training for control center and other team staff based on the results of this research. In essence, while Task 1 and 2 are being done during the planning stages, this task will be conducted after the system and center becomes operational.

personnel actively involved from a human factors standpoint in the driver information and'traffic management center components of state, regional, and national IVHS programs. HSRC will provide necessary information and training to these experts as needed and coordinate their involvement in all subcontract of consulting efforts. Although shown as a lower order task, this effort will be initiated early in the project.

Task 10. Transfer the Developed Knowledae to other IVHS Users. This will be done through participation and IVHS america meetings, the ENTERPRISE consortium, TRB meetings and committees, and other pertinent meetings.

Summary

This HSRC effort is attempting to introduce human factors aspects to the North Carolina IVHS work early in CARAT project planning efforts, and to further introduce these human factors considerations throughout the evolution of the project. We will be bringing a new "perspective" to the CARAT efforts in that our team incorporates a team leader with extensive experience in related human factors efforts, but from a air transportation and control perspective, and engineering/safety expertise from a group of researchers with extensive experience in all components of highway safety research. This core team is to be supplemented through technical review and assistance from other human factors and engineering design expertise within the UNC system and private industry. Through this combination, we will be able to maximize the development of knowledge concerning IVHS-related human factors and safety issues, and to distribute this information and knowledge to other IVHS users across the region and the nation.

APPENDIX C

G.I.S. "PILOT" PROJECT ON I-77

```
ENTER COMMAND >RES TYPE > * ' '                 C.1  LANDUSE
       219 RECORD(S) SELECTED

ENTER COMMAND >LIST

             15
AREA                 = 284,584.100
PERIMTER             =   2,826.175
LANDUSE#             =      15
LANDUSE-ID           =     427
TYPE                 =WATER
SYMBOL               =0

             16
AREA                 = 27637230.000
PERIMTER             =   76,376.460
LANDUSE#             =       16
LANDUSE-ID           =        2
TYPE                 =EXISTING RESIDENTIAL
SYMBOL               =0

             17

AREA                 = 1377873.000
PERIMETER            =   5,046.388
LANDUSE#             =      17
LANDUSE-ID           =     641
TYPE                 =EXISTING RESIDENTIAL
SYMBOL               =0

             18

AREA                 = 6.729903E+08
MORE?Y
PERIMETER            =   189,378.800
LANDUSE#             =        18
LANDUSE-ID           =       830
TYPE                 =RURAL RESIDENTIAL
SYMBOL               =0

             19
AREA                 = 62381060.000
PERIMETER            =   36,938.940
LANDUSE#             =       19
LANDUSE-ID           =      831
TYPE                 =MAJOR PARKS AND OPEN SPACE
SYMBOL               =0

             20
AREA                 = 1328766.000
PERIMETER            =   4,500.667
LANDUSE#             =      20
LANDUSE-ID           =     832
TYPE                 =MAJOR INSTITUTIONAL
SYMBOL               =0

             21
AREA                 = 1967917.000
PERIMETER            =    6,772.637
LANDUSE#             =       20
LANDUSE-ID           =      833
TYPE                 =EXISTING EMPLOYMENT
SYMBOL                =0
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	22	
AREA		= 1550757.000
PERIMETER		= 7,461.879
LANDUSE#		= 22
LANDUSE-ID		= 834
TYPE		=EXISTING EMPLOYMENT
SYMBOL		=0
	23	
AREA		=11639570.000
PERIMTER		= 17,471.360
LANDUSE#		= 23
LANDUSE-ID		= 826
TYPE		=EXISTING EMPLOYMENT
SYMBOL		=0
	24	
AREA		= 1086663.000
PERIMTER		= 3,948.396
LANDUSE#		= 24
LANDUSE-ID		= 825
TYPE		=COMMUNITY COMMERCIAL CENTER
SYMBOL		=0
	25	
AREA		=1.710875E+08
PERIMTER		= 87,620.970
LANDUSE#		= 25
LANDUSE-ID		= 829
TYPE		=DEVELOPING EMPLOYMENT
SYMBOL		=0

ENTER COMMAND >SEL TRF_GEN.POL.PAT C.2 MAJOR TRAFFIC GENERATORS
10 RECORD(S) SELECTED

ENTER COMMAND >LIST

1
AREA =-214,875,899.34008
PERIMETER = 160,222.33520
T R F GEN.POL# = 1
TRF-GEN.POL-ID = 0
NAME =
LOCATION =

2
AREA = 257,860.97256
PERIMETER = 2,033.24415
TRF_GEN.POL# = 2
TRF GEN.POL-ID = 8
NAME =-PROPOSED MALL
LOCATION =-ON REAMES RD. NEAR THE INTERSECTION OF I-77 AND REAMES RD, JU

3
AREA = 52,448,755.91003
PERIMETER = 34,051.77981
TRF_GEN.POL# = 3
TRF_GEN.POL-ID= 7
NAME = CENTRAL BUSINESS DISTRICT
LOCATION = UPTOWN CHARLOTTE, INSIDE THE LOOP OF THE BROOKSHIRE FREEWAY

4
AREA = 1,084,184 3360
MORE?Y =
PERIMETER = 4,339.41550
TRF_GEN.POL# = 4
TRF GEN.POL-ID = 6
NAME =PROPOSED NFL STADIUM
LOCATION =NEAR I-77, HAVING THE FOLLOWING BOUNDARIES; MINT=SOUTH STONEWA

5
AREA = 27,484,281.80176
PERIMETER = 324,174.91512
TRF-GEN.POL# = 5
TRF-GEN.POL-ID = 2
NAME =HERITAGE USA THEME PARK
LOCATION =APPROXIMATELY 1 MILE PAST THE NC LINE, IN SC, NEAR THE EAST S

6
AREA = 609,991.51097
PERIMETER = 3,209.30703
T'RF GEN.POL# = 6
TRF-GEN.POL-ID = 1
NAME =KNIGHTS STADIUM
LOCATION =INTERSECTION OF GOLD HILL RD AND I-77, IN S.C., APPRXIMATELY

7
AREA = 13,081,294.34999
PERIMETER = 14,044.82363
TRF GEN.POL# = 7
TRF-GEN.POL-ID = 5
NAME =CHARLOTTE COLISEUM
LOCATION =101 PAUL BUCK BLVD., NEAR TYVOLA AND YORKMOUNT, WEST OF I-77

8

AREA = 76,982,468.20864
PERIMETER = 36,096.32510
TRF GEN.POL# = 8
TRF-GEN.POL-ID = 4
NAME = ARROWOOD BUSINESS AREA
LOCATION = BETWEEN EXITS 1 AND 3 OFF OF I-77

9

AREA =40,971,895.73329
PERIMETER = 45,234.37800
TRF GEN.POL# = 9
TRFIGEN.POL-ID = 3
NAME = CAROWINDS
LOCATION = AT THE INTERSECTION OF CAROWINDS BLVD. AND I-77

10

AREA = 1,955,166.81923
PERIMETER = 5,716.97787
TRF_GEN.POL# = 10
TRF_GEN.POL-ID= 9
NAME =CAROLINA PLACE MALL
LOCATION =NEAR HWY 51 AT I-485, 1125 CAROLINA PLACE PARKWAY, IN PINEVIL

```
ENTER COMMAND >SEL PARK-RIDE.PTS.PAT
      6 RECORD(S) SELECTED

ENTER COMMAND >LIST
               1
AREA             =            0.00000
PERIMETER                     0.00000
PARK_RIDE.PTS#   = 1
PARK-RIDE.PTS-ID-  1
LOTS-            =SAV-A-LOT #1 (CITY-OWNED)
LOCATION         -LAWYERS RD. & IDLEWIDE ROAD NORTH
               2
AREA                          0.00000
PERIMETER        =            0.00000
PARK_RIDE.PTS#   = 2
PARK-RIDE.PTS-ID-  2
LOTS             =SAV-A-LOT #2 (CITY-OWNED)
LOCATION         -NORTHEAST CORNER OF PROVIDENCE & FAIRVIEW RD
               3
AREA             =            0.00000
PERIMETER        =            0.00000
PARK  RIDE.PTS#  = 3
PARK_RIDE.PTS-ID=    4
LOTS             =QUEENGATE SHOPPING CENTER
LOCATION         =WILKINSON BLVD. & ASHLEY RD.
               4
AREA             =            0.00000
MORE?
PERIMETER        =            0.00000
PARK  RIDE.PTS#  = 4
PARK_RIDE.PTS-ID=    5
LOTS             =EASTLAND MALL
LOCATION         -5471 CENTRAL AVENUE
               5
AREA                          0.00000
PERIMETER        =            0.00000
PARK_RIDE.PTS# =     5
PARK-RIDE.PTS-ID-    6
LOTS-            =CENTRAL CHURCH OF GOD
LOCATION         =5301 SARDIS ROAD
               6
AREA             =            0.00000
PERIMETER        5            0.00000
PARK  RIDE.PTS#  = 6
PARK-RIDE.PTS-ID-   3
LOTS-            -ARBORETUM SHOPPING CENTER
LOCATION         =PROVIDENCE ROAD & NC 51
```

```
ENTER COMMAND >LIST
               217
RECORD          =  27
ROUTE           = 10000077
MP              = 0268
COINCID         - 0
NUMVEH          - 2
YR CASE         = 89138745
YR-ACC          = 89
MONTH           =  9
DAY             = 10
REF ROAD        = 50000348
TOROAD          = 00000000
ROADON          = 10000077
DIST            =    4
DIR             = 1
DAYWK           = 7
TIME            = 1756
ACCTYPE         = 23
RDCOND          = 1
LIGHT           = 1
WEATHER         - 1
YLINE           = 0
PLOT            = 0
MORE?
TOTKACC         =  0
TOTAACC         =  0
TOTBACC         =  0
TOTCACC         =  0
VEH1            =  7
VEH2            = 1
VEH3            =  0
JUNK            =
ENDR            =
FIPS            =119
RTNUM           =00077
RTDESC          =0
RTENO           =119000770
EPDO            = 407
               218
RECORD          =  28
ROUTE           = 10000077
MP              = 0268
COINCID         = 0
NUMVEH          = 2
YR_CASE         = 89189037
YRACC           = 89
MONTH           = 11
MORE?
DAY             = 30
REF ROAD        = 50000348
TOROAD          = 50010605
ROADON          = 10000077
DIST            =    1
DIR             - 1
DAYWK           = 4
TIME            =  835
ACCTYPE         = 14
RDCOND          = 1
LIGHT           = 1
WEATHER         = 1
YLINE           = 0
PLOT            = 0
TOTKACC         = 0
TOTAACC         =  0
TOTBACC            0
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NUM-SYS = 17
ROAD_SYS =INDEPENDENCE BLVD. SYSTEM
SIGNAL# - 3
CONTROLLER -ON-LINE INTERSECTION CONTROLLER
498
AREA = 0.00000
PERIMETER = 0.00000
SIGNALS.PTS# = 498
SIGNALS.PTS-ID = 412
SYSTEM =ON-LINE SYSTEM ASSIGNMENTS
NUM-SYS -17
ROAD SYS =INDEPENDENCE BLVD. SYSTEM
SIGNAL# = 4
CONTROLLER -ON-LINE INTERSECTION CONTROLLER
499
AREA = 0.00000
PERIMETER = 0.00000
SIGNALS.PTS# = 499
SIGNALS.PTS-ID = 501
SYSTEM =
NUM SYS - 0
ROAD SYS =
SIGNAL# = 0
CONTROLLER -ISOLATED INTERSECTION CONTROLLER

```
ENTER COMMAND >SEL CNTRL.PTS.PAT
      3 RECORD(S) SELECTED

ENTER COMMAND >LIST
               1
AREA                          0.00000
PERIMETER                     0.00000
CNTRL.PTS#       =     1
CNTRL.PTS-ID           2
STATUS           -PROPOSED
DESCRIPTION      =NCDOT TRAFFIC CONTROL CENTER
LOCATION         =NE OF INTERCHANGE OF I-77 & PROPOSED OUTER LOOP
               2
AREA             =            0.00000
PERIMETER        =            0.00000
CNTRL.PTS#       =     2
CNTRL.PTS-ID     =     1
STATUS           -CURRENT
DESCRIPTION      -CHARLOTTE'S TRAFFIC CONTROL CENTER
LOCATION         -600 EAST TRADE STREET
               3
AREA             =            0.00000
PERIMETER                     0.00000
CNTRL.PTS#             3
CNTRL.PTS-ID           3
STATUS           -CURRENT
DESCRIPTION      -TEMPORARY NCDOT TRAFFIC OPERATIONS CENTER
MORE?Y
LOCATION         -1436 EAST INDEPENDENCE BLVD.
```

TOTCACC	= 0
VEH1	= 1
VEH2	= 1
VEH3	= 0
JUNK	=
ENDR	=
MORE?	
FIPS	=119
RTNUM	=00077
RTDESC	=0
RTENO	=119000770
EPDO	= 407

491
AREA 0.00000
PERIMETER 0.00000
SIGNALS.PTSt = 491
SIGNALS.PTS-ID = 274
SYSTEM -ON-LINE SYSTEM ASSIGNMENTS
NUM-SYS = 3
ROAD SYS -CENTRAL AVE. SYSTEM
SIGNAL# -10
CONTROLLER =ON-LINE INTERSECTION CONTROLLER

492
AREA = 0.00000
PERIMETER 0.00000
SIGNALS.PTS# = 492
SIGNALS.PTS-ID = 275
SYSTEM -ON-LINE SYSTEM ASSIGNMENTS
NUM-SYS = 3
ROAD_SYS =CENTRAL AVE. SYSTEM
SIGNAL# =11
CONTROLLER =ON-LINE INTERSECTION CONTROLLER

493
AREA 0.00000
PERIMETER 0.00000
SIGNALS.PTS# = 493
SIGNALS.PTS-ID = 500
SYSTEM -ON-LINE SYSTEM ASSIGNMENTS
NUM-SYS = 3
ROAD_SYS =CENTRAL AVE. SYSTEM
SIGNAL# -12
CONTROLLER -ON-LINE INTERSECTION CONTROLLER

494
AREA 0.00000
PERIMETER 0.00000
SIGNALS.PTS# = 494
SIGNALS.PTS-ID = 402
SYSTEM =ON-LINE SYSTEM ASSIGNMENTS
NUM_SYS = 3
ROAD_SYS -CENTRAL AVE. SYSTEM
SIGNAL# =13
CONTROLLER -ON-LINE INTERSECTION CONTROLLER

495
AREA 0.00000
PERIMETER = 0.00000
SIGNALS.PTS# = 495
SIGNALS.PTS-ID = 427
SYSTEM -ON-LINE SYSTEM ASSIGNMENTS
NUM_SYS =17
ROAD_SYS -INDEPENDENCE BLVD. SYSTEM
SIGNAL# - 1
CONTROLLER -ON-LINE MASTER & INTERSECTION CONTROLLER

496
AREA 0.00000
PERIMETER 0.00000
SIGNALS.PTS# = 496
SIGNALS.PTS-ID = 416
SYSTEM -ON-LINE SYSTEM ASSIGNMENTS
NUM SYS =17
ROAD SYS =INDEPENDENCE BLVD. SYSTEM
SIGNAL# - 2
CONTROLLER -ON-LINE INTERSECTION CONTROLLER

497
AREA = 0.00000
PERIMETER 0.00000
SIGNALS.PTS# = 497
SIGNALS.PTS-ID = 417
SYSTEM --ON-LINE SYSTEM ASSIGNMENTS

```
ENTER COMMAND >SEL CAMERAS.PTS.PAT
      7 RECORD(S) SELECTED

ENTER COMMAND >LIST
              1
AREA           =            0.00000
PERIMETER                   0.00000
CAMERAS.PTS#   =     1
CAMERAS.PTS-ID  = 1
STATUS         -CURRENT
              2
AREA           =            0.00000
PERIMETER                   0.00000
CAMERAS.PTS#   =     2
CAMERAS.PTS-ID  = 2
STATUS         -CURRENT
              3
AREA           =            0.00000
PERIMETER                   0.00000
CAMERAS.PTS#   =     3
CAMERAS.PTS-ID  = 4
STATUS         -CURRENT
              4
AREA                        0.00000
PERIMETER      =            0.00000
CAMERAS.PTS#    = 4
CAMERAS.PTS-ID  = 5
MORE?Y
STATUS         -CURRENT
              5
AREA           =            0.00000
PERIMETER                   0.00000
CAMERAS.PTS#   =     5
CAMERAS.PTS-ID  = 7
STATUS           =
              6
AREA                        0.00000
PERIMETER                   0.00000
CAMERAS.PTS#  =    6
CAMERAS.PTS-ID =    3
STATUS        =PROPOSED
              7
AREA                        0.00000
PERIMETER        =          0.00000
CAMERAS.PTS#    = 7
CAMERAS.PTS-ID  = 6
STATUS        -PROPOSED
```

```
ENTER COMMAND >SEL BUSPRE.PTS.PAT
      9 RECORD(S) SELECTED

ENTER COMMAND >IT
DATAFILE NAME: BUSPRE.PTS.PAT                                    01/08/1993
   5 ITEMS: STARTING IN POSITION     1
COL ITEM NAME          WDTH OPUT TYP N.DEC ALTERNATE NAME
   1  AREA                8    18F    5
   9  PERIMETER           8    18F    5
  17  BUSPRE.PTS#         4      5B   -
  21  BUSPRE.PTS-ID       4      5B   -
  25  SIGNAL             10    10C    -

ENTER COMMAND >LIST
              1
AREA           =           0.00000
PERIMETER      =           0.00000
BUSPRE.PTS#          1
BUSPRE.PTS-ID        1
SIGNAL         =ROSEHAVEN
              2
AREA           =           0.00000
PERIMETER                  0.00000
BUSPRE.PTS#    =     2
BUSPRE.PTS-ID        2
SIGNAL         =KILBORNE
              3
AREA                       0.00000
PERIMETER      =           0.00000
BUSPRE.PTS#    =    3
BUSPRE.PTS-ID  =    3
SIGNAL         =EASTWAY
              4
AREA           =           0.00000
PERIMETER                  0.00000
BUSPRE.PTS#          4
BUSPRE.PTS-ID        4
MORE?Y
SIGNAL         -BRIAR CRK
              5
AREA           =           0.00000
PERIMETER                  0.00000
BUSPRE.PTS#          5
BUSPRE.PTS-ID        5
SIGNAL         =THE PLAZA
              6
AREA                       0.00000
PERIMETER                  0.00000
BUSPRE.PTS#          6
BUSPRB.PTS-ID        6
SIGNAL         =THOMAS
              7
AREA                       0.00000
PERIMETER      =           0.00000
BUSPRE.PTS#          7
BUSPRE.PTS-ID  =     7
SIGNAL         -PECAN
              8
AREA                       0.00000
PERIMETER                  0.00000
BUSPRE.PTS#    =     8
BUSPRE.PTS-ID  =     8
SIGNAL         =HAWTHORNE
              9
AREA           =           0.00000
PERIMETER      =           0.00000
```

```
BUSPRE.PTS#       = 9
BUSPRE.PTS-ID   = 9
SIGNAL           -LOUISE
```

ENTER COMMAND >SEL ALT.RTS.AAT

333 RECORD(S) SELECTED

ENTER COMMAND >LIST WOLEST,ROUTE,AAWT 91,CAPACITY_89,V_C_RATIO, LOS

$RECNO	WHOLEST	ROUTE	AAWT_91	CAPACITY_89	V_C_RATIO	LOS
1	N I-85 Hy	119000850	68,000	60,000	1.13	F
2	N I-85 Hy	119000850	68,000	60,000	1.13	F
3	N I-85 Hy	119000850	68,000	60,000	1.13	F
4	N I-85 Hy	119000850	68,000	60,000	1.13	F
5	N I-85 Hy	119000850	68,000	60,000	1.13	F
6	N I-85 Hy	119000850	68,000	60,000	1.13	F
7	N I-85 Hy	119000850	68,000	60,000	1.13	F
8	N I-85 Hy	119000850	68,000	60,000	1.13	F
9	Brookshire Bv	0	0	0	0.00	
10	Brookshire Bv	0	0	0	0.00	
11	N I-85 Hy	119000850	68,000	60,000	1.13	F
12	N I-85 Hy	119000850	68,000	60,000	1.13	F
13	Brookshire Bv	0	0	0	0.00	
14	Brookshire Bv	0	0	0	0.00	
15	W Brookshire Fr	0	0	0	0.00	
16	S I-85 Hy	119000850	68,000	60,000	1.13	F
17	S I-85 Hy	0	68,000	60,000	1.13	F
18	S I-85 Hy	0	68,000	60,000	1.13	F
19	S I-85 Hy	0	68,000	60,000	1.13	F
20	S I-85 Exit 35 Ra	0	68,000	60,000	1.13	F
21	S I-85 Hy	119000850	68,000	60,000	1.13	F
22	W Brookshire Fr	0	0	0	0.00	

MORE?

23	W Brookshire Fr	0	0	0	0.00	
24	W Brookshire Fr	0	0	0	0.00	
25	S-I-85 Hy	119000850	68,000	60,000	1.13	F
26	S-I-85 Hy	119000850	68,000	60,000	1.13	F
27	S-I-85 Hy	119000850	68,000	60,000	1.13	F
28	W Brookshire Fr	0	0	0	0.00	
29	S-I-85 Hy	119000850	68,000	60,000	1.13	F
30	S-I-85 Hy	119000850	68,000	60,000	1.13	F
31	W Brookshire Fr	0	0	0	0.00	
32	S-I-85 Hy	119000850	68,000	60,000	1.13	F
33	W Brookshire Fr	0	0	0	0.00	
34	S-I-85 Hy	119000850	68,000	60,000	1.13	F
35	W Brookshire Fr	0	0	0	0.00	
36	W Brookshire Fr	0	0	0	0.00	
37	S-I-85 Hy	119000850	68,000	60,000	1.13	F
38	S-I-85 Hy	119000850	68,000	60,000	1.13	F
39	W Brookshire Fr	0	0	0	0.00	
40	W Brookshire Fr	119002770	0	90,000	0.00	

C.10 TRANSPORTATION IMPROVEMENT PLAN (Roadway Projects)

```
ENTER COMMAND >SEL MECK.TIP.AAT
    580 RECORD(S) SELECTED

ENTER COMMAND >LIST
                1
FNODE#          =    69
TNODE#          =    29
LPOLY#          =    -1
RPOLY#          =    -1
LENGTH          =       1,982.05070
MECK.TIP#       =      1
MECK.TIP-ID     =44596
TYPE            =0
OLD-ID          =     0
ST DIR          =
ST-NAME         =I-77
ST-TYPE         =HY
LL-ADD          =21401
WL-ADD          =21999
LR-ADD          =21400
UR-ADD          =21998
ST-CODE         =44,430
FLAG            =0
TIP-ID          =I-2716
LOCATION        =I-77,  I-85 TO IREDELL COUNTY LINE
DESCRIPTION     -SAFETY  WORK
MILES           =16.7
MORE?
KMETERS         =26.9
EST COST        =    21,000
PRIOR_COST      =    21,000
PLN-FUND        =
PLN COST        =       0
PLN-BEGIN       =
PLN-END         =
DSN-FUND        =
DSN-COST        =       0
DSN-BEGIN       =
DSN-END         =
ROW-FUND        =
ROW-COST        =       0
ROW-BEGIN       =
ROW-END         =
CNST_ FUND      =IM
CNST-COST       =       0
CNST-BEGIN      =10/92
CNST_END        =01/93
                2
FNODE#          = 71
TNODE#          = 69
LPOLY#          = -1
MORE?
RPOLY#          =  -1
LENGTH          =           78.46417
MECK.TIP#       =    2
MECK.TIP-ID     = 44596
TYPE            =0
OLD-ID              0
ST DIR          =
ST-NAME         =
ST-TYPE
LL-ADD          =    0
UL-ADD          =    0
LR-ADD          =    0
UR-ADD          =    0
ST_CODE         =      0
```

FLAG =0
TIP-ID =I-2716
LOCATION =I-77, I-85 TO IREDELL COUNTY LINE
DESCRIPTION -SAFETY WORK
MILES =16.7
KMETERS =26.9
EST-COST 21,000
PRIOR COST 21,000
PLN FUND =
MORE?
PLN-COST = 0
PLN-BEGIN =
PLN END =
DSN-FUND =
DSN-COST = 0
DSN-BEGIN =
DSN-END =
ROW-FUND
ROW-COST = 0
ROW-BEGIN
ROW-END
CNST FUND =IM
CNST-COST =10/92 0
CNST-BEGIN
CNST_END =01/93
3
FNODE# = 98
TNODE# 71
LPOLY# -1
RPOLY# -1
LENGTH 921.55291
MECK.TIP# 3
MECK.TIP-ID -44596
MORE?
TYPE -0
OLD-ID 0
ST-DIR 3
ST-NAME =1-77
ST TYPE =HY
LL-ADD =21401
UL-ADD =21999
LR ADD =21400
OR-ADD =21998
ST_CODE = 44,430
FLAG =0
TIP-ID -1-2716
LOCATION =I-77, I-85 TO IREDELL COUNTY LINE
DESCRIPTION -SAFETY WORK
MILES =16.7
KMETERS =26.9
EST-COST 21,000
PRIOR-COST = 21,000
PLN FUND
PLN-COST 0
PLN-BEGIN
PLN-END =
DSN-FUND =
MORE?
DSN COST = 0
DSN-BEGIN =
DSN-END =
ROW-FUND
ROW-COST
ROW-BEGIN
ROW-END
CNST_FUND =IM

CNST_COST	0
CNST BEGIN	=10/92
CNST_END	=01/93

7

MORE?	
FNODE#	= 373
TNODE#	= 332
LPOLY#	= -1
RPOLY#	= -1
LENGTH	= 2,031.41314
MECK.TIP#	7
MECK.TIP-ID	=49871
TYPE	=0
OLD-ID	=0
ST DIR	
ST-NAME	=TORRENCE CHAPEL
ST-TYPE	=RD
LL-ADD	-20501
UL-ADD	-20899
LR-ADD	-20500
UR-ADD	-20898
ST-CODE	= 88,670
FLAG	-0
TIP-ID	-R-2555
LOCATION	=SR 2195 (TORRENCE CHAPEL ROAD)
DESCRIPTION	-UPGRADE AND REALIGN INTERSECTION WITH NC 73
MILES	= 1.1
KMETERS	= 1.8
MORE?	
EST-COST	= 8,575,000
PRIOR-COST	= 1,300,000
PLN_FUND	
PLN COST	0
PLN-BEGIN	=01/95
PLN-END	=09/96
DSN-FUND	
DSN-COST	= 0
DSN-BEGIN	=10/96
DSN-END	=00/99
ROW-FUND	=STP
ROW-COST	= 5000000
ROW-BEGIN	=04/98
ROW-END	=00/99
CNST FUND	=S
CNST-COST	0
CNST-BEGIN	=10/92
CNST_END	=09/93

C.ll TRANSPORTATION
IMPROVEMENT PLAN
(Bridge Projects)

```
ENTER COMMAND >SEL MECK.TIP.PAT
      5 RECORD(S) SELECTED

ENTER COMMAND >LIST
                 1
AREA                          0.00000
PERIMETER                     0.00000
MECK.TIP#              1
MECK.TIP-ID      =     1
TIP-ID           -B-1193
LOCATION         =NC 27
DESCRIPTION      -REPLACE BRIDGE NO. 66 OVER CATAWBA RIVER
EST COST         = 3,158,000
PRIOR COST       =    50,000
PLN_FUND         =
PLN-COST         =       0
PLN_BEGIN        =
PLN END          =
DSN-FUND         =
DSN-COST         =       0
DSN-BEGIN        =
DSN-END          =
ROW-FUND         =FA
ROW-COST         = 508,000
ROW-BEGIN        =
ROW-END          =
CNST FUND        =FA
MORE?
CNST COST        = 2600000
CNST-BEGIN
CNST_END
                 2=
AREA                          0.00000
PERIMETER                     0.00000
MECK.TIP#        =     2
MECK.TIP-ID      =     2
TIP-ID           =B-3004
LOCATION         =NC 49
DESCRIPTION      =REPLACE BRIDGE NO. 23 OVER CATAWBA RIVER
EST COST         = 9,200,000
PRIER-COST                 0
PLAN_FUND        =
PLN-COST         =       0
. PLN BEGIN      =
PLN-END
DSN-FUND         =
DSN-COST                 0
DSN-BEGIN
DSN-END
ROW-FUND         =FA
ROW-COST         = 100,000
MORE?Y
ROW BEGIN
ROW-END
CNST FUND        =FA
CNST-COST        = 4550000
CNST-BEGIN
CNST_END
                 3
AREA             =            0.00000
PERIMETER        =            0.00000
MECH.TIP#        =     3
MECK.TIP-ID      =     3
TIP-ID           =B-2056
LOCATION         =SR 2110
DESCRIPTION      -LONG CREEK. REPLACE BRIDGE NO. 104 WITH CULVERT
```

EST-COST		242,000
PRIOR-COST	=	5,000
PLN_FUND		
PLN COST	=	0
PLN-BEGIN		
PLN-END	=	
DSN-FUND	=	
DSN-COST		0
DSN-BEGIN		
DSN-END	=	
ROW-FUND	=NFA	
ROW-COST	=	12,000
ROW-BEGIN	=	
ROW-END	=	
CNST FUND	=NFA	
CNST-COST	=	225,000
CNST-BEGIN	=	
CNST_END		

```
ENTER COMMAND >SEL CTIP.ARC.AAT
      91 RECORD(S) SELECTED
```

C.12 'CHARLOTTE IMPROVEMENT PLAN (Roadway Projects)

```
 ENTER COMMAND >LIST PROJECT,MILES,CNST-FFY,COST,RESPONSIBLE
                1
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST-FFY        -1990
 COST            = 6100000
 RESPONSIBLE     -CITY
                2
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST FFY        -1990
 COST-           = 6100000
 RESPONSIBLE     -CITY
                3
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST FFY        -1990
 COST-           = 6100000
 RESPONSIBLE     -CITY
                4
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST FFY        -1990
 COST-           = 6100000
 MORE?
 RESPONSIBLE     -CITY
                5
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST-FFY        '-1990
 COST            = 6100000
 RESPONSIBLE     -CITY
                6
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST-FFY        -1990
 COST            = 6100000
 RESPONSIBLE     -CITY
                7
 PROJECT         -WESTINGHOUSE BLVD EXTENSION (US 521 TO OLD NATIONS FORD RD)
 MILES           = 0.8
 CNST-FFY        -1990
 COST            = 6100000
 RESPONSIBLE     -CITY
                8
 PROJECT         =I-77/ARROWOOD ROAD INTERCHANGE IMPROVEMENTS
 MILES           = 0.0
 CNST-FFY        -1990
 MORE?
 COST            -15800000
 RESPONSIBLE     -STATE
                9
 PROJECT         =I-77/ARROWOOD ROAD INTERCHANGE IMPROVEMENTS
 MILES           = 0.0
 CNST FFY        -1990
 COST-           -15800000
 RESPONSIBLE     -STATE
               10
 PROJECT         -I-77/ARROWOOD ROAD INTERCHANGE IMPROVEMENTS
 MILES           = 0.0
 CNST FFY        -1990
 COST-           -15800000
 RESPONSIBLE     -STATE
```

```
ENTER COMMAND >SEL CHAR_TIP.PAT
      68 RECORD(S) SELECTED

 ENTER COMMAND >LIST
               1
 AREA            =          0.00000
 PERIMETER       =          0.00000
 CHAR TIP#       =    1
 CHAR-TIP-ID     =    1
 INTERSECTION    =SOUTH BLVD/TYVOLA
 DESCRIPTION     -DUAL LEFT-TURN LANES ON NB SOUTH BLVD APPROACH;RIGHT-TURN LAN
 INTER TYPE      -MAJOR
 STATUS          =COMPLETE
 FY92-93 COST           0
 FY92-93 WORK    =
 FY93-94-COST    =      0
 FY93-94-WORK    =
 FY94-95-COST    =      0
 FY94-95-WORK
 FY95-96-COST    =      0
 FY95-96-WORK    =
 FY96-97-COST    =      0
 FY96-97zWORK    =
 TOTAL-COST      =       0
            2
 AREA            =          0.00000
 PERIMETER       =          0.00000
 MORE? Y
 CHAR TIP#            2
 CHAR-TIP-ID          2
 INTERSECTION    -SOUTH  BLVD./SCALEYBARK
 DESCRIPTION     -REALIGN OLD PINEVILLE & SCALEYBARK: MAKE RIGHT-TURN LANE ON S
 INTER-TYPE      -MAJOR
 STATUS          -COMPLETE
 FY92-93 COST           0
 FY92-93-WORK    =
 FY93-94-COST    =      0
 FY93-94-WORK
 FY94-95-COST           0
 FY94-95-WORK    =
 FY95-96-COST           0
 FY95-96-WORK    =
 FY96-97-COST    =      0
 FY96-97-WORK    =
 TOTAL-CSST     =       0

 AREA                       0.00000
 PERIMETER                  0.00000
 CHAR TIP#            3
 CHAR-TIP-ID     =    3
 INTERSECTION    -CENTRAL/THE  PLAZA
 DESCRIPTION     -LEFT-TURN LANE ON WESTBOUND CENTRAL APPROACH
 INTER-TYPE      -MAJOR
 STATUS          -COMPLETE
 FY92-93-COST           0
FY92-93 WORK
 FY93-94-COST    =      0
 FY93-94-WORK    =
 FY94-95-COST    =      0
 FY94-95-WORK    =
 FY95-96-COST    =      0
 FY95-96-WORK    a
 FY96-97-COST           0
 FY96-97rWORK    =
 TOTAL-COST             0
```

9

AREA	=	0.00000
PERIMETER	=	0.00000
CHAR TIP#	9	
CHAR-TIP-ID	9	
INTERSECTION	-ARCHDALE/SOUTH BLVD	
DESCRIPTION'		
INTER TYPE	=MAJOR	
STATUS	-PROPOSED	
FY92-93 COST	= 220,000	
FY92-93-WORK	-DESIGN	
FY93-94-COST	= 880,000	
FY93-94-WORK	=LAND ACQUISITION	
FY94-95-COST	= 1550000	
FY94-95-WORK	-CONSTRUCTION	
FY95-96-COST	= 160,000	
FY95-96-WORK	-LANDSCAPING	
FY96-97-COST	= 0	
FY96-97zWORK	=	
TOTAL-COST	= 2810000	

APPENDIX D

IVHS INITIATIVES FOR NORTH CAROLINA

TABLE D.l

RATING OF IMPORTANCE OF IVHS INITIATIVES. 1992

INITIATIVES	CONSENSUS RATING'	TRAF.ENG. GROUP	STWDE. PLAN.	AdHoc GROUP	MPO GROUP	ENTPRS. GROUP	CVO GROUP
ATMS							
Surveil.-Freeways	1	1	1	1	1	1	3
Surveil.-Arterial8	2	2	2	1	2	2	3
Freeway Mgt.	2	3	3	2	2	2	2
Arterial Mgt.	3	3	3	2	2	3	2
Coordination	3	1	3	4	3	2	1
Documentation	2	2	3	2	2	2	3
Congestion Mgt.	2	2	2	1	2	2	1
Incident Mgt.	1	1	2	2	1	1	1
Verification	2	2	2	3	3	1	3
Reduce Accidents	1	1	2	1	1	2	1
Focal Point	3	3	2	3	3	2	2
Tech. Transfer	4	4	3	4	4	2	4
Air Quality	3	2	3	3	4	3	*
NHS/TCP	4	3	2	4	5	3	4
Coor. Enf./ Emerg.	1	1	2	2	1	2	1
Coor. Const/Maint.	2	2	*	3	2	2	1
Coor. Local Events	3	1	*	4	3	2	2
TMS Enhancement	4	3	4	4	4	3	2
ATIS							
Route Guidance	3	3	3	3	3	3	3
Congst. Avoidance	2	2	2	1	1	2	
Safety Awareness	2	1	3	2	2	2	1,: 1/
Incid/Congst Rept.	2	2	3	2	1	1	3
Trip Planning	4	5	3	4	5	2	5
Traveler Advisory	3	3	3	3	4	2	2
Warning Systems	3	3	3	3	2	2	1
Human Factors	3	3	3	4	4	2	3
P-way Communication	4	5	3	4	5	3	3
Envir. Monitoring	3	3	3	3	4	3	2
AVCS							
In-vehicle Guidance	4	5	3	5	2	3	5
Vehicle Controls	4	5	3	5	1	3	5
Communication	3	4	3	4	3	3	5
Fully Automated Hwys.	5	5	4	5	5	4	5
CVO							
Real Time Monitor	2	2	3	3	1	2	3
Vehicle/Cargo Monit.	3	3	3	4	2	2	5
Route Planning/Sch.	4	4	2	5	3	2	4
Law Enf./Regulatory	2	2	2	1	2	3	5/1 2/
Private Sector Part.	2	3	2	2	3	2	*
Interstate Coop/Stand	3	3	3	1	5	2	1
Human Factors Enhan.	3	3	*	3	3	3	2
APTS							
Route Scheduling/Info	3	4	3	1	2	2	* 3/
Auto. Fare Collection	4	5	2	3	3	3	*
Dynamic Ride Sharing	3	4	3	2	4	2	*
Signal Preemption	3	3	3	2	2	3	*
Security Systems	3	3	4	3	3	3	*
Congestion Pricing	4	4	3	4	1	4	*
Fleet Management	3	4	*	3	3	2	*
Human Factor Enhanc.	3	3	*	3	5	3	*

TABLE D.2

RATING OF IMPORTANCE OF IVHS INITIATIVES 1997

INITIATIVES	CONSENSUS RATING	TRAF.ENG. GROUP	STWDE. PLAN.	AdHoc GROUP	MPO GROUP	ENTPRS. GROUP	CVO GROUP
ATMS							
Surveil.-Freeways	1	1	2	1	1	1	3
Surveil.-Artials	2	1	2	1	2	2	3
Freeway Mgt.	2	2	2	2	2	2	2
Arterial Mgt.	2	2	3	2	2	3	2
Coordination	2	1	3	3	3	2	1
Documentation	2	1	4	2	2	2	3
Congeetion Mgt.	1	1	2	1	2	1	1
Incident Mgt.	1	1	3	2	1	2	1
Verification	2	1	2	2	3	2	3
Reduce Accidents	1	1	2	1	1	2	1
Focal Point	2	2	3	2	3	1	2
Tech. Transfer	3	3	3	3	3	1	4
Air Quality	3	2	4	3	3	2	*
NHS/TCP	4	2	2	4	5	3	4
Coor. Enf./Emerg.	1	1	3	1	1	2	1
Coor. Const/Maint.	2	1	*	2	2	2	1
Coor. Local Events	3	1	*	3	3	2	2
TMS Enhancement	3	2	3	1	3	3	2
ATIS							
Route Guidance	3	3	3	2	3	2	3
Congst. Avoidance	2	2	2	1	1	2	1
Safety Awareness	2	1	3	1	2	1	1/3
Incid/Congst Rept.	2	2	2	1	1	1	3
Trip Planning	4	4	3	2	5	2	3
Traveler Advisory	2	2	2	2	2	2	2
Warning Systems	3	3	3	2	2	2	1
Human Factors	4	3	4	3	4	2	3
2-way Communication	4	3	4	3	3	2	3
Envir. Monitoring	3	3	4	2	4	2	2
AVCS							
In-vehicle Guidance	3	4	2	4	2	2	3
Vehicle Controls	2	3	2	4	1	2	3
Communication	3	3	3	3	3	2	3
Fully Automated Hwys.	4	4	3	5	5	3	5
CVO							
Real Time Monitor	2	2	3	2	1	2	1
Vehicle/Cargo Monit.	3	2	3	2	2	2	5
Route Planning/Sch.	3	3	3	3	3	2	2
Law Enf./Regulatory	2	3	2	1	2	3	5/1
Private Sector Part.	2	2	3	2	3	2	*
Interstate Coop/Stand	3	2	3	1	5	1	1
Human Factors Enhan.	2	2	*	3	3	2	2
APTS							
Route Scheduling/Info	2	3	3	1	2	2	*
Auto. Fare Collection	3	4	3	1	3	2	*
Dynamic Ride Sharing	3	4	3	2	4	2	*
Signal Preemption	2	2	3	2	2	3	*
Security Systems	3	3	4	3	3	3	*
Congestion Pricing	2	3	2	2	1	4	*
Fleet Management	3	3	*	3	3	2	*
Human Factor Enhanc.	3	3	*	2	5	3	*

NOTES ON TABLES D.1 AND D-2

CATEGORIES OF IVHS INITIATIVES/TECHNOLOGIES:

ATMS - Advanced Traffic Management Systems
ATIS - Advanced Traveler Information Systems
AVCS - Advanced Vehicle Control Systems
CVO - Commercial Vehicle Operations
APTS - Advanced Public Transportation Systems

FOCUS GROUPS USED IN RATING PROCESS:'

Traf.Eng.	- Traffic Engineering Branch, NCDOT
Stwde.Plan.	- Statewide Planning Branch, NCDOT
AdHoc	- Focus group consisting of Public Transp. Div., Emerging Issues Off., Div. of Motor Vehicles, Research Unit, Policy and Programs Branch; all from the NCDOT
MPO	- Metropolitan Planning Organization technical staff from Charlotte/Mecklenburg
Entprs.	- ENTERPRISE group, a seven state, international research consortium, of which NCDOT is a member
CVO	- Commercial Vehicle Operations group, consisting of trucking company executives from the Charlotte Region, and the Executive Director of the N.C. Trucking Association

OTHER NOTES:

1/ Lower rating for VMS used as "Safety Message Signs"

2/ Higher rating for DMV "One Stop Service" for the trucking industry .

3/ Technologies not assessed by a particular Focus Group are identified with a "*"

TABLE D.3

TECHNOLOGIES TO ADDRESS IVHS INITIATIVES

ATMS

INITIATIVES	TECHNOLOGIES
1. Real Time Surveillance Detection and Data Collection for freeways and arterials	1, 2, 5, 6, 10, 17, 20, 21, 25, 44
2. a) Freeway Traffic Flow Management	1, 5, 6, 7, 10, 17, 22, 27, 28, 30, 31, 33, 34, 44
b) Arterial Traffic Flow Management	2, 5, 6, 8, 9, 10, 17, 22
3. Coordination of Arterials with Freeway Flow through Signal Control	1 - 7, 10, 44
4. Documentation and Analysis of Data	1, 2, 19, 24, 26b, 29, 33, 44
5. Congestion Management	1 - 6, 10 - 14, 18, 20, 21, 27, 28, 30, 31, 33, 34, 36, 37, 43, 44
6. Incident Management	1, 4, 5, 6, 15, 16, 18, 20, 21, 26a, 26b, 27, 28, 32, 44
7. Congestion, Incident & Accident Verification	1, 2, 5, 6, 15, 16, 17, 20, 21, 26a, 26b, 32, 44
8. Accident/Injury Severity Reduction	1, 3, 4, 18, 26, 38 - 42

INITIATIVES	TECHNOLOGIES
9. Focal Point for Area-Wide Congestion Management/Incident Management (Control Center)	0, 1, 2, 33, 35
10. Technology Transfer for IVHS	(Management Strategy)
11. Regional Air Quality Enhancement Program Support	1, 2, 3, 18, 25, 33, 35
12. Integration of National Highway System and Statewide Traffic Control Plans	1, 3, 25, 29, 33, 35
13. a) Coordination with Enforcement & Emergency Responders	0, 4, 20, 21, 26b, 32, 35, 38 - 42
b) Coordination with Roadway Construction & Maintenance Scheduling	0, 4, 7, 18, 22, 32
c) Coordination with local Special Events	0, 3, 4, 7, 18, 32, 35
14. Upgrading of Traffic Management Software	22, 23, 24, 29, 33, 35

ATIS

INITIATIVES	TECHNOLOGIES
1. Route Guidance	18, 30 - 35, 39 - 42, 44 - 66
2. Congestion Avoidance	45 - 66, (All ATMS Technologies for Initiative #5 Apply)
3. Safety Awareness	65, 66, (All ATMS Technologies for Initiative #8 Apply)
4. Incident/Congestion Reporting	45, 50, 65, 66, (All ATMS Technologies for Initiative #4 Apply)
5. Trip Planning	45 - 66
6. Traveler Advisory/ Information Services	45 - 53, 59 - 61
7. Warning/ "MAYDAY" Communications	15 - 18, 20, 21, 32, 38, 39 - 42
8. Human Factors Analysis	0, 1; 2, 26b, 45, 66
9. Two-way Communications	20, 21, 32, 38, 45, 59 - 62, 65
10. Environmental Monitoring & Reporting	32, 38, 39 - 42, 65

CVO

INITIATIVES	TECHNOLOGIES
1. Real Time Operational Safety and Efficiency Monitoring	72, 81, 85 - 88, 90 - 92, 94, 96
2. Vehicle and Cargo Monitoring	36, 67, 68, 70 - 72, 74, 88
3. Route Planning and Scheduling	55 - 57, 62, 63, 70, 73, 89, 93, 95
4. Law Enforcement and Regulatory Support	17, 19, 36, 67 - 69
5. Private Sector Participation	(Management Strategy)
6. Interstate Cooperation and Standardization	(Management Strategy)
7. Human Factors Enhancements	(All ATIS Technologies for Initiative #8 Apply)

The majority of technologies that apply to ATMS/ATIS Initiatives also apply to CVO Initiatives.

APTS

INITIATIVES	TECHNOLOGIES
1. Route Scheduling/ Arrival and Departure Information	77, 79, 70, 83
2. Automatic Fare Collection	76, 77, 83
3. Dynamic Ride Sharing	77, 79, 80, 83
4. Signal Preemption Systems	75, 83
5. Security Systems	78, 81, 83
6. Congestion Pricing	76, 83
7. Fleet Management Improvements	82, 83
8. Human Factors Enhancements	83 (All ATIS Technologies for Initiative #8 Apply)

The majority of Technologies that apply to ATMS and ATIS Initiatives also apply to APTS Initiatives.

AVCS

INITIATIVES	TECHNOLOGIES
1. In-vehicle Route Guidance	54 - 57, 63, 68, 73, 89, 91 - 93, 95
2. Vehicle Control Enhancement	84 - 89, 90 - 92
3. Vehicle-to-Vehicle and Roadside-to-Vehicle Communications	72, 87, 91, 92, 95
4. Fully Automated Highways	(All AVCS Technologies Apply)

The majority of technologies that apply to ATMS/ATIS Initiatives also apply to AVCS Initiatives.

TABLE D.4

IVHS TECHNOLOGY LIST

<u>Advanced Traffic Management Systems (ATMS) Technologies</u>

TABLE D.4 (Continued)

IVHS TECHNOLOGIY LIST

ATIS (Technologies in Addition to ATMS)

TABLE D.4

IVHS TECHNOLOGY LIST

APTS*

AVCS

* Note: CVO, APTS, and AVCS will also include many ATMS and ATIS technology.

SECTION D.5

IVHS TECHNOLOGIES: DEFINITIONS

TABLE D.4

IVHS TECHNOLOGY LIST

APTS*

AVCS

* Note: CVO, APTS, and AVCS will also include many ATMS and ATIS technology.

TOCEN

0. TRAFFIC OPERATIONS CENTER

Technological advances in centralized operations have been made possible because of improvements in sensors, communications, information processing, computer and data display systems, automated support for human decision-making, and automated control. These improvements are used to increase network efficiency and provide information to motorists. The qualities that operations systems must possess are:

1) A means of detection to determine the status of the system.

2) A procedure for responding to system demands and modifying system configuration and operation.

3) A centralized control facility to receive information on system status, determine the appropriate response, and then execute the appropriate control strategy.

Traffic Operations Centers (TOC) let highway operations benefit from centralized control. Information on roadway conditions is available to controllers at the center, who take action in response to identified problems. Operations centers are like control centers in most respects, with additional functions in operations centers such as dispatching incident response teams, combined operations locations for emergency response and enforcement teams, colocated highway maintenance units, traffic services units, etc.

SOURCE:

"The Caltrans/Cal Poly Traffic Operations Center Simulator ," Stephen Hockaday, Edward Sullivan, Samuel Taff, and Clinton Staley, REPRINT, January 1992.

FTCC

1. FREEWAY TRAFFIC CONTROL CENTERS

Freeway traffic control centers (TCC) usually deal with operational planning, surveillance, control systems, and incident management. Since the freeways usually carry more vehicle-miles of travel per lane-mile of highway than any other highway class, incident management is a significant part of freeway control. Quick incident management techniques are needed to clear congested areas and return to normal conditions. The basic ideas of incident management are detection, response, on-site management, clearance, and return to normal flow. The strategy is to first restrict other vehicles from approaching the scene, which prevents further build-up from occurring. To do this, ramp metering, gating, or route guidance techniques can be applied.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

CSSACC

2. COORDINATED SIGNAL SYSTEM/ARTERIAL CONTROL CENTER

Metropolitan area-wide traffic can be managed more effectively by coordinating the control functions of freeways and arterials throughout the most broad area possible. A number of communication technologies exist that provide capability for downtown signal system networks to be tied into freeway control centers on a real-time basis. In some cases, it may be advisable and cost-effective to combine the functions of freeway and downtown signal system traffic control in one facility. In other cases, however, the Operations Center and/or Communications Center might be "co-located" with the Traffic Control Center. Microwave and fiber optic systems are technologies that provide for improved communication among separate control centers.

SOURCE: NCDOT.

HOV

3. HIGH OCCUPANCY VEHICLE LANES (HOV)

HOV restrictions limit the use of a lane according to a specified class of vehicles. These particular vehicles may include buses, vans, vehicles with a special permit, or a vehicle containing some specified number of required passengers. In addition to allowing for control of access to a lane, HOV lanes also allow for automatic control of lane direction,

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

RVLANE

4. REVERSIBLE LANES

Reversible lanes are used to economize the road space, in that the directional demand of traffic is the deciding factor in assigning the traffic direction of a lane. HOV lanes are often reversible lanes, and direction of travel always depends on the direction with the peak period demand. A control center controls the direction of the flow.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

FOCS

5. FIBER OPTIC COMMUNICATION SYSTEM

A fiber optic communication system is functionally like using twisted pairs or coaxial cable except the transmitter module converts electronic signals into optical signals, and vice versa for the receiving end. The transmission medium is an optical wave guide. When designed correctly, light rays that enter the fiber (clad with plastic or glass with a different refractive index) are reflected off the fiber wall, so they cannot escape until the end of the fiber.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

TPACCS

6. TWISTED PAIR AND COAXIAL CABLE SYSTEMS

The twisted pair cable (or twisted wire) is the most widely used communication medium in traffic signal control systems. The twisted pair cable consists of sets of two wires wrapped around each other, designed to minimize interference from external sources since the signal-carrying conductors are always right beside each other. The twisted pair cable also reduces cross-talk between adjacent pairs.

The coaxial cable has a single inner conductor and an outer conductor. It is called a *"coaxial" cable because the center of the outer conductor is coaxial with the center of the inner conductor. A dialectical material (selected for its electrical and mechanical properties) fills the space between the conductors. This cable is designed to "obtain minimum signal losses, large signal information capacity, low signal interference susceptibility, and low signal leakage. " It also provides a very high capacity for data communications.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

RSS

7. RAMP SIGNAL SYSTEMS (RAMP CONTROL AND METERING)

Ramp control and metering are examples of capacity management. Ramp signal systems help in the avoidance of freeway overload by limiting the amount of vehicles allowed to enter the freeway in a given time. One example is ramp closures, which are not widely used in the U.S. due to public opposition. Ramp metering is more frequently used. Entry to the freeway is controlled by a regular traffic signal, and these signals are controlled according to real-time information on ramp and freeway traffic flows. This technique has been found to reduce peak period congestion, as well as accidents.

SOURCE:

"The ENTERPRISE Program Concept Definition Report," Castle Rock Consultants, Leesburg, VA.

CLSS

8. CLOSED LOOP SIGNAL SYSTEMS

The preferred method of getting traffic through a series of signals is to coordinate the operation of each signal with adjacent signals so that platoons of traffic can pass through one signal after another without stopping, at least for a certain period of time. This period is called a "green band." One way of controlling the selection of parameters which determine the green band of the system is the Traffic Responsive method, which selects the size of the green band and gives directional preference based on the actual traffic conditions currently in effect at the intersections in the system.

A closed loop system, a type of advanced traffic responsive system, is the predominant type currently produced by most traffic control equipment manufacturers. A closed loop system uses on-street "masters" to respond in a preprogrammed manner to detected traffic patterns, to issue commands to local intersection controllers to implement the appropriate signal operation at each intersection, and receive information back from local controllers regarding its operation. The other major component of a closed loop system is a central personal computer, usually located at the responsible traffic engineering authority's office. It can receive status and event reports, traffic counts, and all other operating and programming information through the communication link with system masters. The closed loop system effectively implements and monitors system operation, provides system analysis, and allows for easy programming methods of coordination.

SOURCE: NCDOT, Traffic Engineering Branch.

AIIC

9. INTERACTIVE TRAFFIC SIGNAL CONTROL

Interactive traffic signal control was designed to combine highway control and traffic signal control by connecting real-time monitoring, short-term travel forecasting, and electronic route guidance into an integrated traffic management system. This system will optimize signal timing, while providing route guidance to vehicles according to real-time traffic conditions. Data on traffic volumes and speeds will contribute to the signal timing. In addition to these features, the system will allow the prediction of the amount and type of vehicles that will be traveling in certain route areas and will be able to send special signals to different vehicle classes.

SOURCE:

AASHTO National Leadership Conference, May 5, 1990.

ILD

10. INDUCTIVE LOOP DETECTORS

Inductive loop detectors are the most , popular form of surveillance technology. They consist of a loop antenna placed below the surface of the roadway, which communicates with a tag mounted underneath the vehicle. When a vehicle passes over the loop, the inductance of the loop is decreased, which causes an impulse to be sent to the controlling unit. Problems associated with inductive loop detectors include:

1) approximately 70-75% accuracy

2) hard to maintain in adverse weather conditions or pavement reconstruction

3) only presence/absence of vehicles can be determined with high degree of accuracy

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

MDM

11. MAGNETIC DETECTOR AND MAGNOMETER

These magnetic devices are installed in the center of a traffic lane. The iron content in vehicles causes a distortion in the earth's magnetic field. Magnetic detectors measure vehicle movement by sensing this distortion. Magnometers operate on the fact that "a vehicle is more permeable, than is air, to the lines of the earth's magnetic field. " It is a small cylinder that is placed in a drilled hole in the road. Magnetic detectors and magnometers are reported to have a limited use for real-time surveillance.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

UDET

12. ULTRASONIC DETECTORS

The ultrasonic detector transmits pulses of energy through a transducer that is directed toward the roadway. If a vehicle is present, the beams are reflected back to the transducer at a different frequency. When the transducer senses the change, it converts it to electrical energy and relays it to a transceiver, which then gives off an impulse to the controller to signal the passage/presence of a vehicle. Because of poor operational performance and reliability, they aren't currently being used.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

IDET

13. INFRARED DETECTORS

Infrared detectors operate by focusing a narrow beam of energy onto an infrared-sensitive cell. When vehicles go through this beam and interrupt the signal, they are detected. The sensors are located above the pavement and can be mounted on posts or barriers on the side of the roadway. They provide the Remote Processing Unit with information on occupancy, volume, and speed by lane of traffic.

SOURCE:

"IVHS User Services and Functions. " WORKING PAPER. Mitre Corp. , July 1992.

M-DET

14. MICROWAVE DETECTORS

Microwave detectors direct a beam of microwave energy onto a detection area from an antenna that is mounted overhead. They provide information on speed, occupancy, and volume by lanes. Vehicle motion is sensed by the detection of a Doppler phase shift.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992, VIDET

15. VIDEO IMAGE DETECTORS

The video-image detector system consists of an electronic camera that overlooks a part of the highway. A computer determines vehicle presence/passage and derives other traffic information from the camera images. Vehicles can be detected at specific points on the highway, and other traffic information can be obtained by looking at selected parts or the entire scene.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

DIPPROC

16. DIGITAL IMAGE PROCESSING

Digital image processing is comprised of an automated detection system which accepts input from a video camera and couples it with a supervisor computer in order to collect and process data. Applications include surveillance, incident detection, traffic classification, traffic counting, ramp metering control and simultaneous monitoring of multiple traffic lanes. These systems use interactive graphics to easily define detection zones on a computer screen using a mouse or standard keyboard. The computer then digitizes the information and processes it into useful data that can be applied to algorithms and used as an effective management tool.

Source:

Econolite Control Products, Inc. , "Autoscope 2002 Video Detection System,** promotional material.

-AVIS

17. AUTOMATIC VEHICLE IDENTIFICATION

Automatic vehicle identification (AVI) refers to the technology that can identify each vehicle as it passes certain points along a facility, without requiring any action by the motorist or observer. There are three basic functional elements common to all AVI systems: a vehicle-mounted transponder/" tag", an adjacent reading device, and a master computer system for the processing and storage of data. Information that identifies a vehicle is encoded onto the transponder/tag. As the vehicle passes through, the transponder/tag is activated to transmit the coded data to a reading device on the roadside. At this point, the data is checked for validity before being transmitted to the master computer for processing and storage. The whole process is completed in a fraction of a second.

AVI can be used for toll collection, parking facility access, and to provide data for real-time speed information, weight, HAZMAT monitoring, fleet management, and emergency assistance requests. Some benefits of AVI include reduced air pollution, fuel savings, improved accountability, travel time savings, and reduced operating and maintenance costs.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992,

VMS

18. VARIABLE MESSAGE SIGNS

Variable message signs (VMS) provide present and changing traffic, weather, and emergency information to the motorist about unusual conditions ahead and advice on possible route alternatives. They are designed to give drivers sufficient notice to exit the interstate and avoid problems or congestion. They use visual displays of words, numbers, or symbols that can be varied electronically or mechanically. The Traffic Operations Center (TOC) controls the various signs and selects the messages, which prove to be its direct link to motorists.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

AVCS

19. AUTOMATIC VEHICLE CLASSIFICATION

Automatic Vehicle Classification (AVC) systems are used on the highway to collect classified traffic data. According to Mitre Corp., systems typically include the following elements :

1) **Sensors which detect the presence or passage of vehicles**
2) **Detectors which receive signals from the sensors**
3) **The processor which calculates the vehicle length, number of axles, etc., from which the vehicle class is determined**
4) **The recorder which stores the data**

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July, 1992.

VP

20. VEHICLE PROBES

Instrumented vehicles can be used to detect congestion on the highway by measuring relative speed and travel time. Vehicles must have an on-board computer and a two-way communications link to the Traffic Operations Center (TOC). Vehicles without on-board computers must be properly equipped for Advanced Vehicle Identification (AVI) readers to serve as data collectors. These vehicles can provide the TOC with real-time information on travel time along links and between origin-destination pairs.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp, July 1992.

VT

21. VEHICLE TRANSPONDERS

A vehicle transponder is a device used in identifying vehicles. For Automatic Vehicle Identification, the transponder is mounted on the vehicle to be in conjunction with the roadside beacon/transmitter. The transponder contains the information which the beacon reads for its identification. Information contained on the transponder data set includes licensing and permitting information plus data on the load being hauled at the time. The device permits "invisible barrier" removal at state lines and improved trucking operations.

SOURCES:

"H.E.L.P. Executive Summary," Castle Rock Consultants, April 1989.

NCDOT.

CSS

22. CONTROL SYSTEM SOFTWARE

Control System software is the software in a central computer that ties together all of the disparate parts of an overall traffic management system. These disparate components can include algorithms performing ramp metering functions, bottleneck metering, queue adjustments and volume adjustments. This software can also control closed circuit television cameras, variable message signs and other field elements, including component malfunction monitoring. Control system software is usually developed on a case-by-case basis reflecting the specified system architecture and desired functionality.

Source:

**Preliminary Engineering Report for the SR90 Traffic Management System," prepared by Fluor Daniel for Washington State DOT, January 1989.

ID-SOFT

23. INCIDENT DETECTION SOFTWARE

The Traffic Operations Center (TOC) can monitor traffic using surveillance equipment, such as loop detectors and video cameras, at strategic locations. The TOC discovers incidents by different means, such as traveler notification, police reports, and through roadway network monitoring. The TOC performs incident management through its response and coordination with other relevant agencies to verify an incident and to determine its location. Incident management may involve a variety of control strategies, information dissemination methods, diversion plans, motorist recommendations, or specialized fleet management strategies to aid emergency vehicles in their response to an accident. Automatic incident detection systems usually include a small computer or distributed microprocessor system, which monitor signals from vehicle detectors spaced along the roadway. Incidents can be detected with the use of special algorithms by finding disturbances in traffic flow.

SOURCES:

"Evaluating New Technologies For Roads : Program Initiatives in Safety and Efficiency (ENTERPRISE)," Castle Rock Consultants, Lcesburg, VA.

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp, July 1992.

TA-SOFT

24. TRAFFIC ANALYSIS SOFTWARE

Traffic analysis software is a generic term used to describe any kind of computer software that can perform data analysis based on certain algorithms or processes. This could consist of basic packages such as level of service calculation based on the Highway Capacity Manual or trend analysis for classified count data, or other more complex, predictive systems that can be custom designed. The purpose of such software in IVHS applications is to take real-time data and process them utilizing algorithms that can, for example, detect incidents or predict bottlenecks.

Source:

Castle Rock Consultants

E-TOLL

25. ELECTRONIC TOLL COLLECTION SYSTEMS

Electronic Toll Collection (ETC) uses Automatic Vehicle Identification (AVI) to identify the vehicle and subtract the appropriate amount from the user's account. It performs a wide variety of functions; included are radio communication between fixed locations and vehicles equipped with small radio communication devices ("tags") , control of lane equipment, collection of vehicle transaction information by a central computer system, accounting and audit functions, invoicing, violation processing, patron enrollment, and tag distribution.

ETC systems collect revenue in compensation for motorist's use of roadways, bridges, or tunnels. Fees are collected automatically, without requiring action by the motorist, and the fees may vary according to the vehicle class, time of day, or other criteria.

ETC systems may be positioned in a lane at a toll plaza, on an open highway, or on a tunnel or bridge structure. Open Highway systems typically conduct transactions while the vehicle is traveling at high speed, while the plaza, tunnel, and bridge systems operate when the vehicle is moving at a slow speed.

SOURCES:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

NCDOT.

AIRS

26a. ACCIDENT INVESTIGATION/RELOCATION SITES

In order to remove vehicles involved in incidents from the roadway as quickly as possible, off-roadway accident investigation sites are provided. These sites, also called vehicle relocation sites, are separate facilities that function like rest areas, with tapered off and on-ramp access from freeways. Quick removal by highway agency or enforcement personnel and equipment can greatly reduce congestion from incidents by minimizing the amount of time that stalled or accident-involved vehicles stay on the road.

SOURCE: Minnesota DOT.

HI-WARS

26b. HAND-HELD, PORTABLE ACCIDENT REPORTING SYSTEMS

Hand-held, portable accident reporting systems are essentially radio units which are used by response personnel to provide information from the incident scene. Several states currently operate dedicated microwave-frequency radio channels that can be used for this purpose. They allow operators to report on the extent of an accident and its likely consequences, and to advise response teams and trauma centers on medical care needs.

For public reporting of accidents, cellular telephones are the primary option at this time. In the future, however, personal digital communications devices have the potential to improve the public's accident reporting capabilities. For example, several companies are currently engaged in the development of compact, portable devices which contain processing and memory components as well as built-in transmit and receive capabilities. Accident reporting is just one of many potential applications for this system.

Source:

Castle Rock Consultants

OHTU

28. OPTICAL HEAD TRANSCEIVER UNITS

Optical head transceiver units are devices which can serve as interactive beacons for road-to-vehicle and vehicle-to-road communications. They can be used for in-vehicle dynamic route guidance and AVI applications. The transceiver units can be mounted on traffic signals or other street furniture and enable data exchange to take place between a traffic control center and in-vehicle devices. This exchange is based on infrared communications links. Key data provided by this link include traveler and route guidance information for use by in-vehicle processors, as well as link journey time information for network analysis.

Source:

"On-Board Navigation/Information Display Systems, ' SAE Topic Series--ATMS/ATIS, Tom Bauer , Siemens Automotive, January 20, 1993.

WARFDN

29. WIDE-AREA RADIO FREQUENCY DATA NETWORKS

Mobile radio systems can broadcast traffic and other traveler information to vehicles or transmit vehicles specific information like route selection and guidance data from a central facility. They can also transmit uplink data from the vehicles related to link transit times, incident reports and assistance requests. The wide-area communications system can provide transmission of common data to all cars equipped with a receiver over a single channel, relying upon the in-vehicle equipment to determine the relevancy of the information, according to the planned route of travel. In addition, these systems can send specific data to individual vehicles, such as selected route information or acknowledgements to assistance requests.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

SSRAD

30. SPREAD SPECTRUM RADIO

The spread spectrum radio is an approach designed to deal with problems such as poor performance, susceptibility to noise, and scarceness of available frequency allocations due to traditional narrow-band radios, which operate in a highly congested region of the RF spectrum. This system should work well for IVHS uses, since radio interference is uncommon. The energy in the spread spectrum radio "is 'spread' across the entire RF spectrum in a way that avoids interference from other radios in the service area within the same band." The two major approaches are frequency hopping and direct sequence.

SOURCE:

"A State of the Art for IVHS in Florida, " Transportation Research Center, University of Florida, August 1992.

SCS

31. SATELLITE COMMUNICATION SYSTEMS

Interstate commercial vehicles presently use dedicated satellite radio channels that provide nationwide coverage. These services allow the driver to communicate with company dispatchers from the cab of the truck. Either voice or data transmissions can be supported by the satellite system. Global Positioning Systems (GPS) are specialized versions of this technology (see #56).

REFERENCE

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp. , July 1992.

CELL-MD

32. CELLULAR RADIO

Cellular radios can provide for alternative two-way communications to support the services that the wide-area radio systems provide, such as the broadcast of traffic and other motorist information to vehicles, route selection and guidance data, transmission of data linking travelers to transit times, incident reports, and assistance requests. The cellular systems are able to be selective in accessing vehicles within specific cells of the system. This could help to select out traffic data for vehicles, which means reducing the in-vehicle task of determining which information is relevant.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp., July 1992.

NWTOP

33. NETWORK-WIDE TRAFFIC OPTIMIZATION PROGRAMS

Network-wide traffic optimizations programs refer to systems that automatically react to changes in traffic flow by adjusting signal timings in accordance with an on-line optimization process. These systems typically monitor cyclic flow profiles in real-time through vehicle detectors such as inductive loops, and use this information every few seconds to make systematic alterations to signal settings. Research suggests that this type of control is likely to achieve a significant reduction in delay each year relative to fixed-time control systems. One of the principal reasons for this is the fact that fixed time plans are subject to "aging, " whereas adaptive approaches constantly readjust signals to match changing traffic conditions.

Source:

"The Guidestar Program Worldwide IVHS Review, " Minnesota Department of Transportation IVHS Management Study, March 1991.

R-BEAC

34. ROADSIDE BEACON

The roadside beacon is a short range transmitter of radio' microwave, or infrared signals that are location-coded. It is also designed to be used as a communication link for localized data, such as traffic and road sign information. (See also #52 for types of Roadside Beacons.)

SOURCE:

"Strategic Plan for IVHS in the US ," IVHS America, May 20, 1992.

MMTII

35. MULTI-MODE TRANSPORTATION INFORMATION INTEGRATION

Multimodal information integration involves the fusing and processing of data from different transportation sources for the purpose of disseminating information to interested parties on different modal opportunities. Computer programs are used which provide accessible information on all relevant transportation modes including transit, rail, air, highway and water. These systems can be interactive, so that travelers can investigate alternative options and select the mode or combination of modes that best meets their trip needs.

Source:

Castle Rock Consultants

SM-CARD

36. SMART CARD

The smart card is a portable onboard computer that looks like a bank card. It has a microprocessor as well as memory chips, which are able to do calculations. It contains a security system to prevent files from unauthorized use. The equivalent of several pages of typewritten material can be held by its electronic memory, which is personalized to the user. This technology is presently being used for electronic toll collection.

SOURCES:

"The ENTERPRISE Program Concept Definition Report," Castle Rock Consultants, February 1991.

"Smart Card Applications Develop Further, " THE URBAN TRANSPORTATION MONITOR, Vol 6, No 24, Lawley Publications, Dec. 24, 1992.

TSTR

37. TELECOMMUNICATION SYSTEMS FOR TRIP REDUCTION

The general idea of telecommunication systems is for people to be able to do more activities at home, such as banking, shopping, and conferencing . These can now be done by phone or computer networks. Some of these systems are telebanking , teleshopping , and teleconferencing. Telecommuting is another application, which has significant business advantages and hope for trip reduction, and improves worker productivity.

SOURCE:

"A State of the Art for IVHS in Florida, " Transportation Research Center, University of Florida, August 1992.

MACB

38. MOTORIST AID CALL BOXES

Much information reported about incidents comes from motorists. Motorist aid call boxes give the drivers a chance to report incidents or call for help. These call boxes are located on the roadside for convenience. In some systems, the motorist must only pick up the phone and be automatically connected with the highway patrol or other 911 emergency responder. In other cases, the motorist must push a button in order to get help.

SOURCE:

"Congestion Avoidance and Reduction for Autos and Trucks (CARAT)," NCDOT, July 1992.

FOG-ICE

39. FOG, ICE, AND SNOW DETECTORS

Electronic roadside sensors are used for detecting adverse environmental conditions. They automatically detect dangerous road conditions that may cause accidents and congestion. They are able to detect pavement slickness as a result of rain, snow, ice, sleet, or commodity spillages. Motorists are informed of the danger by variable message signs, which tell them to slow down. Local sensors can also provide information about flooding, dust storms, and hazardous chemical vapors.

Fog warning systems would be used in areas where fog occurs frequently and rapidly. The systems use sensors to measure visibility range continuously. The data is then sent to the control center where it can be compared with a threshold. In places where visibility is poor, variable message signs, and perhaps hazard lights, are used so motorists can be provided with warning in advance.

SOURCE:

"The ENTERPRISE Program Concept Definition Report," Castle Rock Consultants, Undated.

SDD

42. STRUCTURAL DAMAGE DETECTORS

Two emerging technologies of bridge inspection for detecting structural damage are stress wave and vibration measurements. In particular, they detect small fatigue cracks that may potentially lead to disastrous structural failure. Stress wave measurement, or acoustic emission technology, aims to capture the elastic wave through the structural material caused by an energy release at the crack tip. Sensors are placed near the suspected crack location, and are continuously monitored. A computer actually placed on the bridge is used to collect and analyze information. Vibration measurement allows for "rapid and global inspection." In this case, the sensors are placed at a "predetermined strategic location," and need not be in a place where a crack is suspected. An instrumented impulse hammer strikes the bridge girder, and the sensor picks up the resulting vibration. The bridge's condition is diagnosed by techniques that interrogate the vibration signature. When the system detects a crack, it sends a written message and an audible alarm to the operator.

SOURCE:

"Diagnostic Experimental Spectrall-Modal Analysis of a Highway Bridge," Biswas, M., Pandey, A. K., and Samman, M. M., INTERNATIONAL JOURNAL OF ANALYTICAL AND EXPERIMENTAL MODAL ANALYSIS, Vol. 5, No. 1, 1990, pp. 33-42.

ERPS

43. ELECTRONIC ROAD PRICING SYSTEM

Electronic road pricing and automatic toll collection are technically similar. It is a traffic restraint management policy designed to reduce congestion, in which drivers pay for using the roads according to how much they contribute to the congestion. Vehicles must therefore be charged for being in particular places at certain times. Charging sites can be established on the highway network using roadside units. The charges are varied by time of day and location, according to congestion levels. Vehicles equipped with transponders subtract from their account each time they cross a charging site.

SOURCE:

"IVHS- The Universal Close-range Road/vehicle Communication System Concept," Lewis Sabounghi, Transport Canada, 1991.

AHS

44. AUTOMATIC HIGHWAY SYSTEMS

Highway automation is defined by six different approaches. They represent a broad range of functions that could develop from a few implementations to completely automated highways. The six concepts include:

1) Automated Lane Keeping, which uses sensors to monitor the vehicle's position in the lane.

2) Adaptive Headway Control, which uses sensors that "measure the distance to the preceding vehicle and provide input to automatic power and braking controls to supplement a driver's ability to maintain a safe headway."

3) Automated Collision Avoidance, whose goal is to detect a collision and either stop the vehicle or avoid it by maneuvering the vehicle.

4) Auto-Train, which uses electronic coupling to group vehicles together.

5) Automated Freeway Lane, which allows complete automatic control of vehicles in a certain lane.

6) Autonomous Taxi, which is based on the idea that taxi service could also provide the convenience of an individual vehicle (on a door-to door basis).

SOURCE:

"A State of the Art for IVHS is Florida," Transportation Research Center, University of Florida, August 1992.

SBS

45. TRAVELER INFORMATION CENTER

One of the most basic ideas of an IVHS integrated system is providing motorists with real-time travel information. Travelers need information before leaving, as well as during particular trips. Motorists base their travel on weather and traffic conditions that may have impacts on them. To provide these services, a central facility is needed for data processing, derivation of control strategy, and information dissemination, which can be done in an individual facility or in networked stations.

SOURCE:

"A Strategic Plan for IVHS in Iowa, " Castle Rock Consultants, August 5, 1992.

KIOSK

46. "KIOSK"/ TRAVELER INFORMATION TERMINALS

Kiosks are traveler information terminals that are usually placed at major highway intersections and other terminals such as hotels, airports, parking structures, employment centers, etc. They provide the traveler information through various communications media, including audio/visual systems and direct telephone connections. Some also provide commercial advertising space as an alternative to conventional billboards, which would help pay for the service. It is possible that each kiosk could access statewide information, along with the localized data.

SOURCE:

"A Strategic Plan for IVHS in Iowa, " Castle Rock Consultants, August 5, 1992.

STATE

47. STATEWIDE BROADCASTING SYSTEMS

Statewide broadcasting systems can take on a variety of forms and serve a number of purposes. AM radio for public broadcasting covers large areas with reliability, while FM radio is widely used in urban areas. Both of these media can provide spoken traveler information messages. Through use of subcarriers, they can also carry digital data to suitable portable or in-vehicle receivers.

Microwave communications systems are used in several areas for statewide broadcasting among transportation and other state agencies. Microwave systems have large data carrying capacities, however, they require transmission and relay infrastructure at key locations. They typically offer point-to-point communications capabilities, making them less appropriate for public information dissemination.

Source:

Castle Rock Consultants .

HAR

48. HIGHWAY ADVISORY RADIO

The highway advisory radio (HAR) is a short-range broadcast service that provides localized traffic information on road conditions ahead. It serves as an incident management tool by broadcasting conditions such as construction, new routing patterns caused by special area-events, and warnings of congestion, accidents, or stalled vehicles, that may result in new traffic patterns. Low powered transmitters along the road provide service on standard AM radio, which means motorists are not required to buy any special equipment. Reception of the area broadcast is limited to a radius of about six miles. Beacons on fixed message signs are typically used to notify motorists of areas services by HAR and which frequency to turn to.

SOURCES:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

"The ENTERPRISE Program Concept Definition Report, " Castle Rock Consultants, Leesburg, VA.

" IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

AHAR

49. AUTOMATIC HIGHWAY ADVISORY RADIO

The automatic highway advisory radio (AHAR) provides drivers with real-time information by using roadside transmitters and in-vehicle subsidiary FM receivers. It provides automatic localized traffic information, but roadside signing and manual tuning are not needed. Motorists can be notified of road conditions ahead such as construction, new routing patterns caused by special events in the area, and warnings of congestion, accidents, or stalled vehicles that may result in new traffic patterns. The car radio is automatically muted and tuned to the proper frequency when the vehicle enters the AHAR coverage area. After the message has been repeated twice, the radio is automatically retuned to its previous frequency.

SOURCES:

"A State of the Art for IVHS in Florida," Transportation Research Center, August 1992.

"The ENTERPRISE Program Concept Definition Report," Castle Rock Consultants, Leesburg, VA.

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

COM-RAD

50. COMMERCIAL RADIO

Commercial radio stations usually include traffic reports as part of their regular broadcasting during rush hour periods. This type of traffic information has the benefit of reaching the largest group of vehicles, with no additional costs for specialized equipment; however, their programming is limited in the amount of information that can be provided and in the timeliness of the information.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

TAR

51. TRAVELER ADVISORY RADIO

The concept of the traveler advisory radio (TAR) is to provide real-time traffic information to both the commuter and highway traveler. The focus of the programming will be on travel information, which will be delivered several times per hour. The broadcast will include road conditions, construction reports, slow-downs, detours, and accidents/incidents. Headline news, weather, weather road conditions, lane and road closings, locations of airports, train stations, etc., and information on alternate routes will be given as well. Motorists will be informed of up-coming events such as shows, the arts, and sports in the area. The traveler advisory radio, an FM radio service, will be practical and more effective than the AM lower frequency. It will get its information from the telephone network, cellular phones, and traffic surveillance systems.

SOURCE: NCDOT.

LRT-B

52. LOCAL ROADSIDE TRANSMITTERS/BEACON

Local roadside transmitter systems can be used in several different ways:

1) The highway advisory radio (HAR) is used to broadcast traffic and highway information straight to the driver. Beacons on fixed message signs are frequently used to inform motorists when HAR is being used and what frequency to change to.

2) Roadside transmitters are used for automatic highway advisory radios (AHAR), along with in-vehicle receivers so motorists can be provided with real-time information. The class of information can be preselected by the driver, and there is an automatic emergency override.

3) The simple location beacon is another use of roadside transmitters. Different techniques include : a coded pattern of buried magnets, short-range radio broadcasts, buried loops, leaky coaxial cable, microwave and infrared transmitters.

4) Download hazard warnings make use of local roadside beacon transmitters, as well as network updates and route guidance advice.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

TMC-RDS

53. TRAFFIC MESSAGE CHANNEL/RADIO DATA SYSTEM

The traffic message channel/radio data system (RDS-TMS) is a traffic information broadcasting system that offers major benefits in congestion avoidance. RDS-TMC better informs the drivers when an incident occurs, giving them the opportunity to take alternative routes to avoid build-up at the scene. This reduction of congestion lessens travel times for equipped vehicles, as well as for those not equipped. Improvements in comfort and convenience result from the highly selective nature of the receiver, which only provides relevant information to motorists. Another benefit is awareness; even when drivers are unable to change routes or reschedule trips, they will at least be informed.

SOURCE:

"Assessment of Advanced Technologies for Relieving Urban Traffic Congestion," Transportation Research Board, December 1991.

ELEC-MAP

54a. ELECTRONIC MAP

The base electronic map is on a read-only memory compact disk or on cassette tape reader inside the vehicle. The ATMS control center can broadcast the map (or updates). Some raw sources are USGS quads, Census Bureau DIME and TIGER files, aerial photographs, satellite photographs' country and city maps, and postal service files. The map is not stored as a picture, but as a topological database. Streets, street names, street classifications by importance, railroads, and major bodies of water are included in the basic database. However, there are other features that can be included, such as boundaries (political and administrative), turn restrictions, one-way roads, major freeway signs, general traffic signs, and link travel times.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

ELEC-YP

54b. ELECTRONIC YELLOW PAGES

The electronic yellow pages is a device which provides specific information for commuters as well as highway travelers. The service particularly helps those who are unfamiliar with the area they happen to be in. The electronic yellow pages is defined by its name-- its function is the same as the conventional yellow pages, except the information changes upon entering a new area. In other words, information on hotels, restaurants, etc. , is always relevant. Information is provided to the motorist through the Highway Advisory Radio, Traveler Advisory Radio, Cable TV stations, and other media.

SOURCE: NCDOT.

DRNS

55. DEAD RECKONING NAVIGATION SYSTEM

The dead reckoning navigation system, often used with map matching, is based on the integration of measured increments and distance travelled to determine a vehicle's location and heading in relation to its starting point. A compass, wheel sensors, and an algorithm matching the vehicle's motion to the map make up this system.

SOURCES:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp. , July 1992.

GPS

56. GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) or Global Positioning Satellite uses a "satellite based radio trilateration system" that is able to determine locations. Using Navstar GPS P-Code signals, the locations have an accuracy of 10-30 meters. C/A-Code signals, a less precise system, will determine location with an accuracy of approximately 100 meters. Differential GPS is more accurate, but it requires a reference signal from a base station in addition to the Navstar signals.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp., July 1992.

LORAN

57. LONG RANGE HYPERBOLIC NAVIGATION (LORAN)

Long Range Navigation is a hyperbolic navigation system that uses multiple pairs of ground-based master-slave transmitters. LORAN and LORAN-C are established navigation technologies.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

AWWS

58. ADVANCED WEATHER WARNING SYSTEM

This system would enable motorists to receive real-time information linked to weather reports. It would include advisories on weather and adverse environmental conditions that may affect traffic operations. Also, vehicles or roadside facilities equipped with environmental sensors would help warn motorists of roadway conditions, climate conditions, and pollution levels.

SOURCE:

" IVHS User Services and Functions, " WORKING PAPER, Mitre Corp., July 1992.

AUD-TXT

59. AUDIOTEX

Audiotex is also known as automated telephone inquiry services. This is a convenient and popular method of information retrieval which can cover travel route selection, transit schedules and itineraries. Audiotex can be divided into three levels of technology application: (1) computerized information access, manually recalled by the service operative who answers the telephone; (2) fully-automatic operation making use of touch tone or other remote terminal facilities to select the required options; and (3) a fully-automatic computerized system utilizing voice recognition. The first two systems are currently in use by several transit agencies, as well as groups outside of the transportation sector. The third, voice recognition, is a developing technology and is not widely used at this time.

Source:

Castle Rock Consultants

VID-TXT

60. VIDEOTEXT

The videotext system is a form of fully accessible information, in which its subscribers use a simple remote terminal to get information services. This information is received by telephone and then displayed on television screens. The system can provide real-time information for railroad, bus, and air travel. The French system is called Teletel, while the best known US system is the Prodigy (IBM & Sears). Here, the communication is between the home computer and a central facility by telephone. Prodigy provides a range of services, including home shopping, electronic encyclopedias, and travel information. This system has high potential for transit, paratransit, and carpooling operations with the supply of route and scheduling information.

SOURCE:

"A Strategic Plan for IVHS in Iowa," Castle Rock Consultants, August 5, 1992.

TELETXT

61. TELETEXT/CABLE TV INFORMATION SYSTEMS

In the cable TV system, the public receives traffic information at home, work, etc. , by way of local cable TV stations. Teletext provides its services "by invisibly encoding pages of alphanumeric data onto conventional TV station carriers, which are then read by a special decoder attached to the television receiver. " People that use the teletext service look at a teletext television before leaving, so they can change their travel plans ahead of time according to congestion information.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

MAPMACH

62. MAP MATCHING

Map matching is an advanced method for aid on direction that uses dead-reckoning navigation. The vehicle's present location is shown on an electronic map display. The system requires an extensive database to be highly accurate. The vehicle's position is corrected by comparing the calculated vehicle position with the known map data, usually at turns.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp., July 1992.

NRGS

63. NAVIGATION/ROUTE GUIDANCE SYSTEMS

The main goal of an electronic route guidance system is to show the driver how to get to his or her destination. If at all possible, it also picks the best route. The system can also help distribute the traffic flow over the whole network. The two different types are static and dynamic. static systems are able to consider vehicle type, day of week, time, and road preferred; however, they are unable to keep track of changing traffic conditions. Dynamic guidance systems do keep up with real-time traffic conditions, but must receive information from a traffic control center.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

DFS

64. DATA FUSION TECHNIQUES

A lot of IVHS requires the use of real-time information. This data is collected through a variety of sources that are typically managed by a group of separate agencies. Data fusion will integrate this great diversity of real-time and historical information so that unique estimates can be made of traffic volumes, speeds, and locations of incidents and make it available for various required uses. Some uses include graphical and map displays at the traffic control center, input into traffic assignment models and control algorithms, and translation providing information communicable to travelers and others.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

DIAL-IN

65. DIAL-IN INCIDENT REPORTING EMERGENCY SYSTEMS

Portable or in-vehicle cellular telephones can be used to help facilitate rapid incident response through the quicker detection and verification. Several areas operate programs in which motorists are encouraged to use their cellular telephones to report incidents or highway violations. This can be an effective method of supplementing automatically-collected data, and can be invaluable where no other data collection facilities are in place.

Currently shortcomings of using cellular telephones for incident reporting involve the potential for motorist confusion over whether they should dial 911 or some other number for incident reports. There is also concern that 911 could become overburdened with non-emergency calls. An alternative number can be established, therefore, to ensure that non-emergency incidents can be reported without jeopardizing the emergency system. One way to support this type of accident reporting system is effective public education.

Source:

Castle Rock Consultants

H-FACT

66. HUMAN FACTORS SIMULATION MODELING

The purpose of human factors simulation modeling is the attempt to design IVHS to account for the human components of the system: the driver, traffic control staff, and the general public. With respect to the driver, there is concern for driver attention, information processing, driver performance, and acceptance of the shift in control from "inform" to "direct." The concerns for the Control Center staff lie in manpower, training, and personnel issues. Acceptance from the general public is very important in order to gain and maintain public support/funding. The main goal is to satisfy the individual, along with corporate and public transportation goals.

Simulation modeling is basically one of two categories: (1) Man-in-the-loop simulation uses human subjects to respond in a real-time environment to simulated, graphical images on a screen or simulation chamber; (2) Analytic simulation can be either real-time or non-real-time, and is based on stachastic traffic flow models.

Human factors simulation modeling involves an emphasis on safety from a "system design" standpoint, not just an "after-the-fact" test and evaluation. The IVHS system will increase traffic density at the same or increased speeds and may cause distractions associated with extra guidance and information; however, the human factors design and evaluation focus is aimed at increasing the overall efficiency and safety of IVHS.

SOURCE:

Highway Safety Research Center (HSRC), Dr. Ron Hughes, UNC-Chapel Hill, personal communication.

WIM

67. WEIGH-IN-MOTION

Road mounted sensors and processors take into account axle weights, vehicle length, and vehicle speed to determine the weight of vehicles. WIM devices can determine if vehicles are in compliance with weight standards by classifying them according to length, number of axles, and axle spacing.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

AVLS

68. AUTOMATIC VEHICLE LOCATION SYSTEM

The automatic vehicle location (AVL) system works together with a stored map database and the ability to navigate in relation to the map, locates the vehicle on the road system, and serves up the information either as a visual display to the driver or as electronic data for processing and transmission through a roadside communications link. Vehicle location can be determined in different ways, such as short-range transmitters that transmit location coded signals, dead reckoning, Global Positioning System (GPS) or LORAN, and map matching. The AVL information compensates for the driver's limitations as a navigator and provides a crucial data element by which a downtown control center can assess the status of traffic across the network. Probably the greatest 'benefit of AVL is its potential to relieve incidents and delays that are happening and to let the passengers know the reasons for these delays.

SOURCE: NCDOT.

CVOINFO

69. "ONE-STOP SERVICE" FOR COMMERCIAL VEHICLE OPERATIONS INFORMATION

One-Stop Service is associated with automatic clearance in the "Crescent" Demonstration. It has to do with assimilating all agencies inside a state and grouping a number of states together, producing "multi-state transparent borders." For example, it lets carriers participating in a CVO consortium to apply to a regional authority for all the permits and clearances that are necessary so that they can travel through several states. This particular concept could allow participating trucks to bypass weigh stations and ports of entry (that are properly equipped) and increase operational efficiency.

SOURCE:

"H.E.L.P. Executive Summary," Castle Rock Consultants, April 1989.

ERSYS

70. ELECTRONIC RECORDS SYSTEMS

This system monitors and electronically records the status and safety characteristics of vehicles. It can be used in the trucking industry to record almost everything that goes on in the truck, including road speed, engine rpm, idling time, fuel consumption, oil pressure, coolant temperature, number of brake applications, reefer temperatures, and when the trailer doors were opened. The electronic records system can be used for safety reasons for the vehicle and driver, as well as for bonuses to reward good driving performance.

SOURCE:

"Smart Spec'ing: On-Board Recorders. Extra Eyes On The Road," HEAVY DUTY TRUCKING, Vol. 71 No.1, Jan. 1992, pp 56-62.

HAZMAT

71. HAZMAT CARGO MONITORING SYSTEM

Automatic Vehicle Identification (AVI) technology monitors vehicles carrying hazardous materials. It was designed to provide enforcement and incident response teams with current, highly accurate information on cargo contents. This ability enables coordination of routes, advance notice to the enforcement agencies and truck owner about vehicle status, and improved emergency response for incidents that involve HAZMAT vehicles. Serious accidents can potentially be avoided if problems with the cargo can be detected early on.

SOURCES:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

"Strategic Plan for IVHS in the US, " IVHS America, May 20, 1992.

DWS

72. DRIVER WARNING SYSTEMS

In-vehicle systems are being developed for commercial vehicle drivers to detect drowsiness and other dangerous driver conditions. Also, there are systems to detect obstacles and potential problems associated with the vehicle itself or with surrounding vehicles. When an unsafe condition is detected, the system notifies the driver of the problem either visually or audibly.

SOURCE: NCDOT.

HEADSUP

73. HEADS UP DISPLAY

The heads up displays provide the motorist with a holographic projection of vehicle operating information such as speed, motor condition, or route guidance onto the windshield. This projection is focused about 10 feet forward of the driver. It allows the driver to receive information and react without having to take his or her eyes off the road, refocusing to look at the instrument panel, then looking up again. The heads up display would project the visual display information onto a laser holograph with 2-dimensional projection for motorist viewing while driving.

SOURCES:

"IVHS Benefits," MOBILITY 2000, Dallas, March 1990.

"IVHS User Services and Functions ," WORKING PAPER, Mitre Corp. , July 1992.

VCMS

74. VEHICLE/CARGO MONITORING SYSTEMS

Automatic vehicle monitoring systems use a combination of AVL, WIM, AVC, and AVI technologies and a variety of in-vehicle devices. AVL technology provides real-time information on shipment status (e.g., location of shipment, delays, and temperatures of refrigerated cargoes) to a central controller, eliminating the need for communication between driver and control center. Two-way communication links allow equipped vehicles to communicate with the fleet manager about any problems that they may be having.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

SIG-PRE

75. SIGNAL PREEMPTION TRAFFIC CONTROL

The operator of a properly equipped vehicle can alert the traffic signal so that for that particular vehicle there will always be a reduced red time, and maybe even a green light. Typical applications of this technology are by buses, especially express buses on arterial routes.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp, July 1992.

EFCS

76. ELECTRONIC FARE COLLECTION SYSTEM

Electronic fare collection system uses Automatic Vehicle Identification (AVI) to subtract the proper amount from the traveler's prepaid account. The fares usually vary depending on service demand and congestion levels. The more frequent use of "cashless fare transactions" will also help in transit operations.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp. , July 1992.

CUST-SS

77. CUSTOMER SERVICE SYSTEM

The goal of this system is to increase efficiency and convenience of public transportation by providing useful information to travelers before departure and/or during the trip. Transit arrival information on curbside or transit station monitors would make travelers aware of system delays, enabling them to change routes or travel plans accordingly.

SOURCE:

"Strategic Plan for IVHS in the US, " IVHS America, May 20, 1992.

DR-COND

78. DRIVER CONDITION SENSORS

These sensors monitor drowsiness, slow reactions, and excessive reactions, and could also have a breathalyzer reading. One application of driver condition sensors may be to require people convicted of drunk driving to install the system in the car. If not fit to drive, an alarm would sound.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

DYNAMIC

79. DYNAMIC RIDE SHARING

Dynamic ride sharing systems match travelers to drivers, and vice-versa, dynamically forming carpools. The carpoolers meet at certain locations, such as park and ride lots, and ride in groups. This way, they can use available high occupancy vehicle (HOV) lanes.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp., July 1992.

PARATRAN

80. PARATRANSIT DISPATCHING SYSTEMS

Paratransit , or "demand-responsive transit, " has different needs, which have resulted in advanced technology designed specifically for them. One application is a computerized management information system (MIS) for bus programs. Through this system, services such as advance-reservation and demand-response are provided. It also provides on-line scheduling and generation of a variety of operational, managerial, and statistical reports. Bus systems that use this technology are now able to begin an "innovative fare collection system. "

Another system allows passengers to enter their travel requests into computer terminals at bus stops. This particular system has been found to reduce annual transit operation costs by significant amounts. Other systems have been designed specifically for taxicab fleets, which increase the efficiency and speed of service.

SOURCE:

"Assessment of Advanced Technologies for Transit and Rideshare Applications,l' FINAL REPORT, Castle Rock Consultants, April 1991.

SECURITY

81. SECURITY SYSTEMS

Vehicles that are equipped with a radio transponder can be located by security, emergency response, and dispatch units when trouble occurs en-route. The technology of Automatic Vehicle Identification can be used for security purposes. In emergency situations a distress call from a properly equipped vehicle would automatically notify the police to locate the current position of the vehicle and send help immediately.

SOURCE:

AASHTO National Leadership Conference, May 5, 1990.

F-MGMT

82. FLEET MANAGEMENT SYSTEMS

The basis of fleet management is a central controller that knows the status and location of all vehicles, monitors each vehicle, and communicates with them when needed. The fleet controller is able to give relevant traffic information to specific groups of fleet vehicles, and fleet managers will be able to detect problems and respond to them.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

ATVOS

83. AUTOMATED TRANSIT VEHICLE OPERATION SYSTEMS

Transit operation systems include automatic vehicle location (AVL) and automatic vehicle monitoring (AVM) systems. AVL is used to identify, in real-time, the location of transit vehicles. This ability serves many purposes. For example, vehicles which are ahead or behind schedule can be detected and contacted by the transit dispatcher, providing improved service reliability. Transit vehicles can also be rerouted more easily with AVL, with less disruption in service.

AVM is used to monitor the status of transit vehicles building on AVL capabilities. For example, an AVM system will provide real-time information on the condition of certain vehicle components and the passenger load being carried. This allows transit agencies to more efficiently maintain their fleets and adjust services to meet passenger demand.

Source:

Castle Rock Consultants

ADAPT

84. ADAPTIVE HEADWAY CONTROLS

Adaptive headway control uses sensors that are able to measure the distance to the vehicle ahead, and allows for automatic power and braking control to help the motorist keep a safe headway. This technology will allow for higher lane capacity, since it permits closer headways at higher speeds. It will also cause a reduction in rear-end collisions that result from a short driver reaction time. The driver selects the speed, which the adaptive headway control maintains until the driver brakes or the sensors detect a closing vehicle ahead.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

RAD-BRAK

85. RADAR-ASSISTED BRAKING SYSTEMS

Radar braking technologies will be able to detect a collision risk, and will eventually have automatic override capability to apply brakes at the proper time to prevent a collision. The risks associated with reduced peripheral vision, slower decision making, and delayed reaction times can be reduced with this technology.

REFERENCES

"IVHS Benefits, " MOBILITY 2000, Dallas,. March 1990.

LAT-CON

86. LATERAL CONTROL

Lateral control'or guidance, is responsible for keeping a vehicle in the center of a lane. It must have a discrete or continuous reference system most likely using optical or magnetic media, since there are significant problems in the installation and maintenance of wire reference systems.

SOURCE:

"A State of the Art for IVHS is Florida," Transportation Research Center, University of Florida, August 1992.

COLISION

87. COLLISION WARNING AND AVOIDANCE

The goal of collision warning and avoidance systems is to detect and potentially avoid a collision. These systems tell the driver that he or she is driving too fast or too close, and even automatically hit the brakes to avoid a collision. Radar braking, one form of collision avoidance, has problems with false alarms caused by roadside objects and "blinding" from other cars. Another radar-based collision avoidance system responds to speed changes in the lead vehicle to allow a following vehicle more response time.

SOURCES :

"A State of the Art for IVHS in Florida, " Transportation Research Center, University of Florida, August 1992.

"The ENTERPRISE Program Concept Definition Report," Castle Rock Consultants, February 1991.

AVMS

88. AUTOMATIC VEHICLE MONITORING SYSTEMS

Different in-vehicle devices that are under automatic vehicle monitoring (AVM) are:

1) Electric tachographs are used to tell the motorist time, speed and distance. They also record this information, including the vehicle's characteristics of operation.

2) Taximeters, which were originally used to calculate taxi fares, can now measure and record such characteristics as distance, time, speed, fuel consumption, and engine RPM.

3) On-board computers (OBC) collect internal truck information and record it for later analysis and review. Basic OBC systems record information such as tachometer, odometer, speedometer, power on/off signal, oil temperature, and engine and water temperature data.

SOURCE:

"A State of the Art for IVHS in Florida," Transportation Research Center, University of Florida, August 1992.

COMPASS

89. ELECTRONIC COMPASSES

The electronic compass is made of two coils orthogonally wound around a core material that is highly permeable. An alternating current, carried by a third coil, excites the core and starts alternating voltages in the orthogonal coils. A phase shift in the induced voltages is produced by superimposition of the earth's steady magnetic field.

SOURCE:

" IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

ODOMETER

90. ELECTRONIC ODOMETER

Car odometers are typically driven by flexible shafts attached to the drive train. They can display distances to the nearest 0.1 mile. Electronic odometers are able to measure increments of travel less than one inch and are often used in navigation.

SOURCE:

"IVHS User Services and Functions, " WORKING PAPER, Mitre Corp. , July 1992.

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SOURCE:

"IVHS User Services and Functions,' WORKING PAPER, Mitre Corp., July 1992.

AUTOTRAI

91. "AUTOTRAIN" PROXIMITY SENSORS

Autotrain groups vehicles together using electronic coupling. A motorist may join the group by slowly coming up from behind. When the proximity sensor detects the vehicle ahead, a headway-keeping function takes control of the power and braking systems to bring the spacing down to a few feet. As soon as the vehicle becomes a part of the group, it is kept in the middle of the lane by lateral guidance, and the motorist in the lead position selects the speed of the entire group.

SOURCE:

"A State of the Art for IVHS in Florida, " Transportation Research Center, University of Florida, August 1992.

OBSTACLE

92. OBSTACLE DETECTION SYSTEMS

Obstacle detection devices monitor the front, back, and sides of the vehicle for the existence of objects that the driver should avoid. They can provide both visual and audible warnings of risks involving closing speed problems, blind spot obstacles, and backing-up. This technology will particularly benefit older drivers at intersections and during lane changing.

SOURCE:

"IVHS Benefits, " MOBILITY 2000, Dallas, March 1990.

IN-VEH

93. IN-VEHICLE DISPLAYS

This technology enables roadside information to be displayed on-board. The information comes from short-range transmission from roadside beacons or from on-board data storage. In-vehicle displays are used for improvement of the effectiveness of driver performance, because the driver can easily view the correct information.

SOURCE:

"Strategic Plan for IVHS in the US,'IVHS America, May 20,1992.

VOICE

94. VOICE RECOGNITION SYSTEMS

Voice recognition enables the user to speak to the on-board computer in order to give it commands. The user's speech is picked up by a microphone. It is then processed by a speech recognition module that is attached to the on-board computer. This technology will allow the driver to give commands without looking away from the road: It also is used as a security device to prevent theft or unauthorized use.

SOURCE:

"IVHS User Services and Functions," W&KING PAPER, Mitre Corp., July 1992.

TOUCH

95. TOUCH SCREEN TECHNOLOGY

A touch screen is a good approach to driver selection of options through an on-board system. With touch screens, the position of the user's finger shows the function that he or she will invoke. When the user points to an option, it breaks the infrared light grid overlaying the display screen.

SOURCE:

"IVHS User Services and Functions," WORKING PAPER, Mitre Corp., July 1992.

ASES

96. ADVANCED SENSORY ENHACEMENTS SYSTEMS

Advanced sensory enhancements systems are used to improve the motorist's comfort and safety. Some examples of this technology are:

1) Infrared imaging, which enhances the image of the roadway ahead in bad visibility conditions at night. This technology will reduce the amount/severity of crashes due to a failure to see objects ahead.

2) Climate control inside the vehicle, which improves comfort for the driver, thus allowing for better driving performance.

3) Heads-up display involves projecting information on the windshield with a virtual image located in front of the vehicle. Its purpose is to reduce crashes that are due to dashboard distraction and driver accommodation.

4) **Variable Window/Mirror Transmittance is designed to enable the driver to vary the tint of the windshield and/or mirrors. It aims to cut down on accidents that involve reduced visibility and glare.**

5) **Advanced Technology Headlighting, such as polarized ultraviolet lighting, improve visibility without an increase in glare. It also reduces accidents from reduced visibility and glare.**

SOURCE:

"Automatic Vehicle Control Systems," MOBILITY 2000, Dallas, March 1990.

APPENDIX E

REVIEW OF CURRENT IVHS TECHNOLOGIES

TABLE E.l

INDEX TO IVHS TECHNOLOGY REVIEWS

TABLE E.l (Continued)

INDEX TO IVHS TECHNOLOGY REVIEWS

ADVANCE

Advanced Driver and Vehicle Advisory Navigation Concept

Illinois Department of Transportation

ADVANCE is an Advanced Traveler Information System (ATIS) test project in the Chicago area. Its purpose is to evaluate the performance of in-vehicle navigation systems using vehicle probes in real-time traffic situations. Each system plans optimal routes to destinations based on "shortest time, shortest distance, no expressways, etc." The system then provides the driver with instructions during travel, including alternate route information for congestion avoidance as determined by a traffic information center (TIC) operator. At the same time, the vehicle probes transmit information such as speed, distance, and heading inputs for dead-reckoning navigation calculations to the TIC for analysis. Use of a Global Positioning System (GPS) receiver and an installed digital map on CD-ROM makes up for dead-reckoning calibration errors.

The CD-ROM also contains other information such as tourist information and business yellow pages.

A cost analysis provided by the University of Illinois-Chicago Urban Transportation Center and the Northwestern University Transportation Center shows the greatest expense of the ADVANCE project to be obtaining and installing in-vehicle hardware, followed closely by computer hardware and software, with research and management making up the lowest 14-17% of the cost.

For more information, contact:

Joseph F. Ligas
Illinois Department of Transportation
Phone (708) 7054697

ASSESSMENT OF BENEFITS FOR ADVANTAGE I-75

Center for Urban Transportation Research
University of South Florida-Tampa

March 1992

The Florida DOT sponsored research for the ADVANTAGE I-75 Program along the 2270~mile I-75 corridor from Miami to Sault St. Marie. The entire program also includes Highway 401-20 which connects to I-75 at the Detroit international border crossing and runs to Montreal (See COMPASS, Ontario). As I-75, built on private funding "five years before the government started paying for the interstate system," is one of the "longest, continuous, high volume trucking corridors in the country," elimination of stop and go traffic through Advanced Vehicle Identification (AVI) technologies would provide three major benefits : travel time savings, safety enhancement, and paperwork reduction. Other benefits include:

" - Lower prices to the general public as a result of more efficient movement of goods

- Increased data collection and information sharing for planning, registration/permitting, emergency response, enforcement, and revenue collection

- Improved two-way communications between states/provinces and truckers

- Real-time travel condition monitoring to improve trip-making for all motorists in the corridor ."

The AVI technologies would include electronically linked weigh stations along I-75 . Commercially operated vehicles stop at only the first truck weight station encountered upon entering the freeway corridor. At each subsequent weigh station on that trip, AVI readers simply identify the trucks as they pass by on the freeway, without requiring the truck to enter the station, resulting in reduced fuel consumption, pollution, congestion, and safety hazards associated with trucks exiting and re-entering the freeway travel lanes at weigh stations.

A suggestion from the Florida Center for Urban Transportation Research is to "investigate the feasibility of offering additional safety and cost savings incentives to provide to the motor-carrier industry for participating in the ADVANTAGE I-75 and other similar programs (e.g., training programs in fuel conservation, defense driving, and emergency and evasive driving techniques).

For more information, contact:

Michael C. Pietrzyk, PE
Center for Urban Transportation Research
University of South Florida
Tampa, Florida 33620-5350
Phone (813) 974-3120
FAX (813) 974-5168 SunCom 574-3120

Note: Also available on ADVANTAGE I-75 is a 13 minute video provided by the Kentucky Transportation Center.

AIDS

AIDS

Automated Information Directory System

Washington Metropolitan Area Transit Authority (WMATA)

Systems such as Washington% Automated Information Directory System allow travelers to easily plan transit travel over the telephone. An operator quickly receives schedule and route information from a computerized database and communicates with the customer to help them establish the most efficient travel plan. The purpose of the system is to make public transportation more convenient, resulting in an increase in transit-riders and a decrease in automobile congestion.

ALISCOUT

ALI-SCOUT SYSTEM

A Dynamic Vehicle Route Guidance System from Siemens

Ali-Scout contains the technology of a traffic management system, route navigation system, and driver information system. "The largest and most advanced demonstration of an IVHS system has been the Ah-Scout system test in Germany. " The project included 700 vehicles, 200 traffic lights, and over 2000 infrared beacons. Results of the project include:

- Ali-Scout is "user-friendly," with no complicated maps
- 60% of its volunteer drivers now say that they would buy the system at an average price of $500
- The volunteer drivers missed having the system after returning to their regular vehicles.

The Ah-Scout system contains two parts: the infrastructure equipment and. the in-vehicle equipment. Infrastructure equipment includes the infrared beacon and the central computer. In-vehicle equipment includes the display control unit, display unit, dead reckoning computer navigation system, and infrared transmitter/receiver. Ah-Scout has an up-to-date digitized map of the city in its central computer. It continually computes the path with the least congestion.

For more information, contact:

Seimens Automotive
2400 Executive Hills Drive
Auburn Hills, Michigan 48326-2980
Phone (313) 253-1000
FAX (313) 253-2999

ALV

**An Autonomous Vehicle
Constrained Test and Evaluation**

Norman C. Griswold

Texas Transportation Institute

Today's solution to the problem of traffic increase is not to build roads and add lanes to existing roads, but to develop more innovative ways to deal with congestion. Research undertaken by the Texas Transportation Institute of the Texas A&M University system involved the development and testing of an Autonomous Land Vehicle (ALV) controlled by "computer vision." The objectives of the ALV task were to:

"1) Complete installation of the system executive (a COMPAQ 386/20 computer) in conjunction with a computer vision sensing system.

2) Demonstrate constrained tests consisting of complex routing, obstacle avoidance and a full stop at intersections."

Attention was also given to:

1) The development of a strategic plan of an Intelligent Highway Center.

2) Collision avoidance with moving obstacles.

For technical details of the study, Research Report 1245-l is available from the Texas Transportation Institute.

The most important result of the research is an established "framework for the development of a video-based stop-sign recognition system" for use in future ALV's. Examples can be found in the research report.

For more information, contact:

Texas Transportation Institute
College Station, Texas 77843

Automatic Road ANalyzer (ARAN)

ARAN is a data collection system applicable to Roadway Management. It consists of a vehicle with a computer and modular subsystems that collect information for a complete profile of a lane of roadway in a single pass. The ARAN vehicle's data collection devices are as follow:

1) An ultrasonic sensor-containing "rut bar" bounces ultrasonic waves on the pavement in order to determine rut depth.

2) Aircraft gyroscopes determine the ARAN's orientation including its plane of travel compared to a perfect horizontal and its direction.

3) Accelerometers record roughness data and longitudinal profile.

4) A shaft distance-measuring instrument (shaft encoder) measures chainage.

5) An on-board industrial IBM PC/AT computer, built to withstand the strains of road use, processes and stores data from the measurement systems.

6) Pavement view cameras, equipped with high speed shutters to , eliminate blur, record the surface of the road.

7) Right-Of-Way camera pointing through the windshield records the driver's view during data collection.

The data collected by the ARAN goes to the ARAN work station to be analyzed for use in roadway management.

For more information on ARAN and other ROADWARE data collection equipment, contact :

ROADWARE Corporation
R.R. #l Paris, Ontario
Box 520
N3L 3T6
Phone (519) 442-2264
FAX (519) 442-3680

ARCHITEC

A DISTRIBUTED, HIERARCHICAL SYSTEM ARCHITECTURE FOR ADVANCED TRAFFIC MANAGEMENT (ATMS) AND ADVANCED TRAFFIC INFORMATION SYSTEMS (ATIS)

by Hotz, Much, Goblick, Corbett, Waxman
at MIT Lincoln Laboratory

and Ashok, Ben-Akiva, Koutsopoulos
at MIT Center for Transportation Studies

This paper is a proposed hierarchical system architecture for ATMS and ATIS that is "modular, fault tolerant, and employs distributed processing and data management of measured traffic information." The primary traffic control functions naturally separate into three levels: control of individual facilities, overall coordination of traffic facilities, and routing of vehicles. The architecture presented integrates the control of similar traffic facilities at the lower levels and coordinates dissimilar traffic facilities at the higher levels. Each level is designated as a node, which includes a surveillance module, a state estimation module, and a control module. The system's modularity supports the "phase-in" process, geographical growth, the evolution of sensors, in-vehicle devices, traffic management algorithms, and other related technologies.

For more information, contact:

Hotz , Much, Goblick, Corbett, or Waxman
MIT Lincoln Laboratory
Lexington, MA 02173-9108

or

Ashok, Ben-Akiva, or Koutsopoulos
MIT Center for Transportation Studies
Cambridge, MA 02139

ATIS

INFORMATION REQUIREMENTS FOR AN ADVANCED TRAVELER SYSTEM

IVHS AMERICA

The ATIS committee of IVHS AMERICA has expanded its applications to include travelers outside the transportation system - those who are planning to enter the system, and those who will not enter the system at all, such as foot travelers. Plans include personal/portable traveler information systems in the form of hand-held computers which provide information on restaurants, hotels, filling stations, shopping areas, parking availability, and local events. The system will provide route guidance for walkers and bikers in addition to transit-riders and drivers. They may be radio-linked to provide traffic advisories and to support inertial or satellite positioning route guidance.

"Fixed" systems include a conventional cable traffic channel, interactive cable, and PC applications which can be linked by wire or radio to traffic information sources.

'Applications may be of the following forms:

- Map Display
- Route Planning and Route Guidance
- Real-time Transportation Network Information
- Ride Sharing/Matching
- Information on Local Events
- On-line Business Directory

For more information, contact:

Nancy Marsh
Navigation Technologies
740 East Arques Avenue
Sunnyvale, CA 94086
Phone (408) 737-3200
FAX (408) 736-3734

ATMS.1

ATMS: Seven Steps to Deployment

Richard F. Beaubien
Hubbel, Roth & Clark, Inc.

Published by:
IVHS America ATMS Technical Committee

The Advanced Traffic Management System (ATMS) sector of the national Intelligent Vehicle Highway Systems (IVHS) program is particularly important to state and local Departments of Transportation because it is the transportation improvement area most dependent on public agencies. However, a problem appears in the implementation of ATMS. It is not technological improvements that present the problem, but rather the lack of awareness and coordination of state and local governments in "deploying" the new technologies. Beaubien lists "seven steps to deployment" in his article:

"Build your coalition"

> Mr. Beaubien suggests starting the coalition with an Incident Management Program because "it does not threaten authority, makes good use of existing resources, saves money, and builds the working relationships which foster communication and trust."

"Draft a program for ATMS"

Specific goals and project ideas for achieving those goals should be outlined in the ATMS plan.

"Find funding to deploy, operate and maintain the system"

Funding must be obtained for any project, and the most successful method of doing so is to present clearly to prospective patrons the benefits they will accrue by helping.

"Revise the program"

Revision should be constant so long as adequate funding is available.

"Designate administrative, operations, and maintenance responsibilities"

As with any operational team, a variety of shills must be integrated into a cooperative, organized team.

"Launch ATMS projects"

Projects must be publicized carefully from the start. They must sound exciting when announced, without promising more than they can produce. .

"Conduct project evaluations"

Regular progress reports including the program budget must be provided to the public and coalition partners. They must be written in simple terms so that they are easily understood.

According to Beaubien, establishing an organizational structure is the most difficult step in developing an ATMS program - once it is accomplished, the other steps will follow.

For more information, contact:

IVHS AMERICA
Washington, D.C. 20036
Phone (202) 857- 1202
FAX (202) 296-5408

ATMS.2

MARKETING ATMS AND MEASURING THE BENEFITS

Leslie N. Jacobson
Washington State DOT

An Advanced Traffic Management System is necessary for an effective IVHS plan. It is the base for all other areas of IVHS, "enhancing the future safety, mobility, social, and environmental compatibility of our transportation system.“: . The main purpose of Jacobson’s paper is to explain the importance of marketing ATMS and to give suggestions in carrying out the marketing process.

Jacobson lists three main marketing targets and their primary interests:

Target	Interest
Operating and affected agencies	Costs and benefits information
Elected officials	Cost effective systems supporting the goals of their district
General public and system users	Costs not exceeding public advantages

The most consideration according to Jacobson should be given to operating agencies. These agencies will then become marketers themselves for the rest of the system. A successful method in marketing within operating agencies is the use of educational training programs.

The ATMS Committee of IVHS America established objectives which include constant evaluation of ATMS projects, education of the public on ATMS, marketing of ATMS in order to gain funding and support.

Jacobson’s paper lists the final products needed to successfully market ATMS :

1. a model ATMS evaluation plan
2. a set of typical system component costs
3. an estimate of national ATMS deployment costs
4. an action plan for public awareness of ATMS
5. an action plan for education and training on ATMS

For more information, contact:

Leslie N. Jacobson
Washington State Transportation Center
Seattle, Washington 98105
Phone (206) 543-3331

ATT-ALERT

ATT-ALERT

Advanced Transport Telematics-
Advice and Problem Location for European Road Traffic

The goal of the European DRIVE11 ATT-ALERT project is to promote and internationally standardize a protocol developed in the DRIVE1 project which uses the Radio Data System-Traffic Message Channel (RDS-TMC!) for traffic information broadcasting. The protocol will also be applicable to digital paging and cellular radio. Test projects will help to identify necessary additions to the protocol. Castle Rock Consultants serves as management consultant for the project, coordinating ATT-ALERT and other DRIVE11 and RDS-TMC test projects.

For more information, contact:

Mr. Fotis Karamitsos
DRIVE Central Office
Commission of the European Communities
Rue de Treves, 61
Brussels B-1049
BELGIUM .
Phone +322 236 3461

AUTOSCOP

AUTOSCOPE-
Video Vehicle Detection System

AUTOSCOPE- is a wide-area system that utilizes video imaging instead of inductive loops. It is used in multiple lanes and directions, and can take input from up to four video cameras. The system is rated for outdoor installation in a traffic cabinet, and it is in agreement with NEMA TS l/TS2 and 170/179 environmental requirements. It offers up to 64 detector outputs, which can be directly linked to a controller. The system is able to collect traffic information on a "per-detection or per-time interval basis" for analysis at a later time. Some features of the AUTOSCOPE- system are:

- Eliminates imbedded loops
- Shows detections in real time
- Can obtain vehicle speed and classification (defined by length)
- Different types of detectors
- For temporary and permanent installations
- Field proven concept

"AUTOSCOPE technology offers a long-term and cost-effective solution to the intersection detection, traffic management, surveillance and control concerns of today and tomorrow ." Some benefits include freedom from loops, visual feedback, site flexibility; plus the system is a powerful and economical system, easy to install, and designed for growth. It can be applied to intersection control, traffic surveillance, and special studies.

For more information, contact :

ECONOLITE Control Products, Inc.
3360 E. La Palma Ave.
Anaheim, CA
P.O Box 6150, Anaheim, CA 92816-0150
Phone (714) 630-3700
FAX (714) 630-6349

AWACS

AWACS

Automatic Weight And Classification System

The Automatic Weight and Classification System (AWACS) study for the Iowa and Minnesota Departments of Transportation and the FHWA is an attempt to establish specifications for traffic weight and classification monitoring equipment based on piezo-electric cable sensors linked to roadside microprocessor units.

Tested system characteristics included:

* weighing accuracy
* classification accuracy
* axle spacing and speed measurement accuracy
* system reliability
* system durability

Other items considered were life-cycle system costs and environmental effects.

The specifications were prepared based on the test and analysis results as well as the economic results of the life-cycle cost analysis.

For more information, contact:

Richard Stehr
Minnesota Department of Transportation
Phone (612) 297-3532

AWAINDET

AWA
AUTOMATIC INCIDENT DETECTION SYSTEM

The AWA Automatic Incident Detection System uses algorithms that provide a comprehensive check of speeds, volume, and occupancy data at each site and make comparisons with adjacent lanes and between up and downstream sites to correctly identify an "incident." It can operate free standing, fully automated with direct control of variable message signs, or by advising operators on how to respond. The incident detection system is tied into a centrally managed traffic network, which allows multi-operator access to the alarm status data. The graphics capabilities of the software offers a user-friendly atmosphere for easy operation. The equipment is designed for "in-station" (computer equipment) as well as "out-station" (rugged construction designed for roadside environment). Its software is written in "C," and is supplied as executable code for both the in-station and out-station equipment.

For more information, contact:

AWA Traffic Systems America, Inc.
2127 University Park Drive, Suite 300
Okemos, Michigan 48864-3975
Phone (517) 349-6300
FAX (517) 349-6066

AWASCATS

AWA
SCATS - ADAPTIVE TRAFFIC SIGNAL CONTROL SYSTEM

SCATS, the Sydney Coordinated Adaptive Traffic System, is a traffic responsive Traffic Control System with comprehensive features for fault monitoring, maintenance scheduling, traffic data wllection and analysis, and traffic control. The goal of SCATS was to make the best possible use of a constrained arterial road system in Sydney, Australia, with ultimate application worldwide. Some special features of SCATS are emergency vehicle progression and public transport priority. A recent study found that SCATS saved motorists twenty percent in travel time, forty percent in stops, and twelve percent in fuel usage. AWA provides the total service for SCATS : compatible equipment supply, traffic engineering, strategic design, training, installation, commissioning, and on-going maintenance.

For more information, wntact:

AWA Traffic Systems America, Inc.
2127 University Park Drive, Suite 300
Okemos , Michigan 48864-3975
Phone (517) 349-6300
FAX (517) 349-6066

CALL-BOX

GTE CELLULAR CALL BOX SYSTEMS

The GTE cellular call box system consists of five major components : call box, cellular telephone network, public switched telephone network, GTE call box maintenance system, and GTE call box answer center. The system provides help to stranded motorists with problems such as flat tires, empty gas tanks, or auto accidents. The call box itself consists of an extremely rugged, weatherproof enclosure, a controller, transceiver, power system, controls, support structure, and optional area lighting or strobe light.

The cellular telephone network allows the call box to communicate with the answer center through radio links to cell sites. The public switched telephone network encompasses a complex of telephone lines, trunks, and switching gear that routes telephone calls from the originating telephone to the destination phone number. The maintenance center employs a computer data base with complete, real time alarm information on the entire call box system, keeping the system virtually 100% operational. The call boxes can be programmed to call different types of answer centers.

For more information, wntact:

GTE Government Information Services, Inc.
1 Jenner Suite 100
Irvine, CA 92718
Phone (714) 727-3021

CAL-PATH

THE CALIFORNIA PATH

The California PATH is a partnership between public, private, and academic sectors for the research, evaluation, and development of an advanced technologies intermodal transportation system. It is committed to finding solutions to the problems of California's current surface transportation system. In addition to coverage of all five major IVHS areas, specific current research areas include:

- Enabling Technologies
- Clean Propulsion Technology
- Impact and Application Studies
- Cross Cutting Studies
- Safety/Human Factors Studies

The following are PATH's applications to the five main areas of IVHS technology.

Current projects in the areas of ATMS and ATIS include an analysis of the potential travel time reduction benefits of en-route vehicle guidance and evaluations of integrated traffic management systems, impacts on traveler choices when given real-time traffic information, neural network models for congestion detection, and research on alternative methods.

In the AVCS area, PATH is experimenting with an adaptive headway controls system, lateral (steering) control, and longitudinal (speed and spacing) vehicle control to decrease travel times and space while increasing safety.

Current APTS projects deal with a comprehensive taxonomy of applicable technologies, development of a functional specification for a California standard navigable database, and two field operational tests involving real-time rideshare matching and pre-trip planning.

CVO applications include evaluation of vehicle location and two-way communications for the trucking industry, as well as the use of multimodal technology. PATH is also a participant in the HELP-Crescent Project, which applies automatic vehicle identification and classification, weigh-in-motion, computer integration, and communication in the trucking industry.

For more information, contact:

Anna Marie Bozzini
California PATH
University of California
Bldg. 452 Richmond Field Station
1301 S. 46th Street
Richmond, CA 94804
Phone (510) 231-9495
FAX (510) 231-9565

CANO_FLD

CANOGA VEHICLE DETECTION SYSTEMS MAGNETIC FIELD ANALYZER MODEL MM-9

The Model MM-9 Magnetic Field Analyzer is a self-contained, lightweight, and battery-operated field test instrument used to assist in the design and application of 3M Microloop and Magnetometer Probes in vehicle detection systems. The measuring probe is placed vertically in its holder and located at the site. The large calibrated meter indicates the intensity of the vertical component of the earth's magnetic field, magnetic noise, and AC magnetic fields. Use of the Magnetic Field Analyzer is recommended at such locations as bridge decks, tunnels, overpasses, trolley lines, and subways.

For more information, contact:

3M Safety and Security Systems Division
Building 223-3N-01, 3M Center
St. Paul, Minnesota 55144-1000
Phone 800-328-7098

CANO_MAG

3M TRAFFIC CONTROL SYSTEMS
CANOGA MAGNETOMETER VEHICLE DETECTOR
MODEL P202

The CANOGA Model P202 is a two-channel, shelf mounted Magnetometer Detector that detects passing/present vehicles by sensing changes in the earth's magnetic field. The Magnetometer Detection Systems are optimized by the appropriate placement and configuration of the magnetic probe. There are various wnfigurations that can be applied to the detection of trucks, automobiles, motorcycles, and bicycles. Some features of the Model P202 are:

* Erasable, write-on pads for phase or movement labeling
* Wide angle, hi-visibility LED's
* Two fully independent detection channels
* Four panel selected operating modes
* Electronically set sensitivity
* High sensitivity - uses up to three probes per channel
* O-100 mph speed range
* High count accuracy
* Easy installation - ideal for use in pavements, brick or cobblestone surfaces, temporary construction zones, etc.
* Higher reliability than loops

For more information, contact:

Traffic Control Systems
3M Safety and Security Systems Division
3M Center Bldg. 225-4N-14
St. Paul, MN 55144-1008
Phone 800-328-7098

DAKTRONICS

DAKTRONICS, INC.

Highway Traffic Systems
Variable Message Signs

Transportation departments are quickly recognizing the value of variable message signs (VMS's) in an advanced traffic management system. The Connecticut Department of Transportation is among several DOT's that utilize display signs supplied by Daktronics, Inc., producer of all major display technologies now available to the transportation industry including reflective, LED, fiberoptic and incandescent lamp. The Connecticut system includes a central control system and 3 secondary control systems for flexible use by operations, maintenance, construction, and state police personnel. Equipment used by the CDOT includes:

- 24 x 64 reflective matrix displays using elements on 2 .6" centers to create 18” characters

- Specially designed traffic control system including IBM-based central and local sign controllers

- Speed measuring equipment and loop detectors

- Modems, dial-up, telephone lines and cellular telephones for communication

- Photocells to automatically light the displays at night

Following are features of Daktronics VMS systems:

- Ability to interface with speed, ice, and other wndition detection systems

- Automatic nighttime illumination with photocell

- Unique error detection system advises personnel of element or controller failure

- Remote control through voice grade telephone lines, cellular phone, FM radio or fiberoptic

- Customized software to fit your particular application

- Multi-level password protection on control computer

- Various character and matrix sixes available

- Automatic scheduling

- Full-frame pictograms or icons

- Historical logging of all sign control operations

- Glow Cube reflective, outdoor LED, fiberoptic or lamp technologies offer high visibility, minimal power and low maintenance

- Electronics are located at the base of the display for easy service access

- Front or rear service access to the display

Transportation Departments using Daktronics electronic displays include Indiana, Virginia, and the New Jersey Highway Authority.

Following is a comparison of VMS technologies prepared by Daktronics.

For more information, wntact:

Daktronics , Inc.
P-0. Box 128
Brookings, SD 57006-0128
Phone (605) 692-6145
FAX (605) 697-5171

DATIS

DATIS

Dulles Area Traveler Information System

The Dulles Area Traveler Information System (DATIS) is a project which uses IVHS technologies to wllect and analyze traffic data in order to provide drivers with real-time information including road and traffic conditions, incidents, detours, and parking availability. The objective is to minimize delays and inconvenience due to congestion. Castle Rock Consultants provides reviews of alternative data wllection, information processing, and information transmittal systems.

The project will include an operational test in the Dulles area to evaluate the implementation of the information services based on economic factors, traveler benefits, and public acceptance.

For more information, contact:

Sidney Steele
Dulles Area Transportation Association
Phone (703) 689-9589

DIA

DETECTOR ISOLATION ASSEMBLY

(DIA)

A report presented by Richard Wells of the California Department of Transportation (CALTRANS) describes the Detector Isolation Assembly (DIA) electrical system as follows:

FUNCTION

The DIA allows non-standard census equipment to interface with existing cabinet equipment without interfering With critical signals to the Controller Unit.

OPERATION

The DIA "senses" the electronic switch closure from the Detector Sensor Unit and passes the signal through isolation circuitry to the census equipment. The isolation circuitry prevents feedback from the census equipment to the Controller Unit.

FEATURES

- Allows census equipment to utilize existing loops and equipment
- Low cost
- 30 Channels
- Transparent to the Controller Unit and the Detector Sensor Unit
- Easy installation
- Can be installed anywhere in the cabinet
- Ease of maintenance
- Standard

For more information, contact:

Richard Wells
CALTRANS
Sacramento, CA 95814
Phone (916) 654-4272
FAX (916) 653-3055

DTC

A MULTI-MODE APPROACH TO ATIS FEATURING THE DESTINATION TRAVEL CARD

By Allan Danns
Personal Travel Technologies, Inc.

The Personal Travel Guide - Destination Travel Card (DTC) of Personal Travel Technologies, Inc. , is an Advanced Traveler Information System (ATIS) memory card which can be used "from a desktop, laptop, or palmtop computer, a public kiosk, a TV-top unit in a hotel or living room or an in-vehicle dashboard unit" to provide travel information including trip planning, route guidance, alternate route generation and yellow pages (a guide to hotels, shopping, restaurants, banks, etc.) to motorists. Rather than covering the entire country, travel routes in specific metropolitan areas can be placed on the memory card.

DTC provides a substantial savings compared with the purchase of an installed vehicle navigation system. DTC is also more convenient because it can be removed for use outside of the automobile.

For information, contact:

Allan Danns
Personal Travel Technologies, Inc.
Hempstead, NY 11550
Phone (516) 538-1234
FAX (516) 538-9120

EMC

ECM

Electronique Controle Mesure

Technical descriptions of the following Road Traffic Control Devices are available from Electronique Controle Mesure (ECM):

SENSORS

* Buried and on roadway piezo-electric sensors for detection and classification
* Piezo-electric sensor for weighing-in-motion
* Tubes
* Loops
* Pedestrian detection mat

DETECTORS

* Tubes
* Loops
* Piezo-electric sensors
* Pedestrian detection mat
* Associated logics

COUNTERS

- Simple adding-machine for tube

* MINICOMPT system

* MEMO-SYSTEME system

TRAFFIC ANALYSIS - WEIGHING-IN-MOTION

* Axles histogrammeur : AP16

* Accurate analysis station : AP16

* Universal detector

* Multi-lanes, multi-functions station

* Softwares for analysis

TOLLS

* Automatic classification systems

* Magnetic-cards reader terminal

* Vehicle identification-in-motion

OTHER PRODUCTS

* Anti-intrusion detection by piezo-electric sensors

For more information, contact:

Electronique Controle Mesure
Rue du Bois-Chene-le-Loup
Part d'Activites de Brabois
54500 VANDOEWRE-LES-NANCY
FRANCE
83.44.24.13

ENTERPRISE

ENTERPRISE

Evaluating New Technologies For Roads-
Program Initiatives in Safety and Efficiency

ENTERPRISE is a concept that Castle Rock Consultants defines as "an outreach of separate state IVHS studies." It is aimed at the rapid development and implementation of IVHS technologies, and brings together the Minnesota Guidestar and the Arizona MIDAS with programs in other states such as Colorado and Iowa, and with Canadian transportation . agencies. ENTERPRISE includes both public and private participants. Some IVHS components involved are as follow:

1) Electronic Route Planning - to provide travelers with the shortest route to their destination in terms, of either time, distance, or cost, by direct computer access or over a phone line.

2) Traffic Information Broadcasting - to inform motorists of current traffic conditions by HAR (Highway Advisory Radio) or AHAR (Automatic Highway Advisory Radio) which automatically interrupts regular broadcasts to report traffic conditions.

3) In-vehicle Safety Advisory and Warning (IVSAW) - to "extend the driver's sight" to detect conditions out of his/her line of vision.

4) Incident Detection - to allow traffic operators to make adjustments in traffic control and advise motorists of alternate routes.

5) Freeway Corridor Control - to limit traffic flow onto freeways during peak hours using ramp closures, ramp mete-ring, variable speed control, lane control, and express or reversible lanes.

For more information, contact:

John Kiljan
Colorado Department of Transportation
Phone (303) 757-9506

EURONETT

EURONETT

Evaluating User Response on New European Transport Technologies

EURONETT is a part of the European DRIVE program with the purpose of evaluating the human factors of IVHS technology implementations. The evaluation foci included :

1) How travelers change their behavior in response to possible transportation scenarios

2) How technology implementations impact society and the European transportation industry in the long-run

3) How implementations affect travel in Europe at large

The process involved: . 1) A review of technologies, 2) Experimentation by human factors and psychological evaluation experts, focused on externally-linked route guidance and the traffic message channel. The experiments measured "message comprehension, user affinity, user compliance, and the interaction of information penetration and personality factors."

The results were used to develop behavioral models, called the EURONETT suite. These models help policy makers "predict and simulate responses of travelers, and. of society in general, to various transportation initiatives" and to "assist traffic planners and system designers to improve the human factors aspects of their work."

For more information, contact:

Mr. Fotis Karamitsos
DRIVE Central Office
Commission of the European Communities
Rue de Treves, 61
Brussels B-1049
Belgium
Phone +322 236 3461

E-ZPASS .

INTERAGENCY PROJECT TESTS ELECTRONIC TOLL COLLECTION:

Two Corporations Selected

From
The Urban Transportation Monitor"

September 18, 1992

The Interagency Committee, representing toll authorities in New York, New Jersey and Pennsylvania named AMTECH Systems Corporation of Dallas, Texas and the joint venture of AT&T Corporation of Bridgewater, NJ and Mark IV Industries, Inc., of Buffalo, NY as the finalists in the competition to select one manufacturer's toll technology for future regional use. The regional system "E-ZPass" will include electronically-read tags for automatic toll collection. Once implemented, E-ZPass can be used at any equipped toll facility in the region.

For more information, contact:

Atlantic City Expressway:	Anthony Marino (609)965-6060x19
New Jersey Highway Authority:	Dennis Ingoglia (908)442-8600x6503
New Jersey Turnpike Authority:	Cordon R. Hector (908)247-0900X5600
New York State Thruway Authority:	Arthur D'Isabel (518)436-2983
Pennsylvania Turnpike Commission:	Sally Branca (717)939-9551
Port Authority of New York & New Jersey:	Terry Benczik (212)463-7777
Triiorough Bridge and Tunnel Authority:	Frank Pascual (212)468-8460

FASTOLL .

FASTOLL

The Dulles Toll Road ETTM System

Fastoll is an electronic toll and traffic management system (ETTM) developed by Castle Rock Consultants for the Virginia Department of Transportation. Once implemented, it will prevent drivers from having to stop at toll booths on Dulles Toll Road in Northern Virginia. Using automatic vehicle identification (AVI) equipment, tolls can be collected electronically from vehicles moving at highway speeds. Each vehicle participating in the system will have a uniquely-coded transponder that is detected at toll booths automatically. A control center receives the code and debits the correct account.

For more information, contact:

Floyd Dawson
Virginia Department of Transportation
Phone (703) 734- 1666

FHWA-GA

GEORGIA ADVANCED TRAFFIC MANAGEMENT

TECHNOLOGY AND OPERATION

WEST COAST STUDY TOUR

Circulated by: FHWA Georgia Division

Following an Intelligent Vehicle Highway System (IVHS) workshop in Atlanta, fourteen attenders traveled to the west coast to study Advanced Traffic Management techniques. The group represented Georgia and North Carolina DOT's and included representatives from Atlanta and Charlotte.

The principal foci of the group were the successful traffic management techniques and operations of advanced traffic centers. These foci included Incident Management, Ramp Metering, High Occupancy Vehicle (HOV) lanes, Communication Strategies, Jurisdictional Cooperation, and Special Event Planning. Perhaps two of the most important results of interviews with members of west coast operation centers were: 1) the agreement between those interviewed of the value of local control of ramp meters, and 2) the agreement between system managers that, for a comprehensive traffic operations center, a Geographical Information System (GIS) is the desired data management base.

The group's travels and studies during February 24-27, 1992 included Seattle, Washington; Los Angeles, California; Orange County, California; and San Diego, California.

For more information, contact:

Charles Nemmers, Martin Knopp
FHWA-GA Division

GDI

GDI

General Devices and Instruments

Model 3100

31-O-31.3 GHz
Microwave Modem

The following is a description of the GDI Model 3100 as provided in the product brief:

The GDI Model 3100 Microwave modem is a quick-reaction alternative to a land-line circuit in the 170/NEMA environment. Whether your requirements are for an unconditioned' 1.2-kb/s line or a conditioned 64-kbs/s circuit, the 3100 microwave affords you a low-cost solution. Because of the response time or right-of-way constraints, that you may have with land-line implementation, you will very likely find the 3100 modem to be quicker, easier, and more affordable than a model 400 modem and the land lines it requires.

Two modules make up the Model -3100 system:

- A weatherproof transmitter/receiver/antenna unit

- An Interface unit, RS-232~compatible modem

APPLICATIONS

- Point to point, short haul, light density digital data transmission for applications in the 31.0 to 31.3 GHz band

- Extending communications services, including voice/data distribution, local area networks, and PABX inter-city trunk line connections.

- Last mile connections for wide area networks

FEATURES

- One hour installation - Bolt in place, plug in, aim

- Fast licensing - The 31-GHz band is uncrowded with other users, so local frequency coordination is not required by the FCC

- Flexible - Data rates, from dc to 64 kbs/s in either a simplex or duplex configuration

- 2-year warranty - Low parts count - solid-state - extremely high MTBF

For more information, contact:

GDI
P.O Box 187
Homewood, CA 96141
Phone (916) 525-7272
FAX (916) 525-4441

Go-84 RAPP

GO-84-Regional Automated Permit
Process Demonstration Project

An IVHS project to test electronic license plate (ELP) technology for commercially operated vehicles (CVO) will occur on "1-84" between Portland, Oregon to Salt Lake City, Utah, following a feasibility study to identify problems, organization, benefits, and costs of the project. The function of

ELP technology will be to automate the permit process for commercial vehicles in Oregon, Idaho, and Utah.

Objectives of the test project are as follow:

"1) Show the feasibility of using ELP to facilitate the processing of various permits issued in the participating states

2) Show the practicality of new IVHS technologies for CVO's

3) Identify the practical problems in implementing such a system on a wider regional scale

4) Demonstrate the benefits of ELP to the states and CVO's

5) Identify other users for ELP"

Benefits to states include:

"1) Streamlining ports-of-entry operations

2) Reduction of manpower at ports-of-entry

3) More efficient use of enforcement personnel

4) Smarter operations through automation"

For more information, contact:

Loyd Henion
Oregon Department of Transportation

GPSBRAIN

MAGELLAN GPS BRAIN

The Magellan Corporation reports it has created the "ultimate GPS receiver module" with the GPS Brain, which is a five discrete channel OEM board. Four of the five channels provide continuous tracking of the four satellites that determine a 3D position fix, and the fifth tracks all other satellites. One advantage of this system is the fifth channel, which enables the receiver module to rapidly switch satellites to achieve the most accurate updates of navigation data. Also, the five channel system allows continuous tracking of satellites even in harsh signal environments. The GPS Brain has been developed for maximum flexibility, with the ability to adapt to a variety of applications. For instance, it can be used for vehicle tracking, providing position information for Automatic Vehicle Location. Another application is vehicle navigation. Operational parameters are as follows: a position update rate of 1 second continuous; maximum velocity is 950 mph; maximum acceleration is 2 g; time to first fix with warm start is 30 seconds, cold start is 75 seconds, and autonomous start is 8-12 minutes.

For more information, contact:

Magellan Systems Corporation
960 Overland Ct.
San Dimas, CA 91773
Phone (714) 394-5000
FAX (714) 394-7050

GUIDESTAR

GUIDESTAR

IVHS Management Study

The Minnesota Department of Transportation (Mn/DOT) and the University of Minnesota's Center for Transportation Studies (CTS) have created the Guidestar program for coordination of their advanced technology programs with future IVHS deployments. The goal is to develop a comprehensive, statewide IVHS plan for the state, including "technical, organizational, and management issues appropriate to the state and its unique circumstances." The plan discusses implementation of technologies in both metropolitan and rural areas. Castle Rock Consultants reviewed IVHS initiatives in North America, Europe, and Japan to identify appropriate applications to Minnesota. CRC also outlined future IVHS activities in a strategic plan for Guidestar. The plan involved investigation of funding issues and development of an organizational managerial structure to guide the implementation process.

For more information, contact:

James L. Wright
IVHS Program Director
Minnesota Department of Transportation
Phone (612) 296-8567

HELP

HELP/Crescent

Heavy Vehicle Electronic License Plate Program

The Heavy Vehicle Electronic License Plate Program (HELP), including the Crescent test project, is an effort to improve heavy vehicle management through the use of IVHS technologies such as Automatic Vehicle Identification (AVI), Weigh-in-Motion (WIM), and Automatic Vehicle Classification (AVC) equipment. These technologies as a system provide: 1) identification of vehicles equipped with coded transponders, 2) verification of credentials and required safety inspections, and 3) collection of axle and gross vehicle weights 4) evaluation of axle spacing data "to confirm vehicle configuration, enable axle group weight verification and develop information necessary for the design, management and maintenance of the highway network." Once implemented, the HELP SYSTEM will provide long-range benefits to both public and private agencies such as:

"- Promoting more uniform size and weight regulations

- enabling law enforcement and taxation agencies to be more efficient and effective

- improving productivity by reducing costly delays to motor carrier industry and reducing workloads of monitoring agencies at ports-of-entry and weigh stations

- providing timely highway planning data useful in highway management at the state and federal levels"

The Crescent Demonstration is an implementation program to test the "capabilities, functions an applications enabled by the system." The steering committee for the demonstration is the Crescent Implementation Group (CIG).

For more information, contact:

WHM Transportation Engineering Consultants, Inc.
2414 Exposition Blvd.
Suite BC-230
Austin, TX 78703
Phone (512) 473-8343
FAX (512) 473-8237

IBIRIGS

REAL-TIME INTERACTIVE GRAPHICS SYSTEM (RIGS)
IBI Group

RIGS has been designed by IBI Group to provide real-time monitoring and control. The major components of the system are: a 286/383 microcomputer, a high resolution monitor, and an interactive graphics editor. The interactive graphics editor offers the ability to create, link, and edit real- time displays. The system has special features, such as a "full editing capability to create dynamic displays and the ability to import images created by standard CAD software. ' RIGS systems can be applied to the following:

- urban traffic control systems
- freeway traffic management systems
- train control systems
- airport traffic management systems

For more information, contact:

Scott Stewart
IBI Group
240 Richmond St. West, 5th Floor
Toronto, Ontario, Canada M5V 1W1
Phone (416) 596-1930
FAX (416) 596-0644

INFORM

INFORM Evaluation

From Volume 2: Executive Summary

Abstract By:

Federal Highway Administration

INFORM (Information FOR Motorists, formerly known as the Integrated Motorist Information System - IMIS) is a corridor traffic management system designed to obtain better utilization of existing highway facilities in a 40-mile (64.4-km) long highway corridor on Long Island, New York. The system includes integrated electronic traffic monitoring, variable message signing, ramp metering, and related strategies to optimize traffic flow through a heavily congested corridor.

The evaluation of INFORM was conducted using extensive field data, surveys, and data collected through the system. The Executive Summary presents the overall results of the evaluation, including comparisons of vehicle miles of travel, vehicle hours of travel, speed, occupancy, ramp delays, and equipment failures, motorist perceptions, and other congestion-related measures for the a.m. and p.m. peak periods. Incident case studies were used to evaluate motorist response to and effectiveness of variable message signing strategies. In addition to presenting the quantitative results, the Technical Report documents the many lessons learned in the design, implementation, operation, and evaluation of INFORM.

Volume 2: Executive Summary is one of two reports on the INFORM evaluation. The other volume is :

FHWA-RD-91-075 Volume 1: Technical Report

For more information, contact:

Office of Safety and Traffic Operations R&D
FHWA
McLean, Virginia 22101-2296

International Road Dynamics, Inc.
(IRD)

International Road Dynamics, Inc. , is a company "specializing in the development, manufacturing, marketing, installation, and service of transportation monitoring equipment and systems." IRD offers three systems for weigh-in-motion (WIM) data collection:

SYSTEM 1: IRD weigh-in-motion and classification using piezoelectric sensors.

Advantages

- low cost
- easy installation in existing pavement
- line, solar, or battery powered
- expandable to 4 weighing lanes and six additional classification lanes

SYSTEM 2: IRD low profile bending plate weigh-in-motion and classification.

Advantages

- can be installed in existing pavement
- includes an "innovative load cell design" featuring "completely sealed, waterproof weighing pads"
- load cells can be serviced in the field
- line, solar, or battery powered

SYSTEM 3: IRD single hydraulic load cell weigh-in-motion and classification.

Advantages

- high reliability
- extremely low maintenance
- can be serviced from the road surface without removing the scale mechanism
- sealed scale pit for minimum water and dirt intrusion

IRD WIM systems have been implemented in at least thirty states in the U.S.

IRD also provides Integrated Environmental and Traffic Monitors to alert drivers to current road conditions and alternative routes via Variable Message Signs (VMS) . Fog and ice detection and even carbon monoxide sensing are integrated into the environmental monitoring system.

Other IRD products include toll plaza treadles, bi-directional sensors for counting and classification, portable WIM scales, axle sensors, and epoxy mortar "Ready Packs" for easy anchorage of monitoring equipment. For more information a traffic accessories catalog is available. Contact:

IRD, Inc.
P.O Box 9270
Albuquerque, NM 871199270
Phone (505) 272-7545
FAX (505) 842-8018

IVHS

INTELLIGENT VEHICLE HIGHWAY SYSTEMS

An Overview of the IVHS Program
Through FY 1992

Circulated by: FHWA

January 1, 1992

After an enormous period of highway expansion, the United States is at a point in time when it must pause and look at the problems that accompany a fast-paced society. It must begin to evaluate its already-established transportation systems and invent methods for improving the efficiency of their use. The transportation plan of the United States is quickly changing and uses the following themes to describe its purpose:

"* Maintain and expand the Nation's transportation system
* Foster a sound financial base for transportation
* Keep the transportation industry strong and competitive
* Ensure that the transportation system supports public safety and national security
* Protect the environment and the quality of life
* Advance the U.S. transportation technology and expertise*'

A national IVHS program serves all six of these purposes. The specific goals of the system include "improved safety, improved efficiency of the highway in terms of capacity and speed of travel, reduced energy consumption and improved air quality, improved efficiency/profitability of commercial fleets and public transportation providers, and improved incident response." . These goals are addressed by five specific system areas :

* Advanced Traffic Management Systems (ATMS)
* Advanced Traveler Information Systems (ATIS)
* Commercial Vehicle Operations (CVO)
* Advanced Vehicle Control Systems (AVCS)
* Advanced Public Transportation Systems (APTS)

Some recent or in-progress projects include: INFORM - Long Island, N.Y .; SMART Corridor -Santa Monica Freeway, Los Angeles, CA; TRANSCOM - New Jersey and Staten Island Corridor; DIRECT - Detroit, Michigan; ADVANCE - Chicago, Illinois; HELP (Heavy Vehicle Electronic License Plate) program.

Administrations involved in the U. S . Department of Transportation IVHS program are: Federal Highway Administration (FHWA); National Highway Traffic Safety Administration (NHTSA) ; Federal Transit Administration (FTA) ; Research and Special Programs Administration (RSPA).

For more information, contact:

FHWA
Washington, D.C.
Phone (202) 366-2196

IVHS AMERICA

The Design of an Organizational Framework for Cooperation in IVHS

IVHS AMERICA
Second Annual Conference
Newport Beach, California

May, 1992

Hans K. Klein, MIT

The most predominant question in the application of Intelligent Vehicle Highway System (IVHS) technology to transportation is : How do we form an organized developmental structure? Hans Klein points out that because products or technologies are constantly evolving, and the process or "strategy" used to bring about those evolutions is also changing, it is difficult to create a stable "structure** to carry out the unstable strategies. IVHS programs evolved from independent projects to a national project in just a few years; some projects take very little time, others last many years; some projects are private, many are public. Klein emphasizes the only constant in the national development program: Change.

Mr. Klein explains the-need for a "meta-structure" and "meta-strategy" to facilitate change. The transportation technology meta-structure is IVHS AMERICA. The meta-strategy which it must carry out consists of three C's:

1) uniting the Community
2) facilitating Communication
3) promoting Consensus

Klein notes the importance of distinction between the following three groups:

IVHS "community"	All of the organization participating in IVHS development. Most belong to IVHS AMERICA.
IVHS AMERICA	A group made up of IVHS community members who come together to make decisions that affect Federal Policy.
IVHS AMERICA organization	Group of less than a dozen people whose purpose is to facilitate the making of final national decisions.

Klein's paper continues to explain the strategic plans and functions of IVHS AMERICA in detail, and is an appropriate information source for those interested in its structure and purpose.

For more information, contact:

Hans K. Klein
Research Staff
MIT
Cambridge, MA 02139
Phone (617) 253-2472

IVHS ARIZONA

ADOT/ASU/U of A

Minutes of the IVHS Retreat

Sedona, Arizona
April 2-4, 1992

From preparation by Larry Scofield

In contribution to the United States IVHS (Intelligent Vehicle Highway System) program to reduce congestion and improve travel efficiency, Arizona's public Universities, ADOT and consulting community members participated in an IVHS retreat in Sedona, Arizona on April 2-4, 1992. Arizona's need for a strategic plan for research and application of IVHS technologies stimulated the meeting. IVHS experts led the meeting with presentations covering national and local transportation technology needs.

The following are presentation summaries:

NORM VAN NESS	Provided information on the FHWA research structure and areas of IVHS Emphasis. He spoke of the $136 million increase in FHWA IVHS funding between 1990 and 1992, and mentioned the Federal Register as a source for selection criteria for proposed IVHS programs.
HENRY B. WALL	Discussed ADOT's freeway management plans and future research needs. Some elements of ADOT's Freeway Management System are: Loop detectors every l/3 mile, trip travel time instead of occupancy for monitoring and control, central command facility, and fiber optic cables on both sides of roadway.
LOUIS SABOUNGI	Provided an overview of IHVS technologies including eight-lane radar monitoring and absence of need for loop detectors by 19%. He listed the following critical success factors: 1) Champion 2) Marketing 3) Delivery 4) Resources 5) Commitment
JONATHAN UPCHURCH	Discussed ASU's study of variable message sign, including several forms of available VMS units: lamp matrix, flip disk, LED, fiber optic, and liquid cell. Of these, the shuttered fiber optic and LED performed the best.
ED SADALLA	Spoke of the effect of driving stress on humans. Researchers are able to measure the effect that different activities have on the stress levels of human beings.
PITU MIRCHANDANI	Presented information on the RHODES(Real-time, Hierarchical, Optimized, Distributed, Effective System) research program which he heads. The program's goal is to utilize IVHS structure, technology, and theory for **real-time traffic adaptive signal control."

At the close of the retreat, the group set up an action plan for IVHS research in Arizona. The plan included regular meetings and a monthly/quarterly newsletter. It also included four emphasis areas with appointed champions as follow:

Emphasis Area	Champion
Human Factors	Ed Sadalla
Freeway Management	Pitu Mirchandani
Rural IVHS	Larry Scofield
Test Tracks	Louis Lagomarsino

For more information, contact:

Larry A. Scofield
Arizona State University
Tcmpe, Arizona 85287
Phone (602) 965-2372
FAX (602) 965-9267

IVHS-20

PROVIDING RADICAL FUNCTIONALITY TO SERVE HIGHWAY TRANSPORTATION: A 20-YEAR VISION FOR IVHS

Robert D. Ervin
Kan Chen

University of Michigan
1990

The importance of an IVHS program is its ability to provide travelers with their basic transportation need - safe, comfortable travel. The means to providing these needs involve the reduction of congestion and the improvement of efficient travel. The plan to improve travel conditions includes providing drivers with technological services as follow:

Traffic Management

- Traffic Surveillance
- Ramp Metering
- VMS (Variable Message Signs)
- Automatic Vehicle Identification (AVI)
- Automatic Mayday

Traveler Information

- Automatic Vehicle Location (AVL)
- Destination and Route Guidance
- Trip Planning Advice
- Traffic Advisory Service

Vehicle Control

- Driver Fitness Assessment
- Driver Vision Enhancement
- Collision Avoidance System
- Automatic Control Intervention

Forecasts are that most drivers and their vehicles will be using these technologies by the year 2010, thus the title of the report A 20-Year Vision for IVHS.

IVSAWS

IN-VEHICLE SAFETY ADVISORY AND WARNING SYSTEM

The In-Vehicle Safety Advisory and Warning System (IVSAWS) makes use of in-vehicle signing to increase driver safety. It is a FHWA project to create a system that notifies motorists of hazardous road conditions in advance. The program issues are hazard scenario identification, system architecture design, driver alert warning subsystem design, communication subsystem design, and proof of concept field testing. The following are major IVSAWS parameters:

- Simple warning unit operation
- Audio/icon/text driver alert
- Maximum alert distance of 1 kilometer
- Optimal (variable) alert distance
- Flexible advisory message
- Bi-directional communication with ranging
- Slotted aloha protocol
- FCC allocation in 420 to 450 MHz
- 4.915 MHz spread spectrum
- Omni directional antennas
- 4 watt transmitters
- 12 volt battery power source
- -100 dBm receiver sensitivity
- CRC error detection

"The overall design philosophy has been to first determine the impact of human factors on the system functionality and then determine the communication architecture that will support these human factors considerations." The system is designed to provide messages that give drivers enough time to safety respond to dangerous situations. Warnings are given at a distance of "maximal effectiveness" which depends on vehicle type, hazard type, and vehicle speed.

For more information, contact:

Gregory L. Mayhcw or Keith L. Shirkey
Hughes Aircraft Company
Fullerton, CA

MDOT

METROPOLITAN DETROIT INCIDENT MANAGEMENT
COORDINATING COMMITTEE AGENDA

June 5, 1992

The agenda to the June 5 committee meeting, along with usual committee announcements and updates, contains several informative statements that can be related to incident management programs not only in Michigan, but nationally.

Donn Shelton of Southeast Michigan Council of Governments (SEMCOG) named communications as the biggest problem within an incident management program. It is important to warn travelers of traffic problems, such as detours, by use of signs far in advance of decision points, or even give them congestion avoidance guidance days earlier. The primary audience of these communications would be people who are willing to leave freeways but don't know where to go from there. One problem with improving or adding new signs stems from the reluctance of some DOT's to spend in that area.

The MDOT proposed to participate in a congested corridor program that presents the use of cellular phones to obtain travel times through a network.

Another idea being considered by MDOT is to use Automatic Vehicle Identification (AVI) in relation to American/Canadian border crossing.

The Michigan State Police use a computer to deliver information to Michigan Emergency Patrol, Metro Traffic Control, AAA Michigan, and the MDOT on pending traffic incidents in the following areas :

1) Incidents not yet responded to by Michigan State Police

2) Traffic incidents to which Michigan State Police Officers have been assigned

3) Surface street incidents which have been turned over to other agencies. The listing will indicate which local agency has been asked to respond to the surface street incident.

For more information, contact:

Michigan Department of Transportation
Detroit, Michigan
Phone (313) 256-9800
FAX (313) 256-9036

MTC

METROPOLITAN TRANSPORTATION CENTER (MTC)

BACKGROUNDINFORMATION

Office Memorandum From: Thomas Mullin, IVHS Engineer

Michigan DOT

In his memorandum, Mr. Mullin explains, "The MTC is conceived as a permanent national resource administered by the Transportation System Section of the Traffic & Safety Division."

According to Mr. Mullin, the MTC serves the following three purposes:

--> Create and maintain an infrastructure enabling the participation of qualified public and private organizations in field experiments and demonstrations with IVHS components.

--> Create, maintain and operate an infrastructure supporting advanced services to the motoring public on behalf of improved efficiency and safety. The services may include advanced traffic management (ATMS), advanced driver information (ATIS), and vehicle control functions to support vehicle operations with technologies that have reached a suitable state of readiness.

--> Cooperate with universities and private industrial partners in developing new IVHS technologies and further refining existing technology. Universities now actively participating are University of Michigan, Michigan State University and Michigan Technological University. Key industrial partners at present are General Motors, Ford Motor Company, Chrysler Motors and Ericsson/GE.

The Center is developing a test project called DIRECT (Driver Information Radio using Experimental Communication Technologies), which involves communication with individual vehicles in order to advise them of incidents and delays in their course of travel. The technology to be used for communication includes a Cellular Inquiry Terminal, Special Localcast (Interrupt) Transmission, Commercial Station FM Subcarrier, Roadside Localcast Transmitters, and Flashing Signs .

Although the focus of the DIRECT project is a corridor connecting Detroit to its international airport, the results are expected to be utilized in the future for services in other areas.

ONTARIO

COMPASS
from video by
Ministry of Transportation
Ontario

Compass is an example of communication technology for advanced traffic management of the "401 freeway" in Canada, which is second only to the Santa Monica Freeway as the busiest freeway in North America. Compass technology includes the electronic generation of traffic speed, volume, and density to operators in control booths whose duties are to warn travelers of congested areas and traffic incidents, and to take steps toward quick incident clearance. Variable message signs notify drivers of problem areas but allow them to choose their own alternate routes. Only when a section of the freeway is closed will traffic be redirected on specific alternate routes. Results of COMPASS traffic management are reduced traffic congestion, fuel consumption, air pollution, all-around costs, and driver frustration. The Ministry of Transportation's plan is to implement COMPASS technologies on other freeways in Canada such as the future "407 freeway."

OPTICOM

OPTICOM PRIORITY CONTROL SYSTEM

The OPTICOM Priority Control System is a signal preemption system that aims to insure the safest and most efficient traffic control under emergency situations. It increases safety for motorists, and provides improved response time for fire, medical, and police emergency vehicles. It allows the controller to assist emergency vehicles by placing temporary command of the intersection with the emergency vehicle operator. After the emergency vehicle passes through the intersection, the controller is returned to normal operation. The Opticom system consists of three major components :

™ The optical emitter, which is on the vehicle, to generate optical signals

™ The optical detector near the intersection to receive optical signals and transmit an electronic impulse to the phase selector

™ The phase selector in the controller cabinet to process the electronic impulse and manipulate the controller to provide a green signal

If the signal is already green, the controller keeps the green until the emergency vehicle has cleared the intersection. If the signal is red. the controller gives a green signal to clear existing traffic before the emergency vehicle arrives. The Opticom system also provides priority service on a first-come, first-serve basis. Once the first priority vehicle calls the system, it prevents other vehicles from calling the system until the first vehicle has cleared the intersection.

For more information, c&tact:

Safety and Security Systems Division/3M
Building 223-3N-01 3M Center
St. Paul, Minnesota 55144-1000
Phone 800-328-7098

PATHFINDER

PATHFINDER

PATHFINDER is an IVHS in-vehicle navigation system test project sponsored by the California Department of Transportation, the FHWA, and General Motors. The project consists of vehicle probes with installed positioning systems and computerized map displays. The goal of the test project is to provide motorists with alternate-route information to avoid incidents and congestion. Motorists receive information via Control Center communications. The Control Center collects data from the vehicle probes and detectors installed in the roadway, and transmits traffic information back to the PATHFINDER vehicles. The PATHFINDER project has become a part of the larger, SMART Corridor project for the Santa Monica Freeway in Los Angeles.

PIEZO

DEMONSTRATION PROJECT NO. 76

AUTOMATED TRAFFIC/TRUCK WEIGHT MONITORING EQUIPMENT (Weigh-In-Motion)

Arkansas Highway and Transportation Department

FHWA

March 1992

Piezo-electric cable, a ceramic-containing cable that produces an electric charge under pressure, is one technology being used in weigh-in-motion studies. Vehicle weight can be determined based on the cable electric charge. The cable was patented by the European firm Philips Corporation under the "Vibracoax" trademark in 1971. A piezo film, manufactured and marketed by Atochcm North America is a related technology being used for WIM tests in the United States. Tests using the piezo-electric cable in the past have shown mixed results. The equipment used for measuring vehicle weights by cable electric charge appears functional but has accuracy problems. For a description of testing done on Demonstration Project No.76 by the Arkansas State Highway and Transportation Department, a booklet is available on the "evaluation of piezo-electric weigh-in-motion equipment at four sites in asphaltic pavement in Arkansas."

For more information contact:

Arkansas State Highway and Transportation Department

PREDICT

PREDICT

Pollution Reduction by Information and Control Techniques

The European DRIVE program included a pollution reduction study to evaluate the potential of new technologies to improve air quality, and to develop new environmental standards in Europe. The study consisted primarily of models which integrated effects of direct emission-level control. Results of the studies included pollution-reduction estimates in relation to various levels of traffic control. Plans for a test project in Athens concluded the study.

For more information, contact:

Mr. Fotis Karamitsos
DRIVE Office
Commission of the European Communities
011 322 2362476

PROMISE

PROMISE

Mobile and Portable
Transportation Systems in Europe

PROMISE is an Advanced Traveler Information System (ATIS) project to develop and test a personal, portable information terminal. The project will include the "development of an integral system architecture, prototype terminals, and application software." Traffic data will be collected and analyzed, then information will be transmitted to travelers. Communications may eventually use RDS-TMC (Radio Data System-Traffic Message Channel), GSM, and one- and two-way paging and mobile data services. The portable system terminals will allow travelers to access traffic information from any location and at any time of day.

For more information, contact:

Mr. Fotis Karamitsos
DRIVE Central Office
Commission of the European Communities
Rue de Treves, 61
Brussels B-1049
Belgium
+322 236 3461

PTC

PTC

PAT*
TRAFFIC
CONTROL

PAT traffic control equipment consists of the following Advanced Traffic **Management (ATMS) technologies :**

TRAFFIC CONTROL CENTERS

- **Traffic Monitoring and Control Technic**
- **Geographical Displaysystems/GPS**
- **Rescue Management**

WEIGH-IN-MOTION SYSTEMS

- **Road Load Statistics**
- **Axle Overload Control**
- **Toll Stations**

TRAFFIC DATA COLLECTION NETWORKS

- **Real Time Traffic Flow Monitoring**
- **Environment Data Collection**
- **Data Networks**

TRAFFIC INFORMATION SYSTEMS

- **Real Time Information Systems**
- **Driver Warning Signals**
- **Driver Guidance Systems (Warning Waves)**

BRIDGE CONTROL SYSTEMS

- **Bridge Traffic Flow Management**
- **Bridge Overload Protection**
- **Harbor Traffic Control**

STATIC WHEEL LOAD WEIGHER

- Mobile Weighing Systems
- Weight Law Enforcement
- Safety Check On Trucks, Caravans, Cars

For more information, contact:

PAT Equipment Corporation
1665 Orchard Drive
Chambersburg, PA 17201
Phone (717) 263-7655
FM (717) 263-7845

• Registered trademark of PIETZSCH Automatisierungstechnik.

QMB

QUICKCHANGE MOVEABLE BARRIERS (QMB)

Barrier Systems, Inc.

A moveable barrier system consists of safety-shaped concrete barriers that are connected to form a continuous wall between roadway lanes and a Transfer and Transport Vehicle (TTV) that moves the wall. This gives Transportation Departments the ability to change roadway configuration quickly to increase capacity and reduce traffic delays. The barriers can be moved to reflect travel demand by providing more lanes in the direction of greatest traffic flow and can be used to close lanes for incident removal and road repair and maintenance.

Moveable barriers are placed accurately due to the computerized automatic steering system in the TTV that reads a signal emitted by a cable buried in the road. One mile of barrier wall can be moved in under 20 minutes. A QMB system is an economical way to increase the capacity of existing highways without adding new lanes – it is much less expensive, and can be implemented in months as opposed to years.

For more information, contact:

Barrier Systems, Inc.
P.O Box 125
Sausalito, CA 94966-0125
Phone (415) 331-3137
FAX (415) 331-2403

ROADCHECK
and Automatic Vehicle Identification

ROADCHECK provides equipment that is able to deal with one-way and two-way communications. In addition, new equipment is not required to upgrade one-way communication to two-way. The system uses an in-pavement antenna so that toll plazas, barriers, and overhead facilities are not needed. The "Reader" is kept in a weatherproof box on the roadside, and can deal with up to eight lanes of flow. One single Reader is able to provide all the information for the whole system. The major components of the Roadcheck system are: the in-pavement or overhead antenna, the roadside reader, and the transponder. Roadcheck is able to communicate with standard computers, along with other traffic monitoring systems like Weigh-In-Motion and Automatic Vehicle Classification.

The in-pavement antenna "kit" includes the antenna, its housing, and a fcedline assembly. "In-pavement antennas are simple to install, easy to maintain, and extremely reliable," and do not require closing of lanes for maintenance. Problems of shadowing are eliminated by using the in-pavement antennas.

The Reader causes a response from all Roadchcck transponders that pass, by continuously sending a pulse through the antenna. The information from the transponder is then sent to a remote computer or stored locally. Roadcheck has also developed the Compact Reader, designed for single lanes.

The purpose of the transponder is electronic identification. It responds to a 20 microsecond pulse traveling through the antenna, providing its identification (and other data). They can be used on any type of vehicle, and can be mounted anywhere that the they can be clearly sensed. .A lithium battery is its energy source, which provides a minimum life of 15 years. ROADCHECK also offers an interior transponder.

The Communicator, about the size of a calculator, is an on board "Smart Card reader" developed by MARK 1V IVHS and AT&T. This device allows two-way communication by interacting with a roadside reader.

For more information, contact:

MARK IV IVHS Division
10655 Henri-Bourassa West
Montreal, Quebec H4S 1Al
Phone (514) 335-4200
FAX (514) 335-4231

SURFACE CONDITION ANALYZER
(SCAN)

The California Department of Transportation received an Award of Merit from the FHWA in the 1992 Biennial Awards for its SCAN, a system which allows maintenance crews to accurately forecast hazardous roadway conditions through the use of early warning ice detectors buried in the pavement and weather stations by the roadside. This helps northern Los Angeles county to keep its "I-5" open during the snow season.

SCOOT Urban Traffic Control System

There are three key concepts of SCOOT; they are measuring Cyclic Flow Profiles (CFP's-average one-way flow of vehicles past any point on the road during each part of the cycle time of the upstream signal) in real time, updating an on-line model of queues continuously, and incrementally optimizing signal settings. Traffic information for CFP's is obtained from inductive loop detectors, which is collected about every second, and can anticipate "gridlock." The coordination plan responds to new traffic situations "in a series of frequent, but small, increments." SCOOT is most likely to be of benefit in areas of heavy, complex, and unpredictable flows.

SCOOT offers traffic information such as delay, stops, queues, flow, congestion, degree of saturation, spare capacity, and traffic signal settings.

For more information, contact:

P.B. Hunt, PhD, MSc
Transport and Road Research Laboratory
Crowthome, Bershire RGll

or

T.R. Holland, AFC, BA
Midlands County Council
The Traffic Control Centre
New Union St.
Coventry CV2 5BD

SMARTCOM

SMART COMMUTER
IVHS DEMONSTRATION PROJECT

The basis of the Houston Smart Commuter demonstration project is this idea: Commuters who can conveniently access relevant up-to-date information on traffic conditions, bus routes, bus schedules, and how to use the services at home and work will be more likely to use public transit services. In addition, Houston% HOV system provides reduced travel time, which encourages travel mode changes as well. The purpose of the two components of the project, the bus and carpool components, is to better utilize the Houston HOV facilities. The main focus of the bus component is real-time pre-trip information on current traffic conditions, bus schedules, and how to use the bus system. This data will be provided via videotext and telephone technologies. The aim of the carpool component is to make car-pooling a more desirable option for travel, causing an increase from 2 person to 3 person carpools. It utilizes an "employer-based real-time carpool matching service." The Smart Commuter project offers a test of the ability to gather, process, and transmit current traffic, transit, and instant rideshare matching information services to the public.

For more information, contact:

Texas Dept. of Transportation or
Texas Transportation Institute or
Texas A&M University or
Metropolitan Transit Authority of Harris County (METRO)

TELETRIP

TELETRIP

Long Island Railroad, N.Y.

An example technology applicable to the IVHS Advanced Public Transportation System (APTS) functional area, Teletrip is an information system which allows travelers to receive fare and schedule information through the telephone. Rather than speaking with an operator, the caller punches codes into his/her phone describing trip origin and destination, as well as other menu items. Then a computerized system provides the caller with requested travel and trip planning information. The purpose of this type of system is to make travel by public transportation easier and more desirable in order to reduce the number of automobiles on the road, especially during peak travel times.

USING THE TRAFFIC MONITORING GUIDE TO DEVELOP A TRUCK WEIGHT SAMPLING PROCEDURE FOR USE IN VIRGINIA

B.H. Cottrell, Jr.
Virginia Transportation Research Council

The Traffic Monitoring Guide (TMG) "provides a method for the development of a statistically based procedure to monitor traffic characteristics such as traffic loadings." VDOT developed a plan for using Weigh-In-Motion (WIM) systems with TMG to accurately monitor truck weights for use in:

- Pavement design and monitoring
- Bridge design and monitoring
- Size and weight enforcement
- Legislation and regulation
- Administration and planning

As a result of VDOT's research, the outline for the final plan includes:

1) Truck weight sample sites
2) Data collection procedures
3) Cost and resources estimates
4) Data from permanent WIM sites
5) Data management information

A. data task force was developed to resolve data problems and coordinate the WIM program.

For more information, contact:

Virginia Transportation Research Council
Charlottesville, Virginia 22903-0817

The CALTRANS / CAL POLY

TRAFFIC OPERATIONS CENTER SIMULATOR

Stephen Hockaday, Edward Sullivan,
Samuel Taff, and Clinton Staley

Traffic Operations Centers (TOC) are planned by the California Polytechnic State University (CAL POLY) and funded by the California Department of Transportation (CALTRANS) for urbanized areas throughout the state. The purpose of the TOC's is to centrally control traffic conditions to reduce congestion and ease travel. Preparation, construction and testing are the three phases of a project to successfully operate these centers. A TOC simulator has been constructed for use as a model for actual TOC's and is presently being tested, and personnel trained in its use. Methods accompanying the centralized control include "dispatching incident response teams, diverting traffic from congested areas, and providing motorist information through changeable message signs (CMS) , and radio messages.

Cal Poly studied centralized control centers around the country before creating floor plans for their TOC simulator facility, examples of which can be found in the. complete article by Hockaday, Sullivan, Taff, and Staley . Rooms in these plans include a projection room, control room, and most importantly, a TOC simulation room. A computer network for the system must perform three major tasks: "1) model traffic activity on the transportation network, 2) display activity to the TOC controllers, and 3) allow for the interactive exchange of information between the model and the control center. " The complete article provides an in-depth description of the simulation hardware and software.

The CALTRANS/CAL POLY TOC simulator project will set an example for other TOC's as an off-site testing center for traffic management technology.

For more information, contact:

Stephen Hockaday , Edward Sullivan,
Clinton Staley , or Samuel Taff
California Polytechnic State University
San Luis Obispo, CA 93407
Phone (805) 756-5062

TOLLS

TRAFFIC STUDIES GAINING NEW STATUS
ENR News
The McGraw-Hill Construction Weekly

ENR

July 20, 1992

The success of proposed toll road projects depends on traffic studies involving sociological and demographical factors in addition to traffic volumes. The biggest question is whether or not travelers will choose toll roads and bridges over slower-moving alternative routes.

According to Daniel W. Greenbaum, managing partner of Vollmer Associates, New York, also taken into consideration is "traffic that is not out there today but will be because you've made the trip much easier." Study methods include:

1) Using technologies to count traffic on existing roads

2) Stopping traffic and handing out questionnaires to drivers involving origin and destination points, purpose of trips and number of riders

3) Video-taping traffic to collect license plate numbers, mail postcards to motorists, and process their responses

A question that arises is how the price of the toll will affect travelers.

Edmund J. German, chief financial officer of Morrison Knudsen Corp., makes an important comment that the preference of residents "would be not to pay a toll, but they have a greater preference not to be 15 or 20 minutes late ."

Studies range from simple to the most complex. Richard R. Mudge, president of Apogee Research, Inc., Bethesda, Md. "conducts feasibility studies involving three dozen variables and focuses on answering just one crucial question : 'What is the likelihood of the rate of return falling below zero percent?"'

TRACKER

TRACKER TDW-10 WIDE BEAM VEHICLE DETECTOR

TRACKER Vehicle Detectors have been developed to provide specific traffic information, for overhead or pole mounted "maintenance free operation." The elimination of false readings (caused by vibration, background motion, or weather conditions) is the emphasis of its vehicle speed algorithm. Tracker detection devices use a low power, microwave radar transceiver, which is tuned/fixed for the X-band of the frequency spectrum. The TDW-10 is designed for multiple lane coverage to detect variable speeds. It provides real-time speed information, and can also be configured for incident detection. Vehicles are detected when they pass through the wide beam detection zone, which is usually 100-200 feet. TRACKER detection, which is based on the Doppler principle, is accurate for speeds from 5-80 mph and can cover as many as five lanes.

For more information, contact:

WHELEN Engineering Company
Route 145, Winthrop Rd.
Chester, CT 06412-0684
Phone (203) 526-9504
FAX (283) 526-4078

TTI/TXDOT

Development and Implementation of Systems To Collect, Analyze, and Disseminate Real-Time Traffic Information: A Private/Public Enterprise

Kevin N. Balke
William R. McCasland

Texas Transportation Institute
Texas A&M University System

The Texas Department of Transportation(TxDOT) and the Texas Transportation Institute (TTI) are developing an Advanced Driver Information System (ADIS) specifically for Houston, one of the most congested cities in the U.S. The system would use IVHS technologies "to obtain travel time and incident information in real-time directly from motorists traveling on the freeway system." An example of this type of system, the Real-Time Traffic Information System (RTTIS), was begun in October 1991 and will be tested in two phases; one using commuters with cellular phones to obtain information, and another using an Automatic Vehicle Identification (AVI) system.

Challenges faced by TxDOT and TTI include:

- Determining the appropriate role of the private sector in the design and implementation of the system
- Recruiting individuals to serve as probes in the system
- Developing procedures and methods for managing the flow of information through the system
- Developing methods of disseminating the information to the appropriate users"

The part of the system that is now operational provides reliable travel time and incident information. Plans include expansion into a more automated system by the beginning of 1993.

For more information, contact:

Kevin N. P.E.
Texas Transportation Institute (TTI)
Phone (409) 845 1727

ULTRASON

SPECIFICATION FOR
ULTRASONIC VEIIICLE DETECTOR
(SDU300)

The transmitter-receiver of the ultrasonic detector is designed for outdoor installation (at the road side or overhead), and is used in the detection of vehicles. The ultrasonic detector uses the reflection of ultrasonic waves to accomplish detection. It contains a detector unit, the ultrasonic transmitter-receiver, and fuses. The removable parts such as PCB's, connectors, and relays are put together so that regular shocks and vibration do not cause them to come off. The detector operates without adjusting, and is best used on roads with a consistent reflection of ultrasonic waves from the road surface.

For more information, contact:

Sumitomo Electric Industries, LTD.
l-3, Shimaya 1-chome
Konohana-ku
Osaka, 554 JAPAN

Cable address :

. KONOHANA SUMIDEN
Phone (06)461-1031

VDOT/AUTOSCOPE

VIRGINIA'S TRAFFIC MANAGEMENT SYSTEM

Joan Morris and Stacy Marber
ITE Journal, July 1992

Because development surrounding three major interstates in Northern Virginia prevents much roadway expansion, the Virginia Department of Transportation uses a Traffic Management System (TMS) for computerized surveillance of I-395, I-495, and I-66. The TMS allows VDOT to spot and help clear incidents and prevent accidents caused by traffic flow from ramps. TMS components include:

1) Counters embedded in the lanes and entrance ramps to measure traffic volume so that ramp metering can be used when appropriate.

2) Closed-circuit cameras allow traffic controllers to view an incident closely and provide the needed assistance quickly.

3) Variable Message Signs (VMS) allow traffic controllers to communicate directly with travelers to warn them of problems directly ahead on the interstate and to provide alternate route information. Note: The messages appear in yellow, which produces less glare than white during the daytime.

An interesting concept developed by the VDOT for VMS is that of posting the date and time when there is no congestion information to report, to alleviate motorists' concerns that a sign is malfunctioning when not flashing a message.

VDOT is now testing the "Autoscope" camera which can detect congestion and distinguish between incident- and non-incident-induced congestion. It will be able to automatically notify police when necessary. It will also be able to adjust ramp meter traffic signals and eliminate the need to close traffic lanes for the instalhnent and maintenance of pavement detectors. The camera will have connections to state police, and to radio and television stations.

Virginia DOT's ongoing investigation in Advanced Traffic Management Systems (ATMS) provides an excellent example for other members in the IVHS community to reference for improvement of their own programs.

For more information, contact:

Public Information Office
Virginia Department of Transportation

VNTSC . NH

IVHS Crash Avoidance Study
Volpe National Transportation Systems Center (VNTSC)
National Highway Traffic Safety Administration (NHTSA)

VNTSC and NHTSA chose Castle Rock Consultants, Battelle, and Calspan Corporation to research IVHS technologies applicable to highway safety improvements. The research process involves analyzing vehicle crashes and determining which technologies can either assist motorists in avoiding collisions, or lessen the impact of certain collision types. Economic factors, organization of future research and dev elopment projects, and real-world factors resulting from implementation of proposed technologies are also included in the study.

For more information, contact:

Joseph Koziol
Volpe National Transportation Systems Center
Cambridge, MA 02172
Phone (617) 494-2408

VRC

VEHICLE/ROADSIDE COMMUNICATIONS (VRC) : THE NEXT INFRASTRUCTURE?

by: Daryl S. Fleming, Ph.D., P.E. and Thomas L. McDaniel, Ph.D.

This paper is a discussion of the localized communications link VRC as opposed to regional and sub-area systems for application to IVHS. Regional and sub-area systems are relatively easy to implement (for one-way communication), but only a limited amount of relevant information can be sent to motorists. The authors suggest that there is a better solution to two-way communication: VRC. There are a variety of possible VRC applications. VRC can serve as an alternative to Automatic Vehicle Identification (AVI), as well as provide for electronic toll collection (ETC). In addition, VRC can be applied to electronic road pricing system on the basis of miles driven, when the driving is done, vehicle occupancy, levels of congestion, and emissions levels of the vehicle. Regarding commercial vehicle operations (CVO), VRC is able to automate records for bus/vehicle fleet management and offer non-stop operations (WIM and POE), while aRowing for HAZMAT monitoring. VRC's applications to advanced traveler information systems (ATIS) include coordination with the local highway advisory radio (HAR), specific driver messages, and emergency messages. VRC supports the communications needs for advanced vehicle control systems (AVCS) , as it allows transmission of information on roadway conditions, vehicle operations, hazards, and the vehicle-roadway/vehicle-vehicle relationships. The VRC system provides multiple lane coverage and offers two-way communications at prevailing speeds, read-write capabilities, and a programmable/scratch pad memory of no less than 256 bits.

WAYTOGO

WAY TO GO! PORTABLE TRAFFIC INFORMATION

Way To Go Corporation (WTG) of Berkeley, California has developed an evaluation of an Advanced Traveler Information System (ATIS) as part of the California PATH involvement in ATIS. The WTG system provides urban drivers with trip-specific incident information using a portable traffic information device. It is battery powered and has a microcomputer system, a radio data receiver, and synthesized voice capability. Some new characteristics of the WTG service are its congestion delay predictions, portability, and "eyes-free" operation. In addition, the service is intended to be broadly affordable. The WTG system is currently being tested in the San Francisco Bay Area using twenty-five subjects.

APPENDIX F

ASSUMPTIONS/DATA USED IN COST ESTIMATES

APPENDIX F.l

DERIVATION OF TABLE 5

TABLE 5

CHARLOTTE REGION FUNDING POTENTIAL FOR IVHS DEPLOYMENT
(In Million of 1992 Dollars)

	NATIONWIDE IVHS PUBLIC SECTOR POTENTIAL FUNDING	CHARLOTTE REGION POTENTIAL FUNDING	
		LOW ESTIMATE *	HIGH ESTIMATE **
ATM8	$24,941	$182	$302
ATIS	1,996	14	14
AVCS	4,320	32	32
CVO	4,986	36	36
APTS	2,855	21	21
SUBTOTAL	$39,098	$285	$405
PS & E @ 8%	3,128	23	32
TOTAL	$42,226	$308	$437

* NOTE 1: Low Estimate based on Charlotte Region Urban Freeway Mileage proportion of 0.73 percent of the 18,800 Nationwide Total.

** NOTE 2: High Estimate (ATMS only) made on assumption of $24,941 billion on ATMS Public Infrastructure Costs being distributed among 75 largest metro areas and that Charlotte would be at the mid-range of funding. Other element costs are estimated the same as the Low Estimate.

TABLE F.1

DERIVATION OF TABLE 5

	NATIONWIDE IVHS PUBLIC SECTOR COSTS * ($000,000)	18,800 URBAN MILEAGE ESTIMATE ** (0.73%)	75 METRO AREAS ESTIMATE *** (24.941/75)
ATMS	$ 24,941	$ 182	$ 302
ATIS	1,996	14	14
AVCS	4,320	32	32
CVO	4,986	36	36
APTS	2,855	21	21
	=========	=========	========
	$ 39,098	$ 284	$ 405
PSLE @ 8%		23	32
	=========	===========	===========
TOTAL		$ 307	$ 437

* SOURCE: Strategic Plan, page III - 147

** NOTE 1: (copy from Table 5)

*** NOTE 2: (copy from Table 5)

APPENDIX F.2

DERIVATION OF TABLES 6 & 13

TABLE6
CHARLOTTE REGION ESTIMATED COST OF IVHS PROJECTS
(In Millions of 1992 dollars)

COMPONENTS *	LOW ESTIMATE	MID-RANGE ESTIMATE	HIGH ESTIMATE
A. Capital Costs			
1. Incident Management Start-up	$ .47	$ .47	- **
2. Closed Loop Signal Systems	9.19	9.19	9.19
3. Freeway Surveillance	67.21	77.83	118.19
4. Arterial Surveillance	28.76	51.23	51.23
5. HOV Control System	3.24	6.68	6.68
6. Traffic Control Center	1.00	5.04	5.04
SUBTOTAL	$109.37	$150.44	$190.33
B. PS&E, Construction Engineering, Training @ 10% of A.	$10.94	$15.04	$19.03
SUBTOTAL	$120.31	$165.48	$209.36
C. Operating Costs (20 year totals in 1992 dollars)	$23.00	$29.80	$29.80
	===========	===============	===========
D. TOTAL ESTIMATED	$143.34	$195.28	$239.16

* NOTE 1: Costs estimated include only ATMS, ATIS, & CVO elements

** NOTE 2: Incident Management Costs included in Surveillance Costs

TABLE 13

IVHS DEPLOYMENT COSTS BY PHASE
(In millions of 1992 dollars)

COMPONENTS	PBASEI 1992-97	PHASE II 1997-2002	PHASE III 2002-2012	PHASE IV BEYOND 2012	TOTAL *
System Miles/ Kilometers:	100.4	58.6	107.2	79.4	345.6
A. Capital Costs					
1. Incident Xgt.	0.36	0.11			0.47
2. Closed Loops/ Bus Preemption	2.43		3.34	3.42	9.19
3. Freeway Surveillance	21.06	13.04	4.76	28.34	67.21
4. Arterial . Surveillance		7.29	21.47		28.76
5. HOV Control System		1.41	1.83		3.24
6. Traffic Control Center	1.00				1.00
SUBTOTAL	24.85	21.85	31.40	31.76	109.86
B. PS&E, Construction Engineering, Training @ 10% of A	2.48	2.18	3.14	3.18	10.98
SUBTOTAL	27.33	24.03	34.54	34.94	120.84
C. Operating Costs	5.75 ,	5.75	11.5	N/A	23.00
D. TOTAL ESTIMATED COSTS	33.08	29.78	46.04	34.94	143.84

*NOTE 1: Low Estimates of costs (from Table 6) shown for illustration; other estimates would be similarly distributed; Table 13 shows ATMS, ATIS, CVO elements only.

TABLE F.2

ATMS, ATIS, CVO UNIT ESTIMATED COSTS USED FOR CARAT PHASE I

ITEM	COST/MILE
Solar Call Boxes	$ 10,000
Tower-Mounted Cameras	40,000
Ramp Metering	35,000
Vehicle Detection	75,000
Variable Message Signs	310,000
Communication Cable and Hardware	213,000
Highway Advisory Radio	4,500
WIM and AVC for Commercial Vehicles	14,000
Data Base Management System (Software)	24,000
Motorist Assistance Patrol	13,000*
Electric, Phones, and Misc. Equipment	15,500

* NOTE: Source of all cost estimates is Traffic Engineering Branch, NCDOT, except for Motorist Assistance Patrol (MAP). The latter costs came from actual costs of operating these patrols during 1992, plus estm. for HAR ($4,500/mile) and Alternate Route Signing ($1,000/mile).

TABLE F.3

COST ESTIMATES BASED ON CARAT PROPOSAL

LENGTH OF PHASE I SEGMENT: 15 miles

I.	Capital: Total 4-year estimate		$ 25,122
A.	Control Center & Equipment		4,660
B.	Detection System		1,125
	Misc. Equipment		225
	Cameras		600
	Communication		3,195
	Data Base Management		360
	Ramp Metering		525
	Solar Call Boxes		150
	VMS		4,650
	HAR		68
		15 miles	$ 10,898
		SUBTOTAL(A&B	$ 15,558
C.	Transportation Info. Center & Connection		$ 1,455
		SUBTOTAL	$ 17,223
	CVO Component (WIM, AVC		$ 210
		TOTAL	$ 17,423
II.	Operations		
	Personnel (4-year)		$ 4,400
	MAP		1,483
	Incident Management Manual		255
		TOTAL	$ 6,138
III.	PS&E Training (10.8% of $17,223		$ 1,860

TABLE P.4

MILAGE FOR THE CHARLOTTE REGION IVHS HIGHWAYS
URBAN FREEWAYS

		POTENTIAL IMPROVEMENTS (MILES/SEGMENTS)				
PHASE	TOTAL SYSTEM	INCIDENT MANAGEMENT	CLOSED LOOP	SURVEILL. & VERIF.	HOV LANE	OTHER
I	100.4	42.5 I. B,C,D,E	24.3 I. K	33.6 I.A,G,H,J,F		-
II	37.9	13.1 II. B		20.8 II. C,D	4.0 II. A	-
III	12.8	-	-	7.6 III. I.	5.2 III. D	Tie-in Downtown TCC
IV	45.2	-	-	45.2 IV. A,B,E		-
	196.3	55.6	24.3	107.2	9.2	-

TABLE F.5

MILEAGE FOR THE CHARLOTTE REGION IVHS HIGHWAYS
URBAN ARTERIALS

		POTENTIAL IMPROVEMENTS (MILES/SEGMENTS)				
PHASE	TOTAL SYSTEM	INCIDENT MANAGEMENT	CLOSED LOOP	SURVEILL. & VERIF.	HOV LANE	OTHER
I		-	-		-	-
II	14.2	-	-	14.2 II.E,F,G	-	-
III	55.5	-	8.4 III.A(l)	47.1 III.B,C,E, F,G	-	-
IV		-	-		-	
	69.7	-	8.4	61.3	-	

TABLE F.6

MILEAGE FOR THE CHARLOTTE REGION IVHS HIGHWAYS
RURAL FREEWAYS & ARTERIALS

		POTENTIAL IMPROVEMENTS (MILES/SEGMENTS)				
PHASE	TOTAL SYSTEM	INCIDENT MANAGEMENT	CLOSED LOOP	SURVEILL. & VERIF.	HOV LANE	OTHER
I		-		-	-	-
II	6.5	-		6.5 II. K	-	-
III	38.9	-	25.0 III.A(2)	13.9 III. H,J	-	-
IV	34.2	-	34.2 IV.C,D	-	-	-
	79.6	-	59.2	20.4	-	-

TABLE F.7

MILEAGE FOR THE CHARLOTTE REGION IVHS HIGHWAYS
ALL SYSTEMS

PHASE	TOTAL SYSTEM	POTENTIAL IMPROVEMENTS (MILES/SEGMENTS)				
		INCIDENT MANAGEMENT	CLOSED LOOP	SURVEILL. & VERIF.	HOV LANE	OTHER
I	100.4	42.5 I.B,C,D,E	24.3 I. K	33.6 I.A,F,G,H,J		-
II	58.6	13.1 II. B	-	41.5 II.C,D,E, F,G,K	4.0 II. A	-
III	107.2	-	33.4 III.A(1,2)	68.6 III.B,C,E, F,G,H, I,J	5.2 III. D	-
IV	79.4	-	34.2 IV.C,D	45.2 IV. A,B,E	-	-
	345.6	55.6	91.9	188.9	9.2	-

TABLE F-8

OPTIMAL SYSTEM- COST ESTIMATE, CARAT PHASE I

FMS Costs/Mile
(Capital Costs) ($000)

Traffic Management System/ Freeway Management System Element	Cost/Mile	Cumulative Cost/ Mile	Fixed cost
A. Control Center (TCC)			83,705
Control Center Equipment			855
Misc. Equipment			225
Incident Management Equipment			255
			=======
			85,040
B. ATMS Components			
Vehicle Detection System (Inductive.loops, Fiber optic Connections)	$75		
Verification Systems (Tower Mounted Cameras)	$40	$115	
Data Base Management System (Software)	$24	$139	
Communications System (Fiber Optic Plant, Others Correcting Cable and Hardware)	$213	$352	
Ramp Metering System	$35	$387	
C. ATIS Components			
Variable Message Signs	$310	$697	
Solar Call Boxes	$10	$707	
Highway Advisory Radio	$5	$712	
D. AVC)	$14	$726	

E. Total "Optimal System" Cost for 15 - mile Phase I CARAT System (Capital Costs Only)

Fixed	$5,040
Variable	$10,890
	=======
	$15,930

TABLE F.9

'BASELINE SYSTEM' COST ESTIMATE, CARAT PHASE I

FMS Costs/Mile
(Capital Cost) ($000)

Traffic Management System/ Freeway Management System Element	Cost/Mile	Cumulative Cost/Mile	Fixed cost
A. Control Center (TCC)			$3,705
Control Center Equipment			855
Misc. Equipment			225
Incident Management System			255
			==========
B. ATMS Components			
Vehicle Detection System (Inductive loops, Fiber Optic Connections)	$75		
Data Base Management System (Software).	$24	$99	
Communications System (Fiber Optic Plant, Other Connecting Cable and Hardware)	$213	$312	
C. ATIS Components			
Variable Message Signs	$310	$622	
Highway Advisory Radio	$5	$627	

D. Total "Baseline" Cost for 15-MILE Phase I CARAT System (Capital Costs Only)	Fixed $5,040 Variable $9,405 ====== $14,445

TABLE F.10

"INTERIM SYSTEM" COSTESTIMATE, CARAT PHASE I

FMS Cumulative Costs/Mile
(Capital Costs) ($000)

Traffic Management System/ Freeway Management System Element	Cost/Mile	Cumulative Cost/Mile	Fixed cost
A. Control Center (TCC) *			$1,000
Control Center Equipment			855
Misc. Equipment			225
Incident Management System			255
			=======
B. ATMS Components			
Vehicle Detection System (Inductive loops, Fiber Optic Connections)	$75		
Data Base Management System (Software)	$24	$99	
Communications System (Fiber Optic Plant, Other Connecting Cable and Hardware)	$213	$312	
C. ATIS Components			
Variable Message Signs	$310	$622	
Highway Advisory Radio	$5	$627	
D. Total "Interim" Cost for 15-mile Phase I CARAT System (Capital Cost Only)		Fixed	$2,335
		Variable	$9,405
			======
			$11,740

* NOTE: TCC would be modified control center in existing TOC (City or State Facility)

TABLE F.11

CALCULATION OF CHARLOTTE IVHS COSTS
LOW ESTIMATE

A.	Incident Management 55.6 miles @ $8,500/mi	$ 472,000
B.	Closed Loop Signal Systems 91.9 miles @ $100,000/mi	$ 9,190,000
C.	Freeway Surveillance & Verification 107.2 miles @ $627,000/mi	$ 67,214,000
D.	Arterial Surveillance & Verification 81.7 miles @ $352,000/mi	$ 28,758,000
E.	HOV Control Systems 9.2 miles @ $352,000/mi	$ 3,238,000
F.	Control Center (Assumed modifications to existing TOC)	$ 1,000,000
	Subtotal	$ 109,400,000
G.	F'S & E @ 10%	$ 10,940,000
	Subtotal	$ 120,340,000
H.	Operating Costs 20 years @ $1,150,000/yr	$ 23,000,000
	TOTAL 20-YEAR CAPITAL AND OPERATING/MAINTENANCE COST ESTIMATE	$ 143,340,000

TABLE F.12

CALCULATION OF CHARLOTTE IVHS COSTS
MID-RANGE ESTIMATE

A.	Incident Management 55.6 miles @ $8,500/mi		$ 472,000
B.	Closed Loop Signal Systems 91.9 miles @ $l00,OOO/mi		$ 9,190,000
C.	Freeway Surveillance & Verification 107.2 miles @ $726,000/mi		$ 77,830,000
D.	Arterial Surveillance & Verification 81.7 miles @ $627,000/mi		$ 51,230,000
E.	HOV Control Systems 9.2 miles @ $726,000/mi		$ 6,680,000
F.	Control Center (B)		$ 5,040,000
		Subtotal	$ 150,434,000 .
G.	PS & E @ 10%		$ 15,043,000
		Subtotal	$ 165,477,000
H.	Operating Costs 20 years @ $1,490,000/yr.		$ 29,800,000

TOTAL 20-YEAR CAPITAL AND OPERATING/MAINTENANCE COST ESTIMATE $ 195,280,000

TABLE F.13

CALCULhTION OF CHARLOTTE IVHS COSTS
HIGH ESTIMATE

A. Incident Management (costs included in surveillance)		
B. Closed Loop Signal Systems 91.9 miles @ $l00,000/mi		$ 9,190,000
C. Freeway Surveillance & Verification 162.8 miles @ $726,000/mi		$118,193,000
D. Arterial Surveillance & Verification 81.7 miles @ $627,000/mi		$ 51,226,000
E. HOV Control Systems 9.2 miles @ $726,000/mi		$ 6,679,000
F. Control Center (Based on CARAT Phase I Estm.)		$ 5,040,000
	Subtotal	$ 190,327,000
G. PS & E @ 10%		$ 19,033,000
	Subtotal	$ 209,360,000
H. Operating Costs 20 years @ $1,490,000/yr.		$ 29,800,000
TOTAL 20-YEAR CAPITAL AND OPERATING/MAINTENANCE COST ESTIMATE		$ 239,160,000

TABLE F.14

TOTAL FOUR YEAR CARAT PHASE I ESTIMATE

FMS Cost/Year
(Operating Cost) ($000)

Cost Element	Cost/Year	Cumulative	4-Year costs
PS & E, Construction Engr., and Training	$465		$1,860
Control Center Personnel	$1,100	$1,565	$4,400
Motorist Assistance Patrol	$390	$1,955	$1,560
Total 4-Year Operating Costs - Opt, A	$1,490		$7,820
Opt. B			$7,091
opt. c			$5,763

Total Costs, Capital Cost and
Operating Costs, 4-Year Program

Option A	$23,750
Option B	$21,536
Option C	$17,503

* Average Operating Costs for first 4 years

TABLE F.15

BASIC ASSUMPTIONS/DATA FOR COST ESTIMATES

1. Assumptions for application of IVHS technologies nationwide derived from "Reports on Major Aspects of IVHS" prepared by Working Groups of Mobility 2000, March 1990, page 17

Urban Freeway Mileage:	18,800
Number of urban areas for IVHS application:	75

2. Charlotte Region proportion of Urban Freeway Mileage:
   137.4 mi / 18,800 mi = 0.73%

3. Assumptions for nationwide cost estimated for IVHS components derived from the Strategic Plan for IVHS in the United States, May 20, 1992, page III - 147

   e.g. : 20-year ATMS Public Sector Cost Estimate: $24,941 million

4. Charlotte Region proportion of ATMS public sector investment:

   $24,941 million / 75 urban areas = $332.5 million

   It is assumed this cost applies to freeways and arterials, and that The Charlotte Region would receive a mid-range (average) investment among these 75 urban regions.

5. Cost per mile for surveillance and verification systems: (Source: CARAT Phase I Proposal)

a.	Freeway systems	$726,000/mile
b.	Arterial systems	$627,000/mile

6. Other system mileage - based cost estimates:

   a: Closed loop signal system — $25,000/intersection or $100,000/mile (annual)

   b: Incident Management

Urban segments	$13,000/mile
Rural segments	$8,500/mile

   c: Bus Preemption signal systems $ 38,000/intersection or (Source: Charlotte DOT) 000