Rural Interstate Corridor Communications Study Report to States

final

report

prepared for

U.S. Department of Transportation
Federal Highway Administration

prepared by

Cambridge Systematics, Inc.

with

PB
Telvent Farradyne, Inc.
TransCore

February 2009

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16. Abstract

Section 5507 of the Safe, Accountable, Flexible, Efficient Transportation Act: A Legacy for Users (SAFETEA-LU) directed the Secretary of Transportation, in cooperation with the Secretary of Commerce, State departments of transportation, and other appropriate State, regional, and local officials, to assess the feasibility of installing fiber optic cabling and wireless communication infrastructure along multistate Interstate System route corridors for improved communications services to rural communities along such corridors.

This document is the second of two reports that explore the potential for the use of rural Interstate Highway corridor rights-of-way for the deployment of fiber optic cable and/or wireless communication infrastructure, across multiple States linked by the Interstate Highway system. The first document, the Rural Interstate Corridor Communications Study: Report to Congress, was submitted to Congress on August 18, 2008. This document, the Report to States, provides a summary of study resources available to the Corridor States to begin the process for possible deployment of high-speed telecommunications (HST) in the corridors in question.

As part of the task to develop the Report to States, a preliminary backbone alignment plan for telecommunications has been developed. The report, a White Paper on the Preliminary Backbone Alignment, is included as an appendix to this Report to States. This preliminary backbone alignment report presents information related to the development of preliminary telecommunication infrastructure, alignments, and other supporting material developed by the study team to be utilized by the corridor States in the future. It addresses issues of constructability, scheduling and maintenance, environmental considerations, and utility accommodation policies.

17. Key Word **Rural transportation systems, preliminary backbone alignment, high-speed telecommunications, broadband, fiber optic cabling, wireless, public-private partnership, corridor, utility accommodation**	18. Distribution Statement **No restrictions.**		
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Table of Contents

List of Figures

Executive Summary

Section 5507 of the Safe, Accountable, Flexible, Efficient Transportation Act: A Legacy for Users (SAFETEA-LU) directed the Secretary of Transportation, in cooperation with the Secretary of Commerce, State departments of transportation, and other appropriate State, regional, and local officials, to assess the feasibility of installing fiber optic cabling and wireless communication infrastructure along multistate Interstate System route corridors for improved communications services to rural communities along such corridors. Such a wireless and fiber optic facility would support the delivery of high-speed telecommunications (HST), commonly referred to as "broadband" service, to many currently underserved communities. The corridors identified in Section 5507 are:

- Interstate Route 90 through South Dakota, southern Minnesota, northern Iowa, and central and western Wisconsin;
- Interstate Route 20 through northern Louisiana, Mississippi, and Alabama; and
- Interstate Route 91 through Massachusetts, Vermont, and New Hampshire.

A Report to Congress was submitted on August 18, 2008, laying out information about the corridors, some characteristics of the market for high-speed telecommunications, and some of the potential impacts of the availability of broadband access. As part of the task to develop the Report to States, a preliminary backbone alignment plan for telecommunications has been developed. The report, a White Paper on the Preliminary Backbone Alignment, is included as an appendix to this Report to States. This preliminary backbone alignment report presents information related to the development of preliminary telecommunication infrastructure, alignments, and other supporting material developed by the study team to be utilized by the corridor States in the future. It addresses issues of constructability, scheduling and maintenance, environmental considerations, and utility accommodation policies.

The purpose of the preliminary backbone alignment is to serve as a high-level design guide for a State agency or private telecommunications partner that will allow them to estimate the level of effort required to install the telecommunications infrastructure and initiate discussions with potential private sector or public partners. The backbone infrastructure included in this study includes wireline, in which conduit is buried and filled with fiber optic cable, and wireless infrastructure in the form of tower locations. This report is intended to be neutral with respect both to technology and to the institutional arrangements selected for deployment; where a particular technology (e.g., wireless versus wireline) is proposed, it is for illustrative purposes only.

In conjunction with the Report to Congress, this Report to States summarizes the information resources available for corridors to move forward with high-speed telecommunication programs if they so choose. The Report to Congress was developed under a legislatively defined timeline. Information on the preliminary backbone alignments was developed after the Report to Congress was completed. Table 1 presents the language of Section 5507, along with a cross-reference to the locations within the Report to Congress and within this report that address or respond to the legislative language.

Table ES-1: Cross-Reference to Section 5507

SEC. 5507. RURAL INTERSTATE CORRIDOR COMMUNICATIONS STUDY		
Sec.	**Description**	**Report Location**
(a)	Study- The Secretary, in cooperation with the Secretary of Commerce, State departments of transportation, and other appropriate State, regional, and local officials, shall conduct a study on the feasibility of installing fiber optic cabling and wireless communication infrastructure along multistate Interstate System route corridors for improved communications services to rural communities along such corridors.	
(b)	Contents of Study- In conducting the study, the Secretary shall identify--	
(b) 1	impediments to installation of the infrastructure described in subsection (a) along multistate Interstate System route corridors and to connecting such infrastructure to the rural communities along such corridors;	Report to Congress, Section 4; Report to States, Appendix A
(b) 2	the effective geographic range of such infrastructure;	Report to Congress, Section 2
(b) 3	potential opportunities for the private sector to fund, wholly or partially, the installation of such infrastructure;	Report to Congress, Sections 1 and 4, and Report to States, Section 3
(b) 4	potential benefits fiber optic cabling and wireless communication infrastructure may provide to rural communities along such corridors, including the effects of the installation of such infrastructure on economic development, deployment of intelligent transportation systems technologies and applications, homeland security precaution and response, and education and health systems in those communities;	Report to Congress, Section 3
(b) 5	rural broadband access points for such infrastructure;	Report to Congress, Sections 1 and 4, and Report to States
(b) 6	areas of environmental conflict with such installation;	Report to States, Appendix A
(b) 7	real estate ownership issues relating to such installation;	Report to Congress, Sections 1 and 4
(b) 8	preliminary design for placement of fiber optic cable and wireless towers;	Report to States, Appendix A
(b) 9	monetary value of the rights-of-way necessary for such installation;	Report to Congress, Section 4, and Report to States, Section 3
(b) 10	applicability and transferability of the benefits of such installation to other rural corridors; and	Report to Congress, Sections 3 and 4
(b) 11	safety and other operational issues associated with the installation and maintenance of fiber optic cabling and wire infrastructure within Interstate System rights-of-way and other publicly owned rights-of-way.	Report to Congress, Section 4; Report to States, Appendix A

1.0 Introduction

This document is the second of two reports that explore the potential for the use of rural Interstate Highway corridor rights-of-way for the deployment of fiber optic cable and/or wireless communication infrastructure, across multiple States linked by the Interstate Highway system. The first document, the **Rural Interstate Corridor Communications Study: Report to Congress**, was submitted to Congress on August 18, 2008. This document, the Report to States, provides a summary of study resources available to the Corridor States to begin the process for possible deployment of high-speed telecommunications (HST) in the corridors in question. The primary goal of these deployments would be to benefit rural communities. This telecommunications infrastructure, as envisioned in Section 5507 of the Safe, Accountable, Flexible, Efficient Transportation Act: A Legacy for Users (SAFETEA-LU), would comprise one element of the nation's "telecommunications backbone" system, the "main arteries" of the nation's advanced telecommunications network.

Creation of such a communications infrastructure could potentially have immediate benefits to the transportation agencies that control the Interstate Highway rights-of-way (ROW) that would be utilized. Furthermore, the introduction of high-speed telecommunications can demonstrably improve economic prospects for businesses, individuals, and communities, while also providing a variety of collateral benefits for health care, education, and public safety. However, while construction of a backbone facility could ultimately support the provision of advanced telecommunications services to adjacent communities, the delivery of service to customers is also dependent on the availability of regional and local distribution networks as well as local Internet service providers that would connect the backbone infrastructure to the end user.

The Report to Congress provided the Secretary of Transportation's perspective on the feasibility of deploying high-speed telecommunications in the three study corridors. The Report to States provides the more detailed preliminary backbone alignment and installation issues for potential high-speed telecommunications in the three identified corridors.

1.1 Corridor Conditions

The project team worked closely with the ten States identified in Section 5507 to determine existing deployments of high-speed telecommunication infrastructure along with potential needs and challenges associated with such implementations, both existing and future. Initial webconferences followed by in-person workshops were held for each corridor, and information was presented on the study objectives and defined corridor profiles. These workshops provided an opportunity for the corridor States to discuss the potential for multi-state deployments of HST in the participating States. After this general information sharing and workshop discussions, detailed information requests were issued to each of the ten States. These information requests allowed the project team to gather specific State by State data on technology and communications along the corridors.

The study team developed a library of research for all areas of the study (demographics, economics, education, health systems, etc) as well as DOT-specific material such as existing intelligent transportation systems (ITS) deployments and future plans for communications. A project website was developed for the information to be posted and shared among stakeholders. It was decided that the project website would be password-protected so that e-mail addresses and other information contained on the site would not be subjected to phishing or hacking. At the completion of this project it is envisioned that the website will remain active and available to stakeholders while hosted on the FHWA server.

Through the work of this study each corridor has access to the in-depth research on the demographic, economic, health, education, legal, and technological characteristics of the defined corridor. Each corridor has unique conditions that impact the development of HST along with similarities that can benefit neighboring States. Corridor stakeholder participation was a valuable asset to the study process. Below are capsule descriptions of the three corridors, with the elements that make the corridors unique as well as the similarities, along with potential action items to advance HST.

Interstate Highway 90 through South Dakota, southern Minnesota, northern Iowa, and central and western Wisconsin

The I-90 corridor is considered to be the most rural of the three corridors in the study. Along I-90 the population densities were lower, with far greater distances than the I-20 and I-91 corridors. South Dakota, Minnesota, Iowa, and Wisconsin all had some level of HST and ITS deployments in the State DOT Interstate highway right-of-way. There were limited to no deployments of HST on the I-90 Corridor.

The legal research[1] focused in on the lessons learned by Minnesota when the State DOT initially deployed HST through a resource sharing agreement in the early 1990s. Outside of the legal constraints of the associated rulings from Minnesota, limited legal roadblocks exist for the State DOTs on the I-90 corridor. The I-90 corridor is well positioned to work with the private sector through public-private partnerships and resource sharing agreements for future

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[1] A white paper, “Legislative and Regulatory Background Regarding Advanced Telecommunications Infrastructure for Rural Areas Along Interstate Corridors,” is available from FHWA.

deployments of HST. The right-of-way is generally wide and unobstructed, with minimal urban areas to traverse and limited geological concerns. South Dakota is probably in the best position to work with a partner in deploying due to the absence of HST and constructability of SD right-of-way.

This study provided the I-90 corridor States with the tools and information necessary to approach and work with potential private sector parties. South Dakota brought the private sector telecommunication providers to corridor meetings, and the State and private sector representatives have begun discussions on what the parties can accomplish together.

Many of the stakeholders commented that funding challenges, as well as the lack of feasibility studies and documentation of the need for HST along the corridor, limited deployment of fiber optic or other infrastructure. The next steps for the I-90 corridor include:

- The States should consider whether to harmonize their utility accommodation policies and permitting processes to facilitate installation of high-speed telecommunications facilities across State boundaries.
- Considering the potential impact of major winter weather events, the States should explore how to improve winter maintenance response, including improved center-to-center communications. Such communications could be enhanced through the use of high-speed telecommunications links, which might also enable ITS applications such as improved fleet management, improved traveler information, and other services.

Interstate Highway 20 through northern Louisiana, Mississippi, and Alabama

The I-20 corridor is unique in that one of the study States, Louisiana, has operated for some time with private sector partners in resource sharing and right-of-way barter agreements. As such, the entire State is well-equipped with fiber routes and wireless tower access and ownership. The State's open model of granting access to the right-of-way for fiber conduit and routing projects has led to extensive availability of HST. In contrast, Louisiana's neighboring States of Mississippi and Alabama are quite constrained in undertaking similar ventures. Mississippi and Alabama strictly limit public-private partnerships (PPP); unless transportation agencies are specifically authorized to undertake a program of resource sharing or bartering the Interstate highway right-of-way, the law is interpreted in such a way that the DOT can not carry out such a program.

Mississippi and Alabama are both moving forward with their own deployments of fiber in and around a number of high priority areas such as the urban centers along the corridor. This allows full control of the telecommunications infrastructure, but is also very costly.

The experiences and lessons learned of Hurricane Katrina have shown the State DOTs in this region how corridor deployments of HST networks could greatly aid and assist in corridor interoperability, thereby facilitating evacuation and response to natural disasters. Other steps that States in the I-20 corridor should consider include:

- State DOTs in the I-20 Corridor should consider the advantages of harmonizing utility accommodation policies and permitting processes for the Corridor.
- Current legal and policy restrictions limit opportunities for public-private partnerships in the I-20 Corridor. State DOTs should take steps to lessen legal restrictions by documenting the benefits of working with the private sector to facilitate deployment of high-speed telecommunications in the corridor.

Interstate Highway 91 through Massachusetts, Vermont, and New Hampshire

The I-91 Corridor is the most mature corridor when it comes to advancing HST programs. There were stakeholders on this corridor that had already researched the needs of advanced communications to the residents of the States involved in the study. The State DOTs have also progressed with HST infrastructure projects involving the Interstate highway ROW. New Hampshire had deployed fiber optic infrastructure (at their own expense) along large sections of I-93, a nearby interstate leading to Boston. Massachusetts had worked to secure additional funding to move forward with the first phase of a design-build program to prompt interest in the corridor from the private sector, with Vermont following that same path to secure deployment of HST in the I-91 ROW.

The corridor presents unique challenges, with many difficult geological formations that could obstruct fiber optic installations and a history of environmental protectionism that would make tower siting and ROW disruptions subject to lengthy permitting processes. Other actions Corridor States might consider include:

- I-91 Corridor States should consider sharing lessons learned and experiences as their programs move forward.
- Given the advanced status of planning and implementation in this corridor, this study has focused on advancing some standard design templates that could be applied to promote efficiency in moving the projects forward. These design templates are listed in Appendix C.

2.0 Preliminary Backbone Alignments

As part of the task to develop the Report to States, preliminary backbone alignment plans for telecommunications (fiber/conduit routing and tower locations) have been developed and presented in electronic format. The purpose of the preliminary backbone alignment is to offer a high-level preliminary design to enable State agencies or private telecommunications partners to begin the process of developing estimates of the level of effort required to install telecommunications infrastructure. The backbone infrastructure included in this study includes wireline infrastructure (conduit buried to house fiber optic cable) and wireless infrastructure, such as tower locations.

The major elements considered in developing the preliminary backbone alignment include:

- Constructability (the physical challenges to be addressed in deploying the fiber optic cable or wireless infrastructure);
- Scheduling (a rough estimate of how long construction would take once deployment commences);
- Capital cost (built up from typical unit costs for equipment and installation);
- Maintenance and operating costs (including consideration of maintaining the telecommunications infrastructure with in-house or contract maintenance support);
- Environmental challenges that may be encountered in each corridor; and
- Policy considerations, including the advantages and disadvantages of different utility accommodation policies, and the potential for public-private or public-public partnerships for deployment.

The products of the Rural Interstate Corridor Communications Study are informational only. This study does not obligate Federal, State, or local governments to implement any of the study findings. The products of the study are intended only to inform the public and elected officials.

2.1 Backbone Alignment Development Process

The study team met with the ten States involved in this study in several settings, including Corridor-wide meetings held in central locations along the Corridor and individual State by State meetings. These meetings all took place between February and May 2007.

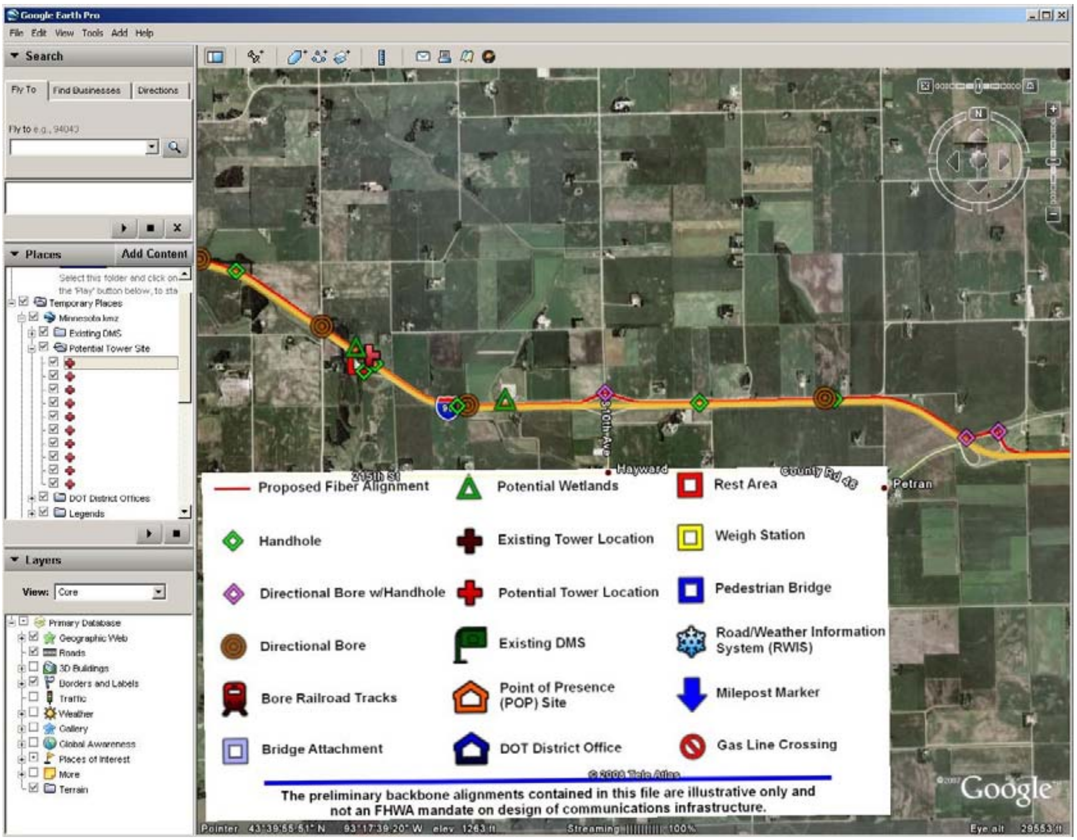
State DOT stakeholders were important participants of this study. Each State provided important baseline information including utility accommodation policies, as-built information, and plans for ITS and HST in the State. Once this baseline information was collected and reviewed, the project teams visited with each State to go over the existing conditions and discuss implementation issues.

For this study the preliminary backbone alignment plans have only been developed for two of the three Corridors identified in Section 5507 of SAFETEA-LU: Interstate Highway 90 and Interstate Highway 20. MassHighway and the Vermont Agency of Transportation along the Interstate Highway 91 Corridor had independently progressed in the development of a Corridor communications program to the point where developing a preliminary backbone alignment as defined by this study would have been of little value. Instead, the study team has developed a series of typical telecommunication installation details that can be used for future telecommunication construction projects. The typical installation details, listed in Appendix C, are on plan sheets in Microstation and AutoCAD 2007 software format, and can be manipulated into a plan sheet based on the requirements of the agency preparing plans. Prints of all typical installation details developed, including electronic files, are under separate cover from this report and are available from the FHWA.

The study team was challenged with how to generate and present a HST preliminary backbone alignment that would be relevant and useful for the corridor States without developing detailed plan sheet that would become out-of-date prior to a project taking form. The traditional method of delivering plans would consist of hard copies of plan sheets. Advances in freely available mapping programs on the Internet led the team to investigate and ultimately use satellite imagery for displaying the preliminary backbone alignments. The study team determined that electronic files utilizing Google Earth as a base map would provide the most flexibility for storing, displaying, and using the preliminary backbone alignment files. This approach also allowed Corridor States to update and maintain the files for use after the conclusion of the study. The electronic Google Earth KML[2] files have been enhanced with the addition of lineation, symbols, and icons representing various existing and proposed infrastructure elements and an example of this is show in Figure 2-1. A final design step was a visual survey of the corridors conducted by the project team. This driving survey allowed the team to resolve questions and issues due to less than ideal satellite imagery, as well as identifying corridor conditions that would otherwise be overlooked.

[2] KML, or Keyhole Markup Language, is an XML grammar and file format for modeling and storing geographic features such as points, lines, images, polygons, and models for display in Google Earth and Google Maps. KML can be used to share places and information with other users of Google Earth and Google Maps.

Figure 2-1 Typical Section of I-90 Corridor using Google Earth as a base map



Included in this report is information related to how the preliminary alignments were developed, and how information developed by the study team can be utilized by the Corridor States in the future. The details included in the alignment files, including criteria for placement, are defined below. The electronic files can be obtained from the FHWA.

The intent of Congress appears to be to provide a look ahead toward a point where Corridor-wide projects could be developed to install a contiguous communication backbone. This backbone infrastructure would serve the needs of each State as well as the communication needs of the communities along that Corridor. It is understood that each State has unique rules and policies that must be adhered to and that those polices will be applicable to any utility work within each State. Therefore, the information presented here looks at each Corridor as a whole while explaining some of the specific issues unique to each State.

2.2 Preliminary Backbone Alignment Design Elements

It should be noted that the preliminary backbone alignments developed as part of this study are, as the name suggests, preliminary and should not be considered a final design nor taken as any indication that a future project to install infrastructure of this type is imminent. The preliminary backbone alignments contained in these files are illustrative only and not an FHWA mandate on design of communication infrastructure. They are intended for information purposes such as preliminary estimation of quantities, identification of construction issues, and preliminary cost estimation to aid in discussions with potential private partners. If a State agency or private provider wishes to use the files to create more detailed designs, such use is allowed and encouraged.

The design criteria presented here acknowledge that to the greatest extent possible, preliminary designs for all utility infrastructure installed on State-owned access-controlled ROW must be consistent with the State's Utility Accommodation Policy (UAP) and the laws and requirements of the State. Before final designs are completed, the policies and regulations of each State should be consulted and adhered to in the final design plans. Private partners involved in the installation of telecommunications infrastructure on State ROW also may have criteria to be considered in the final designs of such infrastructure. The backbone alignments generated as part of this study are preliminary in nature and the UAP and laws of the State would influence final design.

The preliminary design elements included in the Google Earth KML files are presented below along with suggestions regarding the use of the information.

Fiber Optic Line Placement

The preliminary backbone alignment files show the routing of conduit where a fiber optic line would be placed along the right-of-way. The design assumes that conduit for fiber optic cable will be installed by plowing or trenching methods with directional boring to navigate under roadways, streams, or other obstacles. Decisions about the side of the right-of-way in which the conduit is to be placed were based on several factors, including width of ROW, potential obstacles, presence of rock or environmentally sensitive areas, and access for heavy equipment and maintenance personnel.

Handhole/Vault Location

Handholes/vaults are used to access the conduit and fiber optic cable for making splice connections or for the installation of fiber optic cable into the conduit. In this document, the terms handholes and vaults are considered interchangeable and represent a box to accommodate all aspects of fiber optic cable installation such as pulling points, coiling, splicing, etc. For this design handholes have been placed at interchanges, tower locations, weigh stations, and rest areas. For the purposes of pulling fiber into the conduit, handholes are generally located at one-mile intervals (minimum) where the above criteria cannot be met within that distance.

Regeneration Building Placement

Regeneration stations or POP (Point of Presence) sites are locations where the signal being transmitted through fiber optic cable is regenerated and transmitted further along the fiber optic path. These POP facilities are also utilized as a location where connections to local networks are made. The criteria for placement of the regeneration buildings are based on the ability of existing fiber optic transmission equipment and cable to transmit a signal an average of 50 miles. Regeneration stations require access to electrical power, an important design consideration. Proposed regeneration buildings have been placed as closely as possible to 50-mile spacing where access is easily gained from a side road or other non-mainline access, such as an interchange or rest area. Regeneration building sites should have sufficient space to accommodate a 10’ x 20’ one-story building with room for parking one or two vehicles. A perimeter fence may be needed to secure the site (approximately a 1000 sq. ft. footprint). These facilities should be located outside of the clear zone.

Directional Boring

Directional boring would be used at small stream crossings, where bridge attachments are not practical or not allowed by the State, at roads and railroads crossing under or over the Interstate highway, at interchanges, and at existing utilities (such as gas or oil pipelines). The preliminary design indicates directional bore locations with one icon representing the directional bore area versus two icons representing the entrance and exit bore pits. Where applicable, an icon representing a directional bore and handhole, such as at an interchange, has been used to minimize the number of icons at interchanges.

Bridge Attachments

The criteria to determine bridge attachments versus directional boring under a river or stream will depend on State policy and approval. An application for a bridge attachment permit should be submitted when route design plans are submitted by the private entity or private partner prior to final design stage. For the purposes of the preliminary backbone alignment, bridges that span major rivers, railroad yards, or complicated interchanges are shown as bridge attachments (with permit approvals needed prior to final design). For bridge attachments, conduit should be encased in a bullet-proof shroud, located on the downstream side of the bridge, or protected by bridge beams to prevent damage from floating debris, and meeting all State standards for attachment of fixtures to bridges.

Communication Tower Locations

Communication towers shown on the preliminary backbone alignments include existing public agency-owned communication towers and privately owned communication towers. This includes DOT-owned towers, other public agency towers, and towers indicated on the tower maps obtained by the project team. Potential tower locations to be considered for construction at a future date are indicated with an icon. The proposed tower locations allow for sufficient space for the towers and associated structures on public agency-owned ROW. The sites include a handhole and are potentially co-located with a regeneration building due to the availability of ROW associated with a tower site. If the States have identified locations where they are willing to allow a tower to be located, these are also shown.

Towers for use in the backbone become critical when construction of a fiber link is cost-prohibitive or physically difficult. Most tower locations shown on the preliminary backbone alignments are locations that would support middle or last mile connections, though some do represent where backbone links could be installed to reduce installation costs. Spacing of the towers for the backbone becomes dependent upon the transmitting and receiving equipment as well as the frequency used, so tower locations would have to be further designed to accommodate any backbone linkages that may be desired.

3.0 Cost Estimates

3.1 CONSTRUCTION COST

The White Paper on the Preliminary Backbone Alignment (see Appendix A) presents an example cost estimate for installation of 48-SMFO cable along the I-90 and I-20 Corridors. The scenario represented in the cost estimate includes fiber optic cable inside one of two 2" HDPE conduits installed by various methods (i.e. trenching, boring, plowing, etc.). In addition, handholes and regeneration stations are also included. Handholes serve as cable pulling locations, junction points to connect branch cables to the trunk cable, and conduit transition points. Regeneration buildings allow for signal regeneration equipment to be housed in the field and act as a demarcation point for connection to other networks. The cost ranges were developed based on input from both private companies and public agencies through development of similar projects in the United States, and generally represent Year 2007 values. These values do not take into account changing economic considerations, nor do they reflect regional cost differentials. The estimated values were provided from multiple sources experienced in numerous construction situations, i.e. rural and urban interstate right-of-way construction conditions. Table 3-1 presents estimated construction costs for 48-SMFO cable backbone. The low unit cost is indicated where construction is relatively straightforward and unencumbered, while the high values would apply under difficult conditions where more expensive construction techniques are required. These values are provided as an order of magnitude construction cost but it is highly recommended that locally established cost estimates for the items below should be used whenever possible when developing an estimate for a specific project.

Table 3-1: Construction Cost for Installation of 48-SMFO Cable Backbone*

Service/Product	Price-Low	Price-High	Unit	Assumptions
Fiber Plowing	$1.25	$1.75	Foot	Assume std installation method will be plowing. Route mileage for the corridor is from FHWA Route Log
Directional Boring - Rural	$6.00	$7.00	Foot	Assume rural bores avg. 150' each
Directional Boring - Urban	$8.00	$10.00	Foot	Assume 10% of total bores as urban bores, avg. 200' each
Directional Boring - Rock	$42.50	$271.00	Foot	Assume 5% of total bores as rock bores, avg. 150' each
Conduit (2" HDPE)	$0.75	$0.80	Foot	Per foot cost. Assuming installation of two conduits.
Bridge Attachments	$100.00	$175.00	Foot	Includes 6" steel conduit and labor to attach
Handhole	$575.00	$700.00	Each	48" x 30" x 36", higher cost value would apply for load rated
Handhole Installation	$600.00	$800.00	Each	Low-high range for installation cost
SMFO Cable - 48 Count	$0.61	$0.80	Foot	Assuming one fiber cable installed in one conduit
Fiber Installation	$3.25	$5.00	Foot	Includes splices, pulling, splice enclosures, term. panels
Regeneration Building	$280,000.00	$300,000.00	Each	Assumes one building avg. every 50 miles and one on either end of corridor in State. Includes pad, power, A/C, racks, conduit
Design	7.5%	10.0%	Percent of construction cost - Lump Sum (L.S.)	Pre-construction design of route and equipment

Service/Product	Price-Low	Price-High	Unit	Assumptions
Traffic Control	3.0%	7.0%	L.S.	For lane and shoulder closures
Mobilization	3.0%	9.0%	L.S.	Contractor costs to provide equipment and services
Construction Engineering	7.5%	10.0%	L.S.	Inspection, oversight, field engineering
Administration	5.0%	7.0%	L.S.	Construction administration services
Contingency	8.0%	20.0%	L.S.	To cover unknowns and peripheral costs
Estimated Cost for Future Value	12.5%	30.0%	L.S.	Future value, 5 to 10 years out, if avg. inflation is 4%/yr

* The cost data included in Table 3-1 is aggregated from several sources, both public agency and private sector, and is based on costs incurred on similar projects throughout the United States. Whenever possible, local cost data should be utilized to provide the best estimate. Sources include:

Federal Highway Administration
Minnesota Department of Transportation
Mississippi Department of Transportation
South Carolina Department of Transportation
MassHighway
Gresham Smith & Partners
TransCore
Telvent Farradyne
Parsons Brinckerhoff
Cambridge Systematics
Schatz Underground Cable
LightCore

Using the above communication infrastructure cost ranges, and the quantities from the preliminary backbone alignment (including handholes, directional bores, regeneration sites, and bridge attachments as well as the length of fiber and conduit installation), an estimated range of costs has been developed for each State for construction of a communications infrastructure. While the initial cost of deployment to the State DOT can be dramatically reduced through partnerships with private sector parties, there are some unavoidable costs to the State DOT if this approach is used. Inspections are another demand for the State DOT in shared resources projects, especially if the fiber is being built by a third party. The DOT must make sure proper construction techniques are used and that local agency access points are placed where they are needed. Typically, the State DOT will want more access points than a long-haul carrier might specify. This can be a sticking point as the long-haul carriers want to minimize hand holes to ease installation and reduce costs.

The unit costs presented above are estimates only, and furthermore should be considered as representative of the hypothetical alignments only.

3.2 MAINTENANCE COST

An important aspect of developing and deploying communications projects is the proper maintenance of the system. A maintenance plan has two important categorizes: 1) *Preventive Maintenance* is keeping property and equipment in good state of operation and preventing failures, and 2) *Responsive Maintenance* is the action taken by an agency or department to any reported equipment or system malfunction. Both preventive and responsive maintenance have standard industry-accepted ranges of associated costs for maintenance.

No attempt is made in this report to estimate the system maintenance costs a particular State will encounter as costs, existing staff capabilities, existing State resources, other maintenance needs, and capabilities of local contractors vary so greatly. However, based on the above considerations, an estimate of the time and staff required should be calculated that can be used to determine the number of staff hours required per device or mile of infrastructure. Based on those hours, the number of staff required in a given year can be calculated and added to the costs of the spare equipment, tools, and vehicles to determine an approximate budget for yearly maintenance.

3.3 MONETARY VALUE OF RIGHTS OF WAY

Section 5507 of SAFETEA-LU directed the Secretary of Transportation to "identify . . . [the] monetary value of the rights of way necessary for" the installation of high-speed telecommunications infrastructure. While it is difficult to offer a definitive answer to this directive for corridors with such disparate characteristics, it is evident that the nature of Interstate Highway rights-of-way offers unique advantages for deployment of HST infrastructure. A 1999 white paper for the Western Governors' Association (WGA) pointed out that,

> While the telecommunications industry has sought a consistent approach for accessing all highway rights-of-way, the State departments of transportation and highways believe that limited access highways must be managed under unique State laws and constitutional provisions related to State highway trust funds, restrictions on use, and safety and maintenance requirements. Given these characteristics, they believe the limited access highways to be assets where access bears additional responsibility and should serve to enhance the State's transportation and telecommunications objectives.[3]

The American Public Works Administration (APWA) offered the following information for valuing the use of street rights-of-way for telecommunications purposes:

> A number of alternatives or variations have been considered to establish fair market value for street right-of-way. . . .The approach could be

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[3] Western Governors' Association, *Challenge Paper: Telecommunications Access to Highway Rights-of-Way*,

described as an easement analogy with the valuation being calculated as follows:

> [Land Value of right of way by unit area] x [length of area occupied] x [width of area occupied] x [rate of return] x [factor to recognize degree of alienation of area] x [use factor][4]

The APWA goes on to discuss the general issue of valuation:

> The bottom line really is what the right-of-way is worth to the user. What is the user willing to pay in the competitive environment? Unlike real property, there is not a lot of history to go on in street right-of-way. Until very recently, access to the street right-of-way has essentially been given away. It is only now being seen as a scarce resource. As well, recent examples of charges for access have generally been on a percent of revenue basis rather than a linear charge, so it is very early to interpolate a linear value or to determine whether in the long term, those charges are high or low compared to the market.

While several examples exist of resource sharing arrangements that have been beneficial to State Departments of Transportation and other public sector partners, the economic landscape has changed significantly from the heyday of the "Dot Com" boom in the late 1990s and the first years of this decade. The expectation was that telecommunications traffic demand for electronic transactions would grow almost limitlessly. In the private sector; wireline demand would be spurred by new telecommunications firms and services; wireless demand would grow along with personal communications services and demand for cell phone capacity in established networks. At the same time, public sector agencies would require more bandwidth for inter-agency and intra-agency communications and data exchange, both for ITS communications and for other purposes.

The Telecommunications Act of 1996 (TCA) recognized the right of public agencies to control the use of their rights of way and to charge fees for compensation, as long as the access granted was non-discriminatory and posed no barriers to entry. At the same time, FHWA and AASHTO policy guidance encouraged the installation of fiber optic infrastructure within highway rights of way. However, AASHTO guidance on the opportunity presented by resource sharing agreements emphasized that there are limits to the attractiveness of public-private partnerships.[5] The AASHTO guidance pointed out that, "While

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[4] American Public Works Association, *Valuation of Street Rights-of-Way for Telecommunications Facilities*, November 1998, http://www.apwa.net/documents/organization/row-va1.pdf

[5] **"Guidance on Sharing Freeway and Highway Rights-of-Way for Telecommunications;"** American Association of Highway and Transportation Officials, Washington, DC 1996

shared resource ventures offer an excellent opportunity for the public sector to meet their transportation communications requirements cost-effectively, the opportunity is not without limits. The reason: shared resource ventures are market-driven. In practice, this has two implications:

- **Time:** Market conditions dictate private vendor interest in developing a partnership and the timeframe available;
- **Value:** There is no inherent value for access to highway ROW or any other public property; private sector willingness to pay for access derives from the telecommunications revenue potential for private firms, tempered by the cost of competing ROW that might be available to those firms. "[6]

A similar point regarding timing is made in a discussion of the "Connecting Minnesota" project. The National Council for Public-Private Partnerships notes that,

> In an unregulated environment, and without the incentive offered by the State through Connecting Minnesota, private sector long-distance communications companies generally would not consider investing beyond a minimum amount of infrastructure, and would then only do so on the most financially lucrative routes. By offering one-time access to Minnesota's Interstate system to a private communications system developer, the State was able to leverage highly desirable routes in exchange for development of fiber-optic on less desirable routes, but routes that nevertheless are important to government and communities located near them. The value of the program is estimated at over $125 million in private sector investment that meets both public and private sector needs, with an annual benefit to the State of at least $5 million savings in current telecommunications costs-though immeasurable, life-cycle savings for the public sector and economic development benefits for rural Minnesota are clearly evident.[7]

The three corridors under consideration here offer significant potential advantages to private sector partners in terms of the coordination of utility accommodation policies, "one-stop permitting," and other steps designed to cut red tape and facilitate cooperation. However, even among the three corridors reviewed for this study, it may be that private sector partners would have limited interest in participating in a shared resource project.

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[6] ibid, p. 2

[7] National Council for Public-Private Partnerships; http://www.ncppp.org/cases/minnesota.shtml, accessed 10/23/2008

3.4 POTENTIAL FOR PUBLIC-PRIVATE PARTNERSHIPS

It should be noted that different States in the various corridors under study have quite different policies toward public-private or public-public projects (PPP), also referred to as "shared resource" projects. Furthermore, no matter how straightforward a shared resource project may seem, such projects take time to develop and see through to the end. There are multiple decision-makers and stakeholders within a DOT that must be satisfied, as well as in other stakeholder agencies like the department of administration and often the governor's office. The efforts to advertise, negotiate, design, and construct a communications backbone through a shared resource project can easily take several years. Dedicated staff that can act as project champions are needed within the DOTs to ensure success. Adding to the complexity is that communications infrastructure is not an area that DOT staff normally design, construct, or inspect.

In December 1999, the Federal Communications Commission (FCC) issued an opinion on the Minnesota agreement that cast uncertainty on the concept of shared resource projects. The FCC "decline[ed] to find Minnesota's agreement" with a telecommunications contractor "consistent with the Telecommunications Act." In the wake of this decision, the FHWA was able to craft guidance that made it easier for State DOTs to reach agreements with telecommunications contractors that adequately provided for competitive neutrality.[8] This made it easier for State DOTs to reach resource sharing agreements that would provide protections for the DOT, contractors, and competitors.

Nevertheless, it remains a fact that the current economic and fiscal environment is very challenging. Together with the mature status of the national high-speed telecommunications backbone infrastructure, the current economic climate suggests that there might be limited interest on the part of private telecommunications companies in a major expansion of such facilities, absent some compelling value proposition for the private sector partners.

3.5 CORRIDOR COST ESTIMATES

The following tables summarize cost estimates developed for the preliminary backbone alignment for the I-90 and I-20 corridors. Given the advanced status of the telecommunications infrastructure initiative in the I-91 corridor, it was determined that preparing such a cost estimate for that corridor would not be productive. More detailed tables can be found in Appendix A, the Preliminary Backbone Alignment white paper.

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[8] **"Guidance on Longitudinal Telecommunications Installations on Limited Access Highway Right-of-Way,"** Letter from FHWA Executive Director A.R. Kane, December 22, 2000, http://www.its.dot.gov/telecom/tele_srguide.htm, accessed 11/10/2008

3.5.1 I-90 Corridor

Table 3-2: Range of Cost Estimates for I-90 Corridor

Corridor State	Low (U.S. Dollar 2007)	High (U.S. Dollar 2007)
South Dakota (413 miles)	$26,696,593	$47,926,833
Minnesota (276 miles)	$17,968,439	$32,784,644
Wisconsin (109 miles)	$9,058,626	$16,975,041
I-90 Total (494 miles[9])	$53,723,658	$97,686,518

The I-90 corridor presents relatively few geographic challenges to construction. Aside from a handful of locations where river crossings would require either directional boring or bridge attachments, the terrain is suitable for low-cost construction techniques. Utility accommodation policies are generally favorable for deployment.

3.5.2 I-20 Corridor

Table 3-3: Range of Cost Estimates for I-20 Corridor

Corridor State	Low (U.S. Dollar 2007)	High (U.S. Dollar 2007)
Louisiana (190 miles)	$13,566,489	$25,087,452
Mississippi (155 miles)	$10,620,150	$19,511,982
Alabama (215 miles)	$15,275,221	$28,701,956
I-20 Total (560 miles)	$39,461,860	$73,301,390

The I-20 corridor does not present overwhelming physical barriers to construction, despite the prevalence of wetlands and river crossings. More significant is the diversity of policy approaches to utility accommodations within the Interstate highway rights-of-way. In general, Louisiana has a liberal policy regarding utility accommodations, encouraging resource sharing for utilities to place communication infrastructure on Interstate highway right-of-way, including wireless towers. Mississippi and Alabama, however, have not engaged in shared resource projects, and current policies limit the ability of utilities to access Interstate highway right-of-way.

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[9] Cost estimate includes only sections of I-90 Corridor that do not currently have fiber optic backbone installed.

4.0 Project Web Site and SVG Tool

A project website was developed for this project and served as a valuable tool in communicating with the various State and Federal level stakeholders. The web site (http://www.ruralcomm.org) became an early repository of project documentation as literature searches reveal timely information about the telecommunications industry, trends in the nation, and advancements pertinent to this study. The website was also a convenient way to distribute project documents to the stakeholders. As products of the study were finalized the deliverables were posted on the website.

A GIS database was established early in the project to analyze and display the demographic characteristics of the corridors. Through the course of the study, this GIS was further enhanced and constructed as a user-friendly tool for use by the stakeholders of the study. This SVG Tool is intended to assist Corridor States in researching and investigating the subject corridors in order to facilitate and initiate the conversation. A full description of the tool along with step by step instructions for its use is contained in Appendix B.

5.0 Report to States – Next Steps/ Action Items

In an era of constrained public sector funding, State DOTs face limits on both capital expenditures and operating costs. Even ITS projects, which generally have a very high benefit-cost ratio, are difficult to sell in such an environment. While private sector telecommunications companies also face uncertainty, particularly given the current market conditions, it is likely that both State DOTs and private sector partners could benefit from deals that spread the upfront costs and ongoing maintenance expenditures across the two parties.

In undertaking this assessment, the study team was encouraged by the receptive attitudes of participants from the State DOTs. Successful implementation of high-speed telecommunications projects such as those contemplated in this study will require that State DOTs learn about the business conditions, market forces, and trends that make up the environment for action. Projects must meet the needs of the DOTs for communications between traffic management centers, with field devices, and with partners in such services as traveler information. However, to successfully involve private sector partners, agencies must understand the value proposition for telecommunications companies, as well as the political forces promoting widespread availability of broadband service.

DOTs may also be challenged by the governance models implied in a multi-state, public-private or public-public partnership. In some instances, impediments to implementation reside in law, regulation, or policy within the three corridors under study here. It may be necessary to pass enabling legislation or to effect changes in regulations to enable the States to undertake public-private partnerships or telecommunications projects. Fortunately, several models exist for undertaking such enterprises, from consortia established for tolling in the Northeast (E-Z Pass), multi-state bodies set up to handle traveler information (511 Deployment Coalition), to the I-95 Corridor Coalition, which was assembled to advance traffic management, congestion mitigation, and traveler information among States in the Atlantic Seaboard through which Interstate 95 runs.

No matter how straightforward a shared resource project may seem, they take time to develop and see through to the end. There are multiple decision-makers and stakeholders within a DOT that must be satisfied, as well as in other stakeholder agencies like the department of administration and often the governor's office. The efforts to advertise, negotiate, design, and construct a communications backbone through a shared resource project can easily take several years. Dedicated staff that can act as project champions are needed within the DOTs to ensure success. Adding to the complexity is that communications infrastructure is not an area that DOT staff normally design, construct, or inspect. This requires a very quick education by the DOT on communications engineering.

Despite obstacles presented by differing policies and the current economic and fiscal climate, the "corridor" approach has significant potential for the deployment of high-speed telecommunications infrastructure. Given the potential benefits to both rural communities and the State Departments of Transportation, the States should consider working with U.S. DOT and AASHTO to develop processes to harmonize utility accommodation policies, and to promote Public-Private and Public- Public Partnerships in States that do not currently encourage (or allow) such partnerships. States should also consider steps to streamline the permitting process for longitudinal placement of HST infrastructure within Interstate highway rights-of-way, including creation of "one-stop shopping" for telecommunications companies seeking such permits.

States will also be faced with critical choices about managing facilities like fiber optic or wireless infrastructure for high-speed telecommunications. Most DOTs are not equipped to maintain high-technology installations of this sort, and will have to decide whether to create an in-house capability or to rely on contractors for this function. Transportation agencies should look to "best practices" in developing an approach to implementation or expansion of high-speed telecommunications facilities. A listing of potential resources is contained in Appendix D.

In implementing a program for the deployment of a high-speed telecommunications infrastructure, State DOTs will need to balance the advantages presented by the generally clear and unencumbered rights-of-way for deployment with their responsibility for ensuring safety for Interstate highway users and their own workforce. Existing utility accommodation policies support this objective, and these policies can be revised to encourage the use of rights-of-way for a high-speed telecommunications infrastructure, without sacrificing safety.

Construction practices for the installation of fiber optic cables have been refined so that the environmental impact of such construction can be minimized. Still, significant environmental issues can be encountered when installing telecommunications infrastructure in State ROW. Construction activity can disturb vegetation and increase the amount of sediment in runoff that eventually makes its way to local streams and rivers. Directional boring produces manageable amounts of runoff, but it is heavily silt laden. State DOTs have policies regarding the treatment of runoff from construction sites and protection of waterways. Other environmental issues to consider include the disturbance of wetland areas and the timing of construction activities that may interfere with nesting periods of certain bird species. Such issues are generally considered manageable.

While the construction of towers for wireless telecommunications presents fewer problems than laying fiber optic cable, such issues as the visual impact of towers may arise.

A. White Paper: Preliminary Backbone Alignment

Rural Interstate Corridor Communications Study

Task 5: Preliminary Backbone Alignment

white

paper

prepared for

The Federal Highway Administration

prepared by

Cambridge Systematics, Inc.

with

PB
Telvent Farradyne, Inc.
TransCore

May 19, 2008

white paper

Rural Interstate Corridor Communications Study

Task 5: Preliminary Backbone Alignment

prepared for

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Table of Contents

List of Tables

List of Figures

1.0 Introduction

The purpose of this document is to report on the study team's findings with regard to the feasibility and desirability of developing a high-speed telecommunications backbone along the three Corridors that make up the study area. These Corridors include Interstate 20 through Alabama, Mississippi, and Louisiana; I-90 through South Dakota, Minnesota, and Wisconsin (and including Iowa); and I-91 through Massachusetts and Vermont (and including New Hampshire).

The study team met with the States that are subjects of this study in two settings – a Corridor-wide meeting held in a central location along the Corridor where all of the Corridor States could participate and discuss the concepts, and individual meetings where the study team visited each state and gathered additional detail from invited representatives. These meetings all took place between February and May 2007. The States each provided information pertinent to the study that has been used to compile this report.

One of the assignments of the project team was to develop a preliminary backbone alignment for the placement of telecommunications infrastructure along the Corridor right-of-way for all three Corridors. Included in this report is information related to how the preliminary alignments were developed, and how information developed by the study team can be utilized by the Corridor States in the future. It should be noted here that these preliminary alignments were developed for the I-20 and I-90 Corridors only, as the I-91 Corridor States had progressed past the preliminary alignment stage in their development of a shared resource project for I-91 in Vermont and Massachusetts.

Also included in this report is a summary of the various issues that were noted by the Corridor States during the study investigation. These issues relate to the constructability of communications utilities within the Corridors and where difficulties may be encountered; existing utilities and infrastructure in the Corridors that may provide opportunities for cooperation or hinder installations; construction schedules required for the development of a communications backbone along the Corridor; maintenance considerations after installation; environmental issues that need to be addressed before construction can begin or that may be encountered during construction; cost estimates for construction; and policies for the accommodation of utilities that will need to be adhered to in each State.

The report attempts to look forward to a point where a Corridor-wide project could be developed to install a contiguous communication backbone that would serve the needs of each State as well as the communication needs of the communities along that Corridor. It is understood that each State has unique rules and policies that must be adhered to and that those polices will be applicable to any utility work within each State. Therefore, the information presented here looks at each Corridor as a whole while explaining the specific issues unique to each State.

2.0 Preliminary Backbone Alignments

As part of the task to develop the Report to States, a preliminary backbone alignment plan for telecommunications has been developed and presented in electronic format. The purpose of the preliminary backbone alignment is to serve as a high-level design guide for a State agency or private telecommunications partner that will allow them to estimate the level of effort required to install the telecommunications infrastructure. The backbone infrastructure included in this study includes wireline, when conduit is buried and filled with fiber optic cable, and wireless infrastructure in the form of tower locations.

The products of the Rural Interstate Corridor Communications Study are informational only. This study does not obligate Federal, State, or local governments to implement any of the study findings. The products of the study are intended only to inform public and elected officials.

2.1 Backbone Alignment Development Process

The traditional method of delivering plans would consist of hard copies of plan sheets. The study team for this project determined that electronic files utilizing Google Earth as a base map would provide the most flexibility for storing, displaying, and using the preliminary backbone alignment files. The electronic Google Earth KML[1] files have been enhanced with the addition of lineation, symbols, and icons representing various existing and proposed infrastructure elements. The details included in the alignment files, criteria for placement, and the icons used are defined below. The electronic files can be obtained from the FHWA.

2.1.1 Alignment Details Shown

The following list contains topography elements, site-condition, and communication infrastructure details that are included in the preliminary backbone alignment files:

[1] KML, or Keyhole Markup Language, is an XML grammar and file format for modeling and storing geographic features such as points, lines, images, polygons, and models for display in Google Earth and Google Maps. KML can be used to share places and information with other users of Google Earth and Google Maps.

- Proposed conduit routing;
- Proposed boring locations;
- Proposed bridge attachment locations;
- Proposed access points (including handholes/ vaults);
- Proposed regeneration stations;
- Existing tower locations;
- Proposed tower locations;
- State DOT district offices and facilities;
- Major Streams and Rivers;
- State Borders;
- Existing Weigh Stations;
- Existing Rest Areas; and
- Existing potential environmentally sensitive area.

2.1.2 Study Team Visual Field Surveys

In order for the study team to be able to enhance the design content of the preliminary backbone alignment plans, field visits along the I-90 and I-20 Corridors were undertaken to record details and make location decisions that would not have been possible solely through the use of aerial photography, as provided by Google Earth. In the fall of 2007, study teams performed visual surveys by driving the two Corridors and recording their findings in electronic Google Earth base files. During these visual surveys, the teams recorded the preferred alignments for conduit placement, handhole locations, locations where directional boring would be required, potential locations for future wireless towers on State right-of-way (ROW), and bridge and overpass information.

2.2 Preliminary Backbone Alignment Design Criteria

2.2.1 General Criteria

To the best extent possible, preliminary designs for all utility infrastructure installed on State-owned access-controlled ROW are consistent with the State's Utility Accommodation Policy (UAP) and the laws and requirements of the State. Before final designs are completed, the policies and regulations of each State should be consulted and adhered to in the final design plans. Private partners involved in the installation of telecommunications infrastructure on State ROW also may have criteria to be considered in the final designs of such infrastructure.

2.2.2 Fiber Optic Line Placement

The design assumes that conduit for fiber optic cable will be installed by plowing or trenching methods with directional boring to navigate under roadways, streams, or other obstacles. Decisions about the side of the right-of-way in which the conduit is to be placed are based on several factors, including width of ROW, potential obstacles, presence of rock or environmentally sensitive areas, and access for heavy equipment and maintenance personnel. The location and depth of the conduit should follow the State's UAP and is generally near the ROW line and/or a safe distance away from existing utilities to avoid the possibility of disruption. Directional boring locations are shown where the conduit passes under a roadway or railroad, at stream crossings where bridge attachments are not necessary or allowed, where conduit may cross the Interstate highway, and to avoid obstacles in the ROW such as ditch lining.

2.2.3 Handhole/Vault Locations

Handholes/vaults are used to access the conduit and fiber optic cable for making splice connections or for the installation of fiber optic cable into the conduit. In this document, the terms handholes and vaults are considered interchangeable and represent a box to accommodate all aspects of fiber optic cable installation such as pulling points, coiling, splicing, etc. For this design handholes have been placed at interchanges, tower locations, weigh stations, and rest areas. For the purposes of pulling fiber into the conduit, handholes are generally located at one-mile intervals (minimum) where the above criteria cannot be met.

Figure 2-1: Handhole Icon

As a future consideration, the latest recommendations from the Vehicle Infrastructure Integration (VII) consortium for future installation of Roadside Equipment (RSE) locations is that drivers should pass an RSE at a minimum of once every 10 minutes. Assuming an average speed of 65 mph, and that every RSE requires one handhole, this would necessitate a handhole every 10.8 miles. The recommended design criteria exceed the minimum criteria noted above for the future VII.

2.2.4 Regeneration Building Placement

Regeneration stations or POP (Point of Presence) sites are locations where the signal being transmitted through fiber optic cable is regenerated and transmitted further along the fiber optic path. These POP facilities are also utilized as a location where connections to local networks are made. The criteria for placement of the regeneration buildings are based on the ability of existing fiber optic transmission equipment and cable to transmit a signal an average of 50 miles. Regeneration stations require access to electrical power, an important design consideration. Proposed regeneration buildings have been placed as closely as possible to 50-mile spacing where access is easily gained from a side road or other non-mainline access, such as an interchange or rest area. Regeneration building sites should have sufficient space to accommodate a 10' x 20' one-story building with room for parking one or two vehicles. A perimeter fence may be needed to secure the site (approximately a 1000 sq. ft. footprint). These facilities should be located outside of the clear zone.

Figure 2-2: Regeneration Station (POP) Icon

2.2.5 Directional Boring

Directional boring would be used at small stream crossings, where bridge attachments are not practical or not allowed by the State, at roads and railroads crossing under or over the Interstate highway, at interchanges, and at existing utilities (such as gas or oil pipelines). The preliminary design indicates directional bore locations with one icon representing the directional bore area versus two icons representing the entrance and exit bore pits. Where applicable, an icon representing a directional bore and handhole, such as at an interchange, has been used to minimize the number of icons at interchanges.

Figure 2-3: Directional Bore Icon

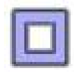
2.2.6 Rock Cuts

When rock conditions exist, the use of a rock saw to create a trench will be required. Avoiding rock cuts is preferred and may require the conduit to be routed away from the ROW line and closer to the shoulder. Rock cuts will not be shown on the preliminary backbone alignments as geotechnical investigations should be done to determine where rock cuts are necessary.

2.2.7 Bridge Attachments vs. Stream Crossings

The criteria to determine bridge attachments versus directional boring under a river or stream will depend on State policy and approval. An application for a bridge attachment permit should be submitted when route design plans are submitted by the private entity or private partner prior to final design stage. For the purposes of the preliminary backbone alignment, bridges that span major rivers, railroad yards, or complicated interchanges are shown as bridge attachments (with permit approvals needed prior to final design). For bridge attachments, conduit should be encased in a bullet-proof shroud, located on the downstream side of the bridge, or protected by bridge beams to prevent damage from floating debris, and meeting all State standards for attachment of fixtures to bridges.

Figure 2-4: Bridge Attachment Icon



2.2.8 Communication Tower Locations

Communication towers shown on the preliminary backbone alignments include existing public agency-owned communication towers and privately owned communication towers. This includes DOT-owned towers, other public agency towers, and towers indicated on the tower maps obtained by the project team. Potential tower locations to be considered for construction at a future date are indicated with an icon. The proposed tower locations allow for sufficient space for the towers and associated structures on public agency-owned ROW. The sites include a handhole and are potentially co-located with a regeneration building due to the availability of ROW associated with a tower site. If the States have identified locations where they are willing to allow a tower to be located, these are also shown.

Towers for use in the backbone become critical when construction of a fiber link is cost-prohibitive or physically difficult. Most tower locations shown on the preliminary backbone alignments are locations that would support middle or last mile connections, though some do represent where backbone links could be installed to reduce installation costs. Spacing of the towers for the backbone becomes dependent upon the transmitting and receiving equipment as well as the frequency used, so tower locations would have to be further designed to accommodate any backbone linkages that may be desired. Additional information on tower design is located in Section 3.0.

Figure 2-5: Potential Tower Location Icon

2.3 TELECOMMUNICATION INFRASTRUCTURE INSTALLATION DETAILS

For this study the preliminary backbone alignment plans have only been developed for two of the three Corridors identified in Section 5507 of SAFETEA-LU, Interstate 90 and Interstate 20. MassHighway and the Vermont Agency of Transportation along the Interstate 91 Corridor have independently progressed in the development of a Corridor communications program to the point where developing a preliminary backbone alignment defined by this study would have been of little value. Instead, the study team has developed a series of typical telecommunication installation details that can be used for future telecommunication construction projects. The typical installation details, listed below, are on plan sheets in Microstation and AutoCAD 2007 software format, and can be manipulated into a plan sheet based on the requirements of the agency preparing plans. Prints of all typical installation details developed, including electronic files, are under separate cover from this report and are available from the FHWA.

2.3.1 List of Typical Installation Details Developed

- Junction Box Details (handhole/ vaults)
  - Installation Cross-Section
  - Cable Management Details
  - Various Sizes and Conduit Routing
  - Construction Notes
- Cabinet Entrance Details
- Under-Roadway Directional Boring Details
- Conduit Trenching Details
  - Under Pavement
  - Open Ground
  - Adjacent to Roadways
- Fiber Marker and Warning Tape Details
- Conduit Routing at Interchanges
- Conduit Bridge Attachment Details
- Typical Regeneration Building

2.4 Use of the Preliminary Backbone Alignment Files

It should be noted that the preliminary backbone alignments developed as part of this study are, as the name suggests, preliminary and should not be considered a final design nor taken as any indication that a future project to install infrastructure of this type is imminent. The preliminary backbone alignments contained in these files are illustrative only and not an FHWA mandate on design of communication infrastructure. They are intended for information purposes such as preliminary estimation of quantities, identification of construction issues, and preliminary cost estimation to aid in discussions with potential private partners. If a State agency or private provider wishes to use the files to create more detailed designs, such use is allowed and encouraged.

3.0 Towers/Facilities

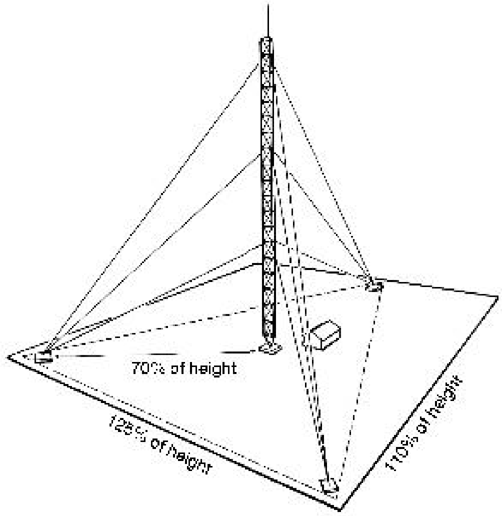
An important consideration of a telecommunications backbone design is the use and accessibility of the backbone infrastructure from points located away from the Interstate ROW. A comprehensive design would be a hybrid design of conduit infrastructure for fiber optic cabling along the ROW in addition to tower location and design for wireless components of the backbone. These towers would allow for wireless transmission outside the limits of the ROW. Including tower facilities as part of the design will enable middle and last mile options in the future.

Several factors are considered in determining the location of a tower (and support building), including:

- Line of Sight: Many wireless technologies require line of sight between the transceivers in order for signals to be exchanged from one location to another. All other wireless technologies are more effective if line of sight can be maintained.
- Topography/Geotechnical: In conjunction with line of sight, high topography can enhance the distance a wireless signal will travel. Valleys will limit the distance a wireless signal will travel. Additionally, a tower site must have soil that can support a tower.
- Ease of Construction/Maintenance: There must be ample room (width) in the ROW for construction staging and on-going maintenance parking. Ideal locations include interchanges and road crossings.
- Safety: The tower should be located far enough from the roadside that it will not cross the roadway should it fall.
- Proximity to existing power and communications infrastructure: The tower and supporting building require power and connection to the existing fiber optic backbone. The closer a tower site is located to existing power and fiber optic access points, the less expensive it will be to construct and operate the tower and its support facilities.

Towers can be self supporting or guyed. Self supporting towers are usually more expensive to construct and require less land. The taller the tower, the larger the concrete foundation needs to be to support the tower. Conversely, guyed towers are usually less expensive to construct and require more land. Towers are generally no more than 300’ high.

Figure 3-1: Guyed Tower



Most tower manufacturers suggest a standard guy radius of 70 percent (80 percent for microwave) of the overall tower height. The table below shows approximate land areas needed for several tower heights.

Table 3-1: Minimum Land Area Required for Guyed Towers

	Area Required	
Tower Height (ft)	80% Guyed (ft x ft)	70% Guyed (ft x ft)
60	87 x 100	78 x 90
80	111 x 128	99 x 114
100	135 x 156	120 x 140
120	159 x 184	141 x 164
140	183 x 212	162 x 188
160	207 x 240	183 x 212
180	231 x 268	204 x 236
200	255 x 296	225 x 260
210	267 x 304	236 x 272
220	279 x 322	246 x 284
240	303 x 350	267 x 308
250	315 x 364	278 x 320
260	327 x 378	288 x 334
280	351 x 406	309 x 358
300	375 x 434	330 x 382

The best use of a tower includes co-location of multiple wireless services/technologies. With the exception of AM (amplitude modulated) radio stations, it should be assumed that all towers will host a variety of co-located wireless services/technologies. AM towers are actually the antenna that transmits the AM radio signals. Therefore, it is nearly impossible to co-locate other wireless services/technologies on an AM tower.

Tower spacing is based on the different types of wireless technologies used and can vary greatly among the different transmitting/receiving frequency bands. It is not possible to develop a typical tower spacing to cover all of the varieties of frequency bands.

- FAA Obstruction Evaluation

The Federal Aviation Administration (FAA) considers antenna towers an obstruction and therefore, their use of airspace must be studied. The FAA requires an analysis to be completed that identifies the public and private airports and heliports (focusing on the location of runways or landing pads), the proposed height of an antenna tower, and the intervening terrain. The FAA sets maximum antenna tower heights based on type (use) of airfield and slope between that airfield and the top of the antenna tower, and the distance to the antenna tower. An application must be filed with the FAA and should be filed a minimum of 60 days before construction is expected to begin. Some States also require an application to the state aviation division for approval of the height of the tower.

4.0 ITS and Related Telecommunications Facilities within the Interstate Highway ROW

The level of telecommunications development along the I-20, I-90, and I-91 Corridors varies from state to state. The telecommunications infrastructure in support of ITS devices that exists in these Corridors or is planned includes both wireline and wireless technologies. Deployments are a combination of agency-owned, public/private partnerships and public/public (State/Municipality) partnerships. The degree of partnerships is often determined by State law and Departments of Transportation policies and procedures. This section summarizes the ITS facilities and related telecommunications infrastructure specific to each Corridor.

4.1 I-20 Corridor

Deployments along I-20 are a combination of agency-owned, public/private and public/public partnerships. Data exchanged across these networks usually support traffic management. However, in some cases data not related to transportation are carried by the network, primarily for agency administrative purposes. Of the three States in the I-20 Corridor, Louisiana is the only one that has engaged in a public-private partnership to install fiber optic infrastructure.

The State of Louisiana, through the Louisiana Telecommunications Act of 1996, has an extensive private sector telecommunications infrastructure as a result of the State's laws permitting the private sector to install long-haul telecommunications infrastructure within the State's Interstate highway rights-of-way. In return, the Louisiana Department of Transportation and Development (LADOTD) can negotiate for use of the fiber along the Corridor and equipment necessary to support the DOTD's ITS network. The Act also allows private providers to negotiate access and services on the State's microwave network by installing microwave equipment on the State's towers. Today, several private telecommunications providers have deployed long-haul telecommunications along I-20. A detailed map identifying the private provider fiber installation locations can be found in Appendix A.

The State of Louisiana continues to negotiate with private sector telecommunications providers in order to expand their ITS infrastructure. The

LADOTD has modified the terms and conditions of standard agreements based upon previously negotiated permits. These modifications include:

- Hardware and software upgrades when negotiating multi-year permits;
- The ability for the DOTD to access the fiber plant in case the provider is not available to accommodate the DOTD needs (in one case the private provider went bankrupt and the State had no method of accessing the installed fiber); and
- The ability to write permits with flexibility to accommodate the DOTD's needs when installation occurs – most permits are requested well in advance of actual construction.

Existing ITS deployments vary along the Corridor, and commonly are concentrated in or near the urban areas. The LADOTD's I-20 Corridor ITS device deployments are concentrated within the Shreveport and Monroe urban areas. According to the LADOTD, on I-20 between I-220 west of Shreveport and US 165 in Monroe, the State has access to eight dedicated fibers. Four fibers are dedicated to traffic management functions. The other four fibers are part of a local area network project connecting various universities in Louisiana and Mississippi. The State of Louisiana has four access points to tap into this network.

The Cities of Monroe and Shreveport have extensive fiber networks to interconnect their traffic signal systems. The LADOTD has deployed ITS devices on some bridges crossing the Mississippi River using solar power and cellular telecommunications technologies. The State of Louisiana also has a robust statewide radio system that includes radio and microwave towers along I-20. The State's radio system is primarily used for State Police communications and emergency operations. A detailed map identifying LADOTD fiber and microwave network can be found in Appendix A.

The States of Mississippi and Alabama currently do not allow private telecommunications providers to place telecommunications infrastructure within the State's Interstate highway rights-of-way. The States of Mississippi and Alabama would need to enact legislation that would allow private-sector shared resource projects before these States could capitalize on private sector participation in telecommunications within the Corridor. Until State law allows for this, the ability of Mississippi and Alabama to partner with the private sector telecommunications providers is limited and the DOTs must independently fund the ITS infrastructure.

All fiber optic telecommunications cable owned by the Mississippi Department of Transportation (MDOT) is within the State-owned right-of-way. Currently MDOT has fiber on several Jackson, MS area freeways, including I-20. MDOT has partnered with the City of Jackson to share fiber and create a communications ring around the City of Jackson.

The Alabama Department of Transportation (ALDOT) Information Systems Division handles all telecommunications for the State government. The primary ALDOT-owned fiber telecommunications network is in the Birmingham area. ALDOT is installing telecommunications conduit on eligible roadway reconstruction projects as a way to expand the traffic management network. Both Mississippi and Alabama utilize State-owned fiber to communicate with their ITS field devices.

Future deployments include expansion of each State's telecommunications network and field devices along I-20 to enhance telecommunications on the Corridor. I-20 Corridor States should focus on information sharing between States, through center-to-center communications, to facilitate traffic information sharing at critical facilities crossing the state lines. Most future ITS field infrastructure expansion projects along I-20 are designated to be part of larger roadway reconstruction projects. Funding availability will determine when these projects are deployed.

4.2 I-90 CORRIDOR

The communications infrastructure along the I-90 Corridor consists of wireline and wireless facilities including underground fiber optic cable, fiber signal regeneration huts, communication hubs, communication towers, and ITS infrastructure. Some examples of ITS infrastructure deployed on the I-90 Corridor are closed-circuit television (CCTV) cameras; dynamic message signs (DMS); traffic detectors; road weather information systems (RWIS) stations; and traveler information kiosks.

Underground fiber optic cable has been installed within (State-owned) or outside (privately-owned) of the highway right-of-way. Most of the fiber optic cable installations on the I-90 Corridor are outside of the right-of-way because they were installed by the private sector.

In 1989 the State of Iowa passed legislation providing for the construction of a shared, statewide telecommunications network. In 1994, the Iowa Communications Network (ICN) became a State agency and the Iowa Telecommunications and Technology Commission (ITTC) was established by the Legislature as the ICN's governing body. The ICN constructed a comprehensive fiber optic communication system that included six fiber rings (known as the Northwest, Northeast, Southwest, Southeast, Des Moines, and East Central rings). This network was constructed between 1990 and 2004 and encompasses the entire State. There are 767 customer nodes that include K-12 schools, colleges/universities, State and federal agencies, National Guard, hospitals, and public libraries. Parts of the communication system are leased from private networks. The ICN exclusively leases its services to public agencies and medical facilities. The Iowa Department of Transportation began use of the ICN network in 2002 (in Des Moines) along with installing its own fiber as part of ongoing ITS projects in Iowa. More recent Iowa DOT fiber installations are in Iowa City and the Quad Cities[2] as part of roadway reconstruction projects. While the ICN does not include installations along I-90, this statewide program is an excellent example of inter-agency cooperation in meeting the State's telecommunications needs.

There are no public fiber optic telecommunication deployments on the I-90 Corridor in the States of Minnesota and South Dakota. The State of South Dakota leases all of their communication services from private telecommunication companies. Private telecommunication companies have fiber optic networks located along the Corridor, and these installations are primarily located outside of the I-90 highway right-of-way on frontage roads, railroad ROW, and other available ROW. There are two known locations where private fiber optic facilities are located in the I-90 highway right-of-way, from the City of Spearfish to the City of Wall (100 miles) and in Sioux Falls (3 miles). Detailed maps identifying South Dakota's telecommunications providers and current ITS deployments are found in Appendix A.

In Wisconsin, fiber optic cable is installed in the I-90 Corridor highway right-of-way where I-90 and I-94 are co-incident from the City of Madison to the City of Tomah. The State of Wisconsin owns one conduit with 36 fibers, and AT&T owns one conduit with 288 fibers. AT&T (known as Touch America at the time) constructed the facilities, providing a dedicated conduit and fiber to the DOT in lieu of paying permit fees for use of the right-of-way to install longitudinal fiber along the I-94 Corridor. A detailed map identifying Wisconsin's fiber optic cable installations is found in Appendix A. This is an example of a successful public/private installation of high speed telecommunications.

All States along the Corridor own wireless communications networks. Microwave towers are located throughout the individual States including towers near the I-90 Corridor. Wireless communication towers along the I-90 Corridor are typically built outside of the highway right-of-way to avoid moving the tower in the future. The trunked microwave radio communications systems are primarily used by the State patrol and emergency services. The States of Minnesota and South Dakota lease tower space to private industry, if space is available. The State of Wisconsin does not allow private industry to use their towers. A detailed map identifying Minnesota's microwave system is found in Appendix A.

ITS communications along I-90 by the State Departments of Transportation is limited. The State of Iowa ICN currently does not have any communications facilities that connect to the I-90 Corridor in Minnesota. The States of Minnesota and South Dakota do not have any fiber optic cable installed along the Corridor. The State of Wisconsin has plans for ITS devices to be installed along sections of

[2] The "Quad Cities" is a bi-state region straddling the Mississippi River consisting of Davenport and Bettendorf in Iowa, and Moline/East Moline and Rock Island in Illinois.

I-90. However, no viable communications links exist between the ITS devices and the State's fiber system. States along the I-90 Corridor have neither near-term nor long-term plans to build out State-owned fiber optic telecommunications along the Corridor.

4.3 I-91 CORRIDOR

The level of communications systems development within the I-91 Corridor varies. Massachusetts is nearing the end of the procurement process for the I-91 Communications/ITS Design Build Project. The private sector partner chosen will install empty conduit along the entire Corridor within Massachusetts. The private sector partner could then potentially deploy fiber and provide high speed internet service to the underserved area of the state. Vermont is beginning ITS planning and deployment for the I-91 Corridor through an advanced cartography mapping of the Corridor with high resolution photographs. Vermont's major initiative is the "Vermont Statewide Rural Advanced Traveler System and Fiber Construction" initiative. Through this initiative, Vermont will wire the State's highways for broadband service. A major component of this effort is a rural advanced traveler information system that provides weather and road condition information to motorists, and which ties into the overall marketing of Vermont's travel and tourism. New Hampshire has built out some fiber associated with specific roadway projects and is planning an expansion of their State-owned network.

To date, the private sector has adequately served urban areas along this Corridor with high speed wireline internet connections. The more rural areas tend to be under-served or unserved with wireline high speed telecommunications service. Various broadband providers serve the I-91 Corridor. These providers have installed and operate their own private communications networks. These include national, regional, and local providers from the traditional telephone and cable television sectors. The national providers tend to concentrate in the more populous areas such as Springfield, Massachusetts, and Brattleboro, Vermont, where the return on their investment is greater. These areas also tend to have a competitive market for broadband services where choice between two and sometimes three providers is available. Rural areas tend to be served by smaller local or regional providers. These areas tend to have less competition and quite often are served by a single provider.

Within the Massachusetts portion of the I-91 Corridor study area, private broadband communications networks are located almost entirely outside the I-91 right-of-way. The exception to this is long-haul fiber provided by Level 3 Communications. This fiber is contained within the Massachusetts Turnpike Authority's (MTA's) duct banks along the I-90 right-of-way, which crosses the I-91 right-of-way to the west of the Connecticut River. No other fiber duct banks are currently installed.

Within the Vermont portion of the I-91 Corridor, the telecommunications network capability is entirely provided by private communications networks. However, no fiber duct banks are currently installed within the I-91 right-of-way. Detailed maps identifying the broadband availability and telecommunications providers in Vermont are located in Appendix A.

MassHighway has released a request for proposals (RFP) to install optical fiber along I-91 through Massachusetts, including I-291 in Springfield. The project will include six conduits, where four have been designated for future use and may be leased out. The private sector partner chosen will install empty conduit and the private partner may install fiber on their own.

In Vermont, the Agency of Transportation has a funding source of $10 million to support a fiber optic installation project traversing the State along I-91. The State is using this funding source to complete the environmental and permitting process. Once this work is complete, the agency will issue a request for proposals (RFP) for a public/private partnership to build out the communications network.

5.0 Constructability Considerations

The following section identifies the physical features and construction issues that may present barriers and opportunities to communications infrastructure deployment within the three study Corridors. Throughout each of the Corridors, these installation activities are subject to the same requirements as more conventional roadway construction activities. While somewhat commonplace in the roadway construction industry, they bear mentioning here as a reminder of the considerations that will present themselves for the construction of a fiber backbone along each of these Corridors.

5.1 I-20 Corridor

The I-20 Corridor through Louisiana, Mississippi, and Alabama is unique amongst the three being examined as part of this study, as it presents the most diversity in policies regarding the accommodation of communication utilities within Interstate highway right-of-way. In general, Louisiana has a liberal policy regarding utility accommodations, encouraging resource sharing for utilities to place communication infrastructure on Interstate highway right-of-way, including wireless towers. Mississippi and Alabama, however, have not engaged in shared resource projects, and current policies limit the ability of utilities to access Interstate highway right-of-way. The following sections provide a more detailed look at issues pertinent to the I-20 Corridor.

5.1.1 Geographic

The overall geography of the I-20 Corridor is flat or rolling terrain with occasional rock outcroppings, primarily in eastern Alabama. The land is heavily forested in rural areas and adjacent to the right-of-way. Wetlands are encountered frequently along the Corridor and the habitat supports a wide variety of plant and animal life. There are several urban centers along the Corridor including Shreveport, LA; Monroe, LA; Vicksburg, MS; Jackson, MS; Meridian, MS; and Birmingham, AL.

The I-20 Corridor contains numerous major water crossings which will present construction challenges. These major water crossings include:

- Red River near Shreveport, Louisiana
- Ouachita River in Monroe, Louisiana
- Mississippi River at the Louisiana/Mississippi border
- Black Warrior River near Tuscaloosa, Alabama

- Cahaba River near Birmingham, Alabama
- Logan Martin Lake near Lincoln, Alabama

In addition, the Cahaba River watershed is an environmentally sensitive area. The Cahaba River serves as the source of drinking water for over one million people and flows through heavily populated areas in the Birmingham metropolitan area. Construction in this sensitive habitat must adhere to the State's environmental policies, as is the case for all crossings of rivers and wetland areas in any of the I-20 Corridor States.

5.1.2 Bridge Attachments

The three States comprising the I-20 Corridor each have different requirements regarding conduit installations on bridge structures. The State of Louisiana requires rigid fiberglass "bullet-proof" conduit when mounting to bridge structures, but generally does not discourage bridge attachments as a method for crossing.

Where a freeway in Mississippi crosses a major valley or river on an existing structure, new utility installations will not be permitted at or after the time the highway route is improved, except for special cases as noted below. Where such structure attachments are requested, the utility owner must in each case show that:

- The accommodation will not adversely affect the safety, design, construction, operation, maintenance or stability of the freeway;
- The accommodation will not be constructed and/or serviced by direct access from the through-traffic roadways or connecting ramps;
- The accommodation will not interfere with or impair the present use or future expansion of the freeway; and
- Any alternative location would be contrary to the public interest. This determination would include an environmental evaluation of the direct and indirect environmental and economic effects covering on- and off-right of way alternatives.

Alabama has adopted a general policy of prohibiting utility attachments to structures except in extreme cases. Under normal conditions, where it is feasible and reasonable to locate utility lines elsewhere, attachments to highway structures will be avoided. Utility lines may be attached to a highway structure only when all of the following conditions exist:

- No other practicable alternative is available, including private easement;
- The attachment will not create a hazard to the public;
- The public interest will suffer if approval is not granted;

- The structural integrity of the facility will not be threatened by the attachment; and
- The Department's basic interests will not be substantially compromised by the attachment.

For reasons of safety, ALDOT looks more favorably upon some types of utilities than upon others where attachments to structures are considered, and limits utility attachments to communications or water supply.

Corridor-wide construction will require consideration of the various water-crossing construction and permitting requirements.

5.1.3 Subsurface Considerations

The preliminary backbone alignment was designed using aerial mapping from Google Earth and a visual survey as noted in Section 2.1. Neither subsurface investigations nor geotechnical surveys were conducted as part of this study. General information regarding known surface conditions in the corridor is presented here.

All three States along this Corridor require that telecommunications conduit to be installed as close to the right-of-way line as possible, and each has similar conduit depth requirements, ranging from a minimum depth of 36 inches in Mississippi and Louisiana to 40 inches in Alabama. In addition, Louisiana employs a "first-come, first-served" utility installation policy. The first utility gaining a construction permit can install their infrastructure as close to the right-of-way line as possible. The next installer is forced to locate their facilities a set distance from the first. When the right-of-way is full, utilities must wait for an opportunity to install their infrastructure or lease infrastructure from an existing provider.

Louisiana also prefers not to have telecommunications infrastructure cross underneath railroad tracks due to the laborious and lengthy process of obtaining railroad permits, which can delay project construction, but they have allowed them in the past, as evidenced by existing communication utility placement along I-20.

The soils found throughout Mississippi are expansive Yazoo clay soils. Yazoo clay expands and contracts extensively. The underground conduit system must be capable of handling this expansion and contraction. The Appalachian foothills lie in eastern Alabama. This rocky region adds difficulty when constructing underground utilities. In the Calhoun area, east of Birmingham, soils are contaminated with PCB's. Construction in this area requires proper disposal of disturbed soil.

The New Madrid Seismic Zone (NMSZ) is a major seismic zone located in the mideastern United States. The effects of the fault zone reach into northeastern Louisiana, which includes the I-20 Corridor. Special structural design is required when constructing in the affected area.

5.1.4 Site Access

Various site access issues exist along the I-20 Corridor. These issues are both physical and regulatory and create site access constraints that require mitigation during construction activities. The most significant of these issues are discussed below.

Vegetation growth within the right-of-way could hinder access to the right-of-way. Vegetation includes mature trees with deep root systems and other undergrowth. Dense vegetation may require directional boring as the preferred method of installing underground conduit.

Where conduit will be mounted on bridges, appropriate construction techniques and equipment such as boats, cranes, and swing boom lifts will be required to gain access to the underside of the bridge deck and structures. This can present various safety-related issues that must be addressed by construction field crews. Where subsurface water-crossings are employed, access to the site could be constrained by natural features such as swift water currents or the presence of rapids.

Regulatory constraints include environmental considerations such as endangered species or water quality issues, and navigation concerns. All construction activity will require that the contractor conform to all State highway access requirements for Mississippi, Alabama, and Louisiana. These requirements include adherence to the Manual of Uniform Traffic Control Devices (MUTCD) traffic control requirements, National Electrical Safety Code, and U.S. Army Corps of Engineers (USACE) Wetlands Regulations, which contain wetlands permitting requirements.

5.1.5 Maintenance of Traffic

Safely maintaining traffic through the construction zone is the highest priority to all the States along the Corridor. To minimize disruption to traffic, the States all prefer to bore conduit under obstacles, especially if the alternative is mounting the conduit underneath a bridge structure. Where necessary, contractors will be required to prepare and seek approval for maintenance of traffic plans to ensure traffic flow safety during the construction period.

5.1.6 Safety

In general, the utility installing the infrastructure is responsible for the safety of the work site. Occupational Safety and Health Administration (OSHA) regulations must be followed at all times. Equipment that is not in active use must be stored in a safe location off of the right-of-way or near the right-of-way fence as far away from live traffic as possible. Construction vehicles must have safety and hazard warning lights active if they are located within the right-of-way work area. All workers must wear high visibility apparel per the requirements in the MUTCD. Hardhats and safety shoes should be worn where head and foot protection is warranted.

The integrity of the infrastructure is also a priority to all the States. All installations must conform to the respective State's specifications, codes, policies, and procedures.

All States require that conduit installed longitudinally along the facility be located as close to the right-of-way line as possible, again to minimize disruption to traffic during installation and maintenance, and to minimize accidental cuts due to State construction or maintenance activities within the right-of-way.

Geographical features can pose an increase in risk to workers and the environment. For example, I-20 crosses several major rivers, including the Mississippi River. Challenges associated with boring conduit underneath these large river systems or making bridge attachments pose an obvious risk to workers. When doing directional boring near river systems, the slurry runoff from the boring pit needs to be contained and not allowed to enter the waterway.

5.1.7 Coordination with Other Projects and Utilities

All utilities must have an approved permit to construct within or pass through State rights-of-way. All permits are reviewed by DOT personnel to determine if the proposed construction conflicts with other roadway or utility construction projects. Even if approved, the contractor must coordinate with the State and other utility providers to minimize conflicts. Each State has a "1-800-Dig" telephone number and requires the contractor to call and coordinate with other utilities in the area.

5.2 I-90 Corridor

The I-90 Corridor, incorporating parts of South Dakota, Minnesota, Iowa, and Wisconsin, presented the most uniformity in policies regarding shared resource construction activity. Each State physically located along the Corridor (Iowa is adjacent to the Corridor) openly encourages shared resource applications along I-90 as a method for obtaining access to high-speed telecommunications infrastructure for their States. All of the States have policies in place to accept applications to install communications along Interstate highway right-of-way and in the case of Minnesota and Wisconsin, to receive compensation in the form of cash or infrastructure. Communication utility access to I-90 in South Dakota is open, meaning that no compensation is sought for granting access to the Interstate highway right-of-way, but this only applies to fiber optic infrastructure. The following sections provide additional detail on constructability along the I-90 Corridor.

5.2.1 Geographic

The overall terrain on the I-90 Corridor is relatively flat and straight farmland. There are a few exceptions. There is mountainous terrain in the western part of South Dakota (Black Hills). In addition, the area approximately 10-20 miles east and west of the Mississippi River (Minnesota-Wisconsin border) is steep and has limited right-of-way due to rock cuts on either side of the Interstate highway. These hilly and mountainous areas make both wireline and wireless communication construction costly.

Urban centers located along the I-90 Corridor include Rapid City, SD; Sioux Falls, SD; Albert Lea, MN; Austin, MN; Madison, WI; and Janesville-Beloit, WI. In addition, Worthington, MN, Rochester, MN, and La Crosse, WI are near by.

The I-90 Corridor crosses several rivers and streams. Most are small and will not require expensive construction techniques or material to install fiber conduit. The major water crossings include:

- Mississippi River at the Minnesota-Wisconsin border
- Lake Francis Case near Chamberlain, South Dakota

These crossings will require relatively costly construction methods such as directional boring or reinforced conduit attached to bridges. In general, all of the Corridor States allow bridge attachments. Minnesota requires the utility to perform structural calculations and provide documentation to the DOT that shows no adverse effects from the attachment. Wisconsin only states that the attachment must not affect the structural integrity or appearance of the bridge and must not interfere with operations or maintenance. South Dakota allows attachments when other methods can be shown to be too costly or impractical.

In locations where the land is very flat, drainage can be a concern. Many landowners adjacent to the freeway belong to specific drainage districts, and if drainage patterns were to change it could affect a farmland's productivity. Particular consideration should be given to this issue during the design and construction process. The flat land can also be problematic for maintenance issues during winter when blowing and drifting snow can occasionally cause road closures.

States along this Corridor generally require that telecommunications conduit be installed as close to the right-of-way line as possible and each has conduit depth requirements ranging from 24 inches in Wisconsin to 36 inches in Minnesota. In South Dakota, the depth of installation is 48" in rural areas and 36" in other areas.

5.2.2 Subsurface Considerations

The preliminary backbone alignment was designed using aerial mapping from Google Earth and a visual survey as noted in Section 2.1. There were neither subsurface investigations nor geotechnical surveys conducted as part of this study. General information regarding known surface conditions in the corridor is presented here.

Subsurface rock is a concern for the entire Corridor. Rock is expensive to trench through and will add significant costs to a telecommunications installation. For a large part of the Corridor, the rights-of-way present relatively easy construction through loam type soils with glacial till encountered. However, significant subsurface rock will likely be encountered and will require mitigation.

5.2.3 Site Access

Various site access issues exist along the I-90 Corridor. These issues are both physical and regulatory and create site access constraints that require mitigation during construction activities. The most significant of these issues are discussed below.

Vegetation growth within the right-of-way could hinder easy access to the right-of-way. Vegetation includes mature trees with deep root systems and other undergrowth. The I-90 Corridor has little problematic vegetation throughout South Dakota and Minnesota, and forested areas are primarily encountered in eastern Minnesota and in Wisconsin.

Where conduit will be mounted on bridges, appropriate construction techniques and equipment such as boats, cranes, and swing boom lifts will be required to gain access to the underside of the bridge deck and structures. This can present various safety-related issues that must be addressed by construction field crews. Where subsurface water-crossings are employed, access to the site could be constrained by natural features such as swift water currents or the presence of rapids. Regulatory constraints could include environmental considerations such as endangered species or water quality issues, and navigation concerns.

All of the I-90 Corridor States require that, where practical, access to the construction site should be gained from a nearby public street or private property and not the freeway or freeway ramps. Fence removal or use of fence gates to access the site is at the discretion of the permitting agency.

5.2.4 Maintenance of Traffic

A traffic control plan should be submitted with each utility permit application. Each State in the I-90 Corridor requires that the traffic control plan conform to the MUTCD. Work must not begin on a site until all the traffic control devices are in place. Work in urban areas must be performed during off peak traffic hours, which are generally 9am to 3pm, and 10pm to 6am.

5.2.5 Safety

In general, the utility installing the infrastructure is responsible for the safety of the work site. OSHA regulations must be followed at all times. Equipment that is not in active use must be stored in a safe location off of the right-of-way or near the right-of-way fence as far away from live traffic as possible. Construction vehicles must have safety and hazard warning lights active if they are located within the right-of-way work area. All workers must wear high visibility apparel per the requirements in the MUTCD. Hardhats and safety shoes should be worn where head and foot protection is warranted.

5.2.6 Coordination with Other Projects and Utilities

All utilities must have an approved permit to construct within or pass through State rights-of-way. All permits are reviewed by DOT personnel to determine if the proposed construction conflicts with other roadway or utility construction projects. Even if approved, the contractor must coordinate with the State and other utility providers to minimize conflicts. Each State has a "1-800-Dig" telephone number and requires the contractor to call and coordinate with other utilities in the area. Of note is that all of the I-90 Corridor States register their State-owned infrastructure with their State's dig-safe service and perform locates as private utilities do.

Work within the highway right-of-way should be coordinated to minimize disturbances to any other contractor working in the right-of-way. It is the responsibility of the utility to coordinate work with other contractors. Traffic control plans should be coordinated to minimize the disruption to traffic.

5.3 I-91 Corridor

The I-91 Corridor comprises portions of Massachusetts, Vermont, and New Hampshire (I-91 is located adjacent to New Hampshire). This Corridor is unique in that it is the most advanced in terms of progress toward developing a shared resource project along the Corridor of the three Corridors studied. Massachusetts has selected a design/build team to install communications infrastructure and Vermont is developing a shared resource project for contracting in the near future. The following sections provide a more detailed look at this and other issues pertinent to these States.

5.3.1 Geographic

The I-91 Corridor generally parallels the path of the Connecticut River through Massachusetts and Vermont. Urban areas along the Corridor include Springfield, MA; Holyoke, MA; Northampton, MA; and Hanover, VT. Along this path, the roadway crosses several rivers and streams. Most are small and will not require expensive construction techniques or material to install fiber conduit. The one major river crossing is the Connecticut River near Springfield, Massachusetts. This major crossing will require relatively costly construction methods such as directional boring or reinforced conduit.

Attachments to structures in Massachusetts are to be avoided in accordance with the State's utility accommodation policy, but are allowed by permit when other methods are impractical and the attachment does not adversely affect operations, maintenance, or safety.

The terrain varies along the 242 miles of the Corridor. Through the Massachusetts portion, the roadway traverses the relatively flat land of the Connecticut River Valley. As the roadway winds its way northward through

Vermont, the terrain becomes steadily more rugged up to and through the Green Mountains. In locations where the land is very flat, drainage can be a concern.

States along this Corridor generally require that telecommunications conduit to be installed as close to the right-of-way line as possible, but in an upcoming project to install fiber optic infrastructure, Vermont is requiring installation along the shoulder due to ROW restrictions and to avoid rock outcroppings. Massachusetts and Vermont have similar depth requirements for conduit installations.

There were neither subsurface investigations nor geotechnical surveys conducted as part of this study. General information regarding known surface conditions include subsurface rock being a concern for the entire Corridor. Rock outcroppings can be expected along the Corridor. In addition, subsurface rock should be expected throughout the Connecticut River valley. Rock is expensive to trench through and will add significant costs to a telecommunications installation.

Massachusetts, Vermont, and New Hampshire are located in an active seismic zone with historically low earthquake activity. However, reasonable steps should be taken to minimize potential seismic damage to vital communications facilities.

5.3.2 Site Access

Various site access issues exist along the I-91 Corridor. These issues are both physical and regulatory and create site access constraints that require mitigation during construction activities. The most significant of these issues are discussed below.

Vegetation growth within the right-of-way could hinder easy access to the right-of-way. Vegetation includes mature trees with deep root systems and other undergrowth. Dense vegetation may require directional boring as the preferred method of installing underground conduit. Forested areas exist along the entire length of the I-91 Corridor and are adjacent to the right-of-way.

Where conduit will be mounted on bridges, appropriate construction techniques and equipment such as boats, cranes, and swing boom lifts will be required to gain access to the underside of the bridge deck and structures. This can present various safety-related issues that must be addressed by construction field crews. Where subsurface water-crossings are employed, access to the site could be constrained by natural features such as swift water currents or the presence of rapids. Regulatory constraints could include environmental considerations such as endangered species or water quality issues, and navigation concerns.

Any construction activity will require that the contractor conform to all State highway access requirements for both MassHighway and the Vermont Agency of Transportation. These requirements include:

- Commonwealth of Massachusetts - Regulation 720 Section 13 – Approval of Access to State Highways
- Vermont Agency of Transportation Regulation - "Work Within Highway Rights-of-Way"

5.3.3 Maintenance of Traffic

A traffic control plan should be submitted with each utility permit application. Each State in the I-91 Corridor requires that the traffic control plan conform to the MUTCD. Work must not begin on a site until all the traffic control devices are in place. Some work may be required to be performed during off peak traffic hours to minimize traffic impacts

5.3.4 Safety

In general, the utility installing the infrastructure is responsible for the safety of the work site. OSHA regulations must be followed at all times. Equipment that is not in active use must be stored in a safe location off of the right-of-way or near the right-of-way fence as far away from traffic as possible. Construction vehicles must have safety and hazard warning lights active if they are located within the right-of-way work area. All workers must wear high visibility apparel per the requirements in the MUTCD. Hardhats and safety shoes should be worn where head and foot protection is warranted.

5.3.5 Coordination with Other Projects and Utilities

All utilities must have an approved permit to construct within or pass through State rights-of-way. All permits are reviewed by DOT personnel to determine if the proposed construction conflicts with other roadway or utility construction projects. Even if approved, the contractor must coordinate with the State and other utility providers to minimize conflicts. Each State has a "1-800-Dig" telephone number and requires the contractor to call and coordinate with other utilities in the area.

Work within the highway right-of-way should be coordinated to minimize disturbances to any other contractor working in the right-of-way. It is the responsibility of the utility to coordinate work with other contractors. Traffic control plans should be coordinated to minimize the disruption to traffic.

5.3.6 Environmental Mitigation

As with any construction project, various environmental concerns will have an impact on the constructability of a fiber optic conduit trench or tower. These concerns include wetlands, endangered species and habitats, and materials disposal. While these concerns are true of any location in the US, they are of particular concern in Massachusetts and Vermont with their histories of environmental activism and legislation. Contractors will need to conform to all

State and federal permitting regulations and develop mitigation strategies where required.

6.0 Scheduling, Maintenance, and Cost Estimation

This section has three parts: 1) Schedule Considerations: proposed and planned projects per Corridor and for different work tasks; 2) Maintenance Considerations: description of different maintenance categories, maintenance procedures for field devices, recommendations for required maintenance equipment, maintenance procedures for roadside activities, and development of a maintenance agreement; and 3) Maintenance and Construction: example cost estimates.

6.1 Schedule Considerations

Creating a construction schedule for a high-speed telecommunications project involves analysis of the work tasks needed, determination of the length of time needed to complete each work task, and a determination of a start and completion date. Scheduling is an important function of the ultimate cost of the project. The factors that should be considered when developing a construction schedule are listed below.

Weather/Seasonal: Underground telecommunication facilities cannot be constructed when the ground is frozen in winter months or when the ground is too wet. Excessive rain will cause delays to any construction project.

Environmental Clearances/Protected Endangered Species: The length of time needed to obtain necessary environmental permits and perform assessments should be included in the schedule if it is known that there will be extensive delays due to circumstances within a State. By law, endangered species in the highway right-of-way must be protected or avoided. The Department of Natural Resources in each State maintains a list of endangered and threatened species that are protected. The protection may be seasonal, as is the case with fish and turtle spawning, or year round.

Holidays: Work is suspended during national and local holidays throughout the year. Holidays include but are not limited to Labor Day, Memorial Day, Fourth of July, Thanksgiving, Christmas, and New Year's Day.

Work Days: Contractor's schedules are based on the total number of workdays needed to complete the project. Workdays are not counted for holidays, weekends (Saturday and Sunday), or days when weather does not allow work to be performed. In a typical month there are 15 to 20 contractor workdays.

Rate of Work: Each construction task has a reasonable rate at which it can be done per day, week, or month. When creating a schedule it is best to look at recent similar projects to develop a rate of work that fits the size and scope of the project being scheduled. Different work tasks can be completed within the same amount of working days if several work crews are employed. For example, on the same day a crew may be trenching fiber optic cable while another crew is installing handholes and yet another crew is installing conduit on a bridge structure. Table 4.1 presents typical rates of work for installation of telecommunication facilities:

Table 6-1: Typical Rate of Work

TASK	RATE OF WORK (DAY)
Underground Fiber Optic Cable, Trench, Urban	½ Mile per Day
Underground Fiber Optic Cable, Trench, Rural	3 Miles per Day
Underground Fiber Optic Cable, Directional Bore for Culverts or Waterway Crossings	2 Days
Underground Fiber Optic Cable, Lateral Freeway Crossing, Directional Bore	3 Days
Conduit Attached to Bridge Structure	7 to 14 Days
Regeneration Building	7 to 14 Days
Communication Handhole	1 Day
Tower Installation*	14 days

* Does not include building construction

Construction Elements: The construction materials suggested for the fiber optic facilities are defined below. These materials have been used for existing fiber optic installations in the Corridors.

HDPE Conduit: This is the most common conduit used for long haul fiber installations. HDPE conduit is high strength to withstand external loads, flexible, lightweight, impact resistant, resistant to corrosive chemicals and aggressive soils, color-coded for easy identification, able to be coiled on reels for fewer joints, and is moisture proof and water tight. The duct can be installed using a plow shoe that inserts multiple conduits in a slit trench, reducing installation costs and time. The number and size of HDPE conduits should be based on partnerships needs.

48-Count Fiber Optic Cable: This size of fiber optic cable will allow for several public agencies to use the fiber optic network along the Corridor. Additional fiber optic cable can be placed in the spare conduit ducts at a future date.

Communication Handholes/Vaults: Communication handholes are placed every mile and at every interchange in the Corridors.

Regeneration Building: Regeneration Buildings are placed approximately every 50 miles in the Corridor for fiber optic signal regeneration. The buildings are small environmentally controlled buildings (typically 10 feet by 20 feet) that house fiber optic communication equipment.

6.2 Hypothetical Example Construction Program

Hypothetical schedules for each Corridor are included below with the assumption that a contractor would complete the telecommunications facilities in each Corridor within two years or less using two crews. Telecommunications facilities include underground fiber optic cable, directional bores (for culverts, small waterways, railroads, and lateral crossings), conduit on bridge structures, communication handholes, regeneration buildings, and potential tower installations on State owned land. Each crew should be able to install on average two miles (as we are taking urban and rural construction into consideration) of fiber optic cable per day since most of the Corridor right of way is rural and open. Typically rural Interstate highway Corridor projects begin construction between the months of April and June. This allows the contractor to begin construction without any initial construction delays that could be caused by severe weather conditions (i.e. excessive rain, winter storms, etc.).

6.2.1 Planned Corridor Projects

This section presents brief description of Corridor specific planned projects and proposed schedules.

I-90 Corridor

- The South Dakota Department of Transportation is reconstructing 13 interchanges along I-90 within the next 1 to 5 years. The majority of the interchange reconstruction is in Sioux Falls, SD (9 interchanges, Exits 410, 406, 402, 400, 399, 396, 395, 390, and the WB Minnesota Rest Area Exit). The remaining four interchanges are located on the western side of the State with two interchanges in Pennington (Exit 51 and Exit 61) and two interchanges in Lawrence (Exit 14 and Exit 17).
- The SDN Communication Group is planning a fiber optic installation on I-90 near Mitchell, SD. As of April 2007, the permits were being processed and installation is planned in 2008.
- The existing I-90/TH 14 Interchange and Mississippi River Bridge on the Minnesota side of the river is to be completely rebuilt by the Minnesota Department of Transportation within the next 5 years. The design effort is underway now. This will be a reconstruction section (approximately ½ mile) on I-90.

I-20 Corridor

- Mississippi DOT's near-term and long-range plans for their communications network include installing fiber optic cable and wireless communications. Communications infrastructure installation projects are likely to be part of larger roadway reconstruction/ rehabilitation projects. Along I-20, communications infrastructure expansion will be part of future I-20 roadway reconstruction projects. The State of Mississippi Department of Transportation has developed a map describing the DOT's fiber optic cable build-out plan. The DOT's priorities are to install fiber along the State's north/south routes with Hwy 49 as the first priority; install fiber across the State's Mississippi River bridge crossings; and expand the Jackson system outside the urban area, including along the I-20 Corridor.
- Alabama DOT's near-term focus is to install and expand telecommunications infrastructure in and around the State's urban areas. As with Mississippi, Alabama DOT capitalizes on roadway reconstruction/rehabilitation projects to install the communications infrastructure.

I-91 Corridor

- MassHighway has released a request for proposals (RFP) to install empty conduit along I-91 through Massachusetts and I-291 in Springfield. The project will include six conduits, where four have been designated for future use and may be leased out.
- The State of Vermont is in the midst of an ambitious effort to develop an interactive, web-based database comprising travel and tourism information about the State. A major component of this effort is a rural advanced traveler information system that provides weather and road condition information to motorists, and which ties into the overall marketing of Vermont's travel and tourism. Project funds will likely be adequate to install broadband fiber along all of Interstates 89 and 91. That fiber, frequently referred to as the telecommunications highway of the 21st Century, will not only serve the rural traveler information system but also improve broadband Internet and telecommunications access throughout Vermont.

6.2.2 Corridor Construction Schedule

The following tables present a hypothetical construction schedule for each Corridor as an example of construction scheduling. The tables include hypothetical construction starting timeframes, holidays, dedicated number of crews, and total number of miles completed per month.

I-90 Corridor Example

Table 6.2 below presents the hypothetical schedule for the I-90 Corridor, which would begin construction in April, 2008 with two crews dedicated to the Corridor, and completing approximately 70 miles of communication infrastructure construction per month. The I-90 Corridor, which is approximately 843 miles, could be complete by August, 2009.

Table 6-2: I-90 Hypothetical Corridor Construction Schedule

Month/Year	Holidays	Work Days[a]	Number of Crews[b]	I-90 Corridor (843 Miles) Miles Completed Per Month
April 2008		18	2	72
May 2008	Memorial Day	17	2	68
June 2008		18	2	72
July 2008	Fourth of July	17	2	68
Aug. 2008		18	2	72
Sept. 2008	Labor Day	17	2	68
Oct. 2008		18	2	72
Nov. 2008 to March 2009	Thanksgiving Christmas New Years	No Work		
April 2009		18	2	72
May 2009	Memorial Day	17	2	68
June 2009		18	2	72
July 2009	Fourth of July	17	2	68
Aug. 2009		18	2	71
	Total	**211**		**843**

[a] Work days are determined by subtracting weekends, holidays, and 2 days for weather from each month.

[b] Assumption is that each construction crew can complete 2 miles of telecommunication infrastructure each working day.

I-20 Corridor Example

Table 6.3 below presents the hypothetical schedule for the I-20 Corridor, which would begin construction in April, 2008 with two crews dedicated to the Corridor, and completing approximately 70 miles of communication infrastructure construction per month. The I-20 Corridor, which is approximately 542 miles, could be complete by November, 2008.

Table 6-3: I-20 Hypothetical Corridor Construction Schedule

Month/Year	Holidays	Work Days[a]	Number of Crews[b]	I-20 Corridor (542 Miles) Miles Completed Per Month
April 2008		18	2	72
May 2008	Memorial Day	17	2	68
June 2008		18	2	72
July 2008	Fourth of July	17	2	68
Aug. 2008		18	2	72
Sept. 2008	Labor Day	17	2	68
Oct. 2008		18	2	72
Nov. 2008	Thanksgiving	17	2	50
	Total	**140**		**542**

[a] Work days are determined by subtracting weekends, holidays, and 2 days for weather from each month.

[b] Assumption is that each construction crew can complete 2 miles of telecommunication infrastructure each working day.

I-91 Corridor Example

Table 6.4 below presents the hypothetical schedule for the I-91 Corridor, which would begin construction in April, 2008 with two crews dedicated to the Corridor, and completing approximately 70 miles of communication infrastructure construction per month. The I-91 Corridor, which is approximately 242 miles, could be complete by July, 2008.

Table 6-4: I-91 Hypothetical Corridor Construction Schedule

Month/Year	Holidays	Work Days[a]	Number of Crews[b]	I-91 Corridor (242 Miles) Miles Completed Per Month
April 2008		18	2	72
May 2008	Memorial Day	17	2	68
June 2008		18	2	72
July 2008	Fourth of July	17	1	30
	Total	**70**		**242**

[a] Work days are determined by subtracting weekends, holidays, and 2 days for weather from each month.

[b] Assumption is that each construction crew can complete 2 miles of telecommunication infrastructure each working day.

6.3 Infrastructure Maintenance

An important aspect of developing and deploying communications projects is the proper maintenance of the system. A maintenance plan has two important categorizes: 1) *Preventive Maintenance* is keeping property and equipment in good state of operation and preventing failures, and 2) *Responsive Maintenance* is the action taken by an agency or department to any reported equipment or system malfunction. In addition to discussing these two types of maintenance plans, this section will also present and discuss typical maintenance procedures that would be required to be performed as part of PM.

6.3.1 Preventive Maintenance

Preventive Maintenance refers to keeping property and equipment in good state of operation and preventing failures by following a set of checks and procedures, tests, and reconditioning performed at regularly scheduled intervals. Preventive maintenance minimizes the need for more costly major repair work or equipment replacement. The life of a system can be prolonged through on-going preventive maintenance.

The core of any preventive maintenance program is a schedule that calls for the regular servicing of all systems. The development of this schedule begins with the identification of each system or item, including its location, that must be checked and serviced; the date it must be serviced; and the individual responsible for the work. The servicing intervals and tasks for each system must be included in the schedule. Typical preventive maintenance activities include the following:

- Inspection and testing
- Record keeping (including date of last service)
- Cleaning
- Replacement based on the function and rated service life of the component

6.3.2 Responsive Maintenance

Responsive Maintenance refers to actions taken by an agency or department in response to any reported equipment or system malfunction or damage due to construction/maintenance activities, acts of God, etc. Responsive maintenance includes following both field procedures used to restore operation and shop procedures followed to troubleshoot, repair and test the malfunctioning or damaged equipment or cable. Responsive maintenance follows the five general steps below.

- Receive notification
- Secure the site
- Diagnose the problem
- Perform interim repairs (repairs to restore the system until permanent repair can be made)
- Log the activity

6.4 FIELD DEVICE MAINTENANCE

6.4.1 Regeneration Building

A regeneration building is a location serving as a central point of signal regeneration and data distribution for the field and central equipment. The regeneration building will distribute communication data such as: voice, data, video, and the like to the adjacent regeneration buildings or to the local/regional traffic management center.

Typical floor space for the regeneration building is approximately 200 sq. ft. This space will accommodate communication equipment racks, HVAC, and cable management racks. The final site selection shall also consider access for maintenance vehicles and parking. Ideal location would be at interchanges and road crossings. The location should be in an area that is well drained and sloped to prevent water runoff from approaching the building. The integrity of the infrastructure is also a priority to all the States. All installations must conform to the respective State's specifications, codes, policies, and procedures. Table 6.5 below presents typical maintenance activities required for the systems in the Regeneration buildings.

Table 6-5: Communication Maintenance Activities

System	Preventative Maintenance	
	Every Six Months	**Annual**
Structural Foundations	Routine inspection for cracks, deterioration	Localized repair of cracks
Exterior Closures – Walls	Visual inspection, cleaning	Localized repairs, painting, replacement of individual steel lintels
Exterior Closures – Windows & Glazed Walls	Visual and physical inspections, cleaning	Repairs/localized replacements of frames, caulking, etc.

System	Preventative Maintenance	
	Every Six Months	**Annual**
Exterior Closures – Doors & Frames	Inspect hardware, lubricate closers and hardware	Repair/replace individual hardware, doors, frames, recaulking, leveling adjustments, general operations
Exterior Closures-Roofs	Debris removal, inspections, check for water stains, leaks, clear roof drains and gutters	Annual inspection, localized repairs of roofing/flashing materials to maintain warranty
Interior Construction – Interior Doors	Inspect hardware, lubricate closures and hardware.	Repair/replace hardware, leveling adjustments, general operations
Interior Construction – Wall finishes	Cleaning	Repainting, localized repair/replacement of vinyl base/trim, etc.
Interior Construction – Floor finishes	Cleaning	Localized repair/replacement of floor tiles/material
Interior construction – ceiling finishes	Wash/dust/vacuum	Paint, patch plaster and textured finish
Heating/Cooling Systems	Inspect system. Clean or vacuum return air grills	Clean supply/return ductwork, repair/replace thermostats, valves, fans and motors, replace filters, etc.
Interior Lighting	Clean diffusers/lenses, replace bulbs, battery packs	Localized repair or replacement of switches, fixtures, lenses, etc.
Exterior Lighting	Check lights, change bulbs, replace cracked lenses.	Replace fixtures, day/night individual sensors, damaged light pole, etc.
Exit Signs	Visual inspections, bulb and/or battery replacement	Repairs due to breakage/ vandalism or replacement
Power & Outlets	Visual inspections, new plates or covers for power switches or outlets	New convenience use power outlets, new miscellaneous power outlets, repair or replacement of interior parts (wall switches, wall outlets, exclusive of covers)
Communication & Security Systems	Visual inspection, cleaning	Annual testing, service and inspection, replace broken components or devices

6.4.2 Communication Towers and Field Equipment

This category includes communication infrastructure along the Corridor such as radio and microwave towers. Any additional communication towers should preferably be installed on State owned land and far enough from Corridor traffic to safely undertake necessary maintenance procedures.

The maintenance of the tower structures and the equipment mounted on the tower should follow the manufacturer's recommended maintenance procedures. Below are typical maintenance procedures for antennae (recommended every six months).

- Check all mounting hardware for looseness, corrosion or any physical damage.
- Check antenna alignment and test point-to-point link integrity.
- Be sure all unpainted surfaces of the antenna or the mounting bracket is free of dirt. Heavy mud can be cleaned off with water.
- If antenna is up for an extended period of time following a major storm or freezing rain a responsive maintenance should be performed by following these steps:
  - Remove power from the antenna
  - Check element tension
  - Check tightness of attachment screws
  - Check tightness of ground wire attachment screw

6.4.3 Fiber Optic Cable Handholes/Vaults

Inspect vaults and handholes once per year to ensure they are draining properly and that there is no water intrusion into conduits and fiber optic cable. Any mud or debris should be removed to assist with drainage. Conduits containing cables should be sealed with appropriate material to prevent water intrusion into system. Empty conduits should have dust plugs installed and pull tapes should be securely fastened to the dust plug or other anchor point within the handhole. The vault cover should be free of debris, seated properly, and identification markers in good repair to make location easier. Inspect cable for rodent bite marks and repair as necessary. Check splice enclosure pressure and inspect for any water intrusion. Clean out and reseal faulty or damaged splice enclosures.

6.4.4 Avoiding Existing Utilities During Construction Activities

This category is for existing utilities infrastructures along the Corridor at risk for damage during construction in the area. Construction activities adjacent to the properties of any utility, including railroads, that causes damage might result in considerable expense, loss, or inconvenience. Hence work shall not commence until all utilities in the area have been properly located through a one-call service and arrangements necessary for the protection of the telecommunication infrastructure have been completed. It would be the contractor's responsibility to communicate any disruption of services or damage to the authorities. The contractor is required to follow all applicable safety laws, regulations, and standard safety procedures during any project. This includes compliance with the requirements of the MUTCD, OSHA, and others as appropriate. Appropriate safety attire for personnel in the field, clear markings, and functional lights on vehicles must be part of the safety plan.

Below is a typical contractor's responsibility prior to and during any activities on the Corridor:

- In the event of disruption to any communications media, it is the contractor's responsibility to repair that cut within one hour of the cut occurring or notify the owner for repair.
- If any utility service is interrupted as a result of accidental breakage or of being exposed or unsupported, the contractor shall promptly notify the proper authority and shall cooperate with the authority in the restoration of service.
- If utility service is interrupted, repair work shall be continuous until service is restored.
- No work shall be undertaken around fire hydrants until the local fire authority has approved provisions for continued service in the event of an accidental disruption or disconnection is needed.
- The contractor shall be responsible for any damage to utilities that are attributable to his neglect or methods of performing work.

6.5 Roadside Maintenance Activity

There are many communications field devices throughout the Corridor that need to be maintained and each site is a potential construction zone during maintenance. There will be many different situations that need to be addressed both on the roadway and beyond the traveled way.

One of the main concerns with roadside maintenance is traffic control. Common traffic control procedures following the MUTCD must be followed at all times during maintenance activities. This requirement is common to all of the States involved in this study.

6.5.1 Maintenance Activities beyond the Roadway

In this situation traffic will generally not be impacted when the maintenance activities are beyond the roadway (e.g., handholes, vaults, repair of FO cable, etc.). The contractor should ensure that there is plenty of room to load and unload maintenance equipment in a safe manner. The contractor shall ensure when placing cones and warning signs that all local and State standards and procedures are in accordance with the MUTCD and are being followed. The contractor shall also ensure that there is sufficient sight distance available to both the motorist and the equipment operator.

6.5.2 Maintenance Activities on the Shoulder and Partial Lane Closures

In this situation shoulder work does encroach into the travel lane and will generally impact traffic, therefore proper signing should be provided to advise the motorist. The contractor should ensure that there is plenty of room to load and unload the maintenance equipment in a safe manner. The contractor shall ensure when placing cones, warning signs, flashing vehicle lights and flags that all local and State standards and procedures are in accordance with the MUTCD and are being followed. The contractor shall also ensure that there is sufficient sight distance available to both the motorist and the equipment operator. Typical lane or shoulder closure procedures of the State should be followed.

6.6 Equipment Maintenance and Agreements

Given the complexity of today's electronic equipment, investment in the skills and time required to repair a hardware problem by a local maintenance technician is not very practical. It is generally much more cost effective and time efficient to consider maintaining an inventory of spare equipment. Most common practice for repair of failed or non-responsive field equipment is to ensure that all corrective action and preventive maintenance procedures have been taken (i.e. verify configuration data, verify patch cables are connected, verify power connection, etc.), and once all the connections have been verified, replace the failed equipment with a spare and return the failed equipment to the manufacturer for evaluation and/or replacement.

The maintenance of communication equipment typically requires the kinds of support tools that a maintenance department is likely to have on hand, including trucks, cherry pickers, sign boards, back hoes, etc. In addition, more specialized equipment specific to the electrical nature of the work are likely to be needed. This equipment can include:

- Optical Time Domain Reflectometers (OTDR)
- Spectrum Analyzers
- Network Analyzers
- Waveform Generators
- Multi-meters
- Power Meters

For responsive maintenance, these types of devices are used to determine what and where the problems may be. For the communication elements, for example, the OTDR is used to determine where on a communications network a break in the connection may have occurred. Following this determination, the traffic control, back hoes, and fiber fusion equipment is needed. When the fiber is repaired, the cable is stripped down to the bare glass fibers, cleaned, and fusion spliced. The glass fibers are then covered with various resins and bonding materials and placed within splice enclosures to protect the fibers. Following this, the cable is retested and the holes filled in. Repairs of this type should not induce greater than a 0.05 to 0.10 dB loss in the fiber. If so, the repairs should be redone. This process needs to take place either as a contracted activity or as an operation performed by the State's staff. Regardless, substantial equipment, expertise, manpower, and materials are required.

6.6.1 Maintenance Agreements

The question of when State forces should perform system maintenance versus contracting out maintenance activities is dependent on many of the factors, as described below:

- Deploying new systems places additional burden on existing maintenance personnel, who already have responsibilities and may already be overloaded. As a result, the maintenance personnel will be obliged to deal with conflicting priorities.
- When new systems are deployed, it is important to have a clear understanding of maintenance responsibilities.
- Maintaining communications systems requires a high degree of technical proficiency, with specialized skills and expertise. This necessitates training of existing personnel and/or hiring new personnel.
- Performing locates on State-owned communications infrastructure that may or may not be registered on a dig-safe program is going to require significant staff time. Response generally needs to be within two working days. There are new GIS based mapping programs that allow a State's inventory of communication assets to be easily stored for locate purposes.
- Relocating communications infrastructure is expensive and time consuming and will require the use of a specialized contractor. If the State engages in a public-private partnership to have infrastructure installed, the agreements need to address who will be responsible for relocates and what percentage of the costs will be born by the parties. It is recommended that the private partner perform relocates and bill the State.

If the State decides to contract out maintenance, agreements should be established at the time that the construction contract is developed or soon after to ensure the best pricing possible. Competitive bidding is the preferred, and sometimes the only allowable method for developing a contract for services, but will ensure reasonable market rates for the services. Maintenance agreements need to be in-place prior to construction being completed. This will eliminate any delay in repair or responsive maintenance activities required immediately. The maintenance agreement should provide a clear assignment of responsibilities between the State maintenance group and the contractor to identify required training, identify a maintenance approach, and any standardized requirements.

6.7 MAINTENANCE COST

As previously mentioned, an important aspect of developing and deploying communications systems projects is the proper maintenance of the system. Both preventive and responsive maintenance have standard industry-accepted ranges of costs associated with for maintenance. For example, preventive maintenance for a CCTV camera is approximately $1,000 annually, while preventive maintenance for a regeneration building is approximately $1,500 annually.

In order to develop a budget for both preventive and responsive maintenance program, the following should be considered:

- Establish mean time between failures (MTBF) per device
- Estimate staffing required for maintenance
- Estimate annual spare equipment and/or replacement cost
- Estimate maintenance equipment and vehicles necessary for staff
- Determine length of communication infrastructure installed and location of infrastructure relevant to maintenance staff location
- Determine number of conduits or fiber strands installed and how many fiber strands are active
- Establish a preventive maintenance schedule - 3, 6 or 12 months

No attempt is made in this report to estimate the system maintenance costs a particular State will encounter as costs, existing staff capabilities, existing State resources, other maintenance needs, and capabilities of local contractors vary so greatly. However, based on the above considerations, an estimate of the time and staff required should be calculated that can be used to determine the number of staff hours required per device or mile of infrastructure. Based on those hours, the number of staff required in a given year can be calculated and added to the costs of the spare equipment, tools, and vehicles to determine an approximate budget for yearly maintenance.

6.8 CONSTRUCTION COST

This section presents an example cost estimate for installation of 48-SMFO cable along the I-90, I-20, and I-91 Corridors. The fiber optic cable is inside one of two 2" HDPE conduits installed by various methods (i.e. trenching, boring, plowing, etc.). In addition, installation of handholes is an integral part of constructing a fiber optic backbone. Handholes serve as cable pulling locations, junction points to connect branch cables to the trunk cable, and conduit transition points. Regeneration buildings allow for signal regeneration equipment to be housed in the field and act as a demarcation point for connection to other networks. The cost ranges used in the table below were developed based on input from both private companies and public agencies through development of similar projects in the United States. A list of the cost sources is included in the Appendix. Table 6.6 presents estimated construction costs for 48-SMFO cable backbone. Locally established cost estimates for the items below should be used whenever possible.

Table 6-6: Construction Cost for Installation of 48-SMFO Cable Backbone*

Service/Product	Price-Low	Price-High	Unit	Assumptions
Fiber Plowing	$1.25	$1.75	Foot	Assume std installation method will be plowing. Route mileage used is from FHWA Route Log
Directional Boring - Rural	$6.00	$7.00	Foot	Assume rural bores avg. 150' each
Directional Boring - Urban	$8.00	$10.00	Foot	Assume 10% of total bores as urban bores, avg. 200' each
Directional Boring - Rock	$42.50	$271.00	Foot	Assume 5% of total bores as rock bores, avg. 150' each
Conduit (2" HDPE)	$0.75	$0.80	Foot	Per foot cost. Assuming installation of two conduits, one empty so length of conduit is double the route length.
Bridge Attachments	$100.00	$175.00	Foot	Includes 6" steel conduit and labor to attach
Handhole	$575.00	$700.00	Each	48" x 30" x 36", higher cost for load rated
Handhole Installation	$600.00	$800.00	Each	Low-high range for installation cost
SMFO Cable - 48 Count	$0.61	$0.80	Foot	Assuming one fiber cable installed in one conduit
Fiber Installation	$3.25	$5.00	Foot	Includes splices, pulling, splice enclosures, term. panels
Regeneration Building	$280,000.00	$300,000.00	Each	Assumes one building avg. every 50 miles and one on either end of corridor in state. Includes pad, power, A/C, racks, conduit
Design	7.5%	10.0%	Lump Sum (L.S.)	Pre-construction design of route and equipment
Traffic Control	3.0%	7.0%	L.S.	For lane and shoulder closures
Mobilization	3.0%	9.0%	L.S.	Contractor costs to provide

Service/Product	Price-Low	Price-High	Unit	Assumptions
				equipment and services
Construction Engineering	7.5%	10.0%	L.S.	Inspection, oversight, field engineering
Administration	5.0%	7.0%	L.S.	Construction administration services
Contingency	8.0%	20.0%	L.S.	To cover unknowns and peripheral costs
Estimated Cost for Future Value	12.5%	30.0%	L.S.	Future value, 5 to 10 years out, if avg. inflation is 4%/yr

* The cost data included in Table 6-6 is aggregated from several sources, both public agency and private sector, and is based on costs incurred on similar projects throughout the United States. Whenever possible, local cost data should be utilized to provide the best estimate. The sources of the cost data include:

Federal Highway Administration

Minnesota Department of Transportation

Mississippi Department of Transportation

South Carolina Department of Transportation

MassHighway

Gresham Smith & Partners

TransCore

Telvent Farradyne

Parsons Brinckerhoff

Cambridge Systematics

Schatz Underground Cable

LightCore

Using the above communication infrastructure cost ranges, and the quantities of handholes, directional bores, regeneration sites, and bridge attachments as well as the length of fiber and conduit installation developed from the preliminary backbone alignment files developed as part of this study, an estimated range of costs has been developed for each State for construction of a communications backbone. The preliminary backbone alignment files have been developed using Google Earth Pro and are available from the FHWA under separate cover. Note that these are estimates only and should be considered as representative of the hypothetical alignments only.

Table 6-7: Estimated Infrastructure Cost (Louisiana)

Louisiana				
Service/Product	**Units**	**Quantity**	**Cost Low**	**Cost High**
Fiber Plowing	Foot	1,003,200	$1,254,000	$1,755,600
Total Bores		298		
Directional Boring - Rural	Foot	37,950	$227,700	$265,650
Directional Boring - Urban	Foot	6,000	$48,000	$60,000
Directional Boring - Rock	Foot	2,250	$95,625	$609,750
Conduit (2" HDPE)	Foot	2,006,400	$1,504,800	$1,605,120
Bridge Attachments	Foot	6,100	$610,000	$1,067,500
Handhole	Each	211	$121,325	$147,700
Handhole Installation	Each	211	$126,600	$168,800
SMFO Cable - 48 Count	Foot	1,003,200	$611,952	$802,560
Fiber Installation	Foot	1,003,200	$3,260,400	$5,016,000
Regeneration Building	Each	5	$1,400,000	$1,500,000
SUB TOTAL			**$9,260,402**	**$12,998,680**
Design	L.S.	1	$694,530	$1,299,868
Traffic Control	L.S.	1	$277,812	$909,908
Mobilization	L.S.	1	$277,812	$1,169,881
Construction Engineering	L.S.	1	$694,530	$1,299,868
Administration	L.S.	1	$463,020	$909,908
Contingency	L.S.	1	$740,832	$2,599,736
Estimated Cost for Future Value	L.S.	1	$1,157,550	$3,899,604
TOTAL			$13,566,489	$25,087,452

Table 6-8: Estimated Infrastructure Cost (Mississippi)

Mississippi				
Service/Product	**Units**	**Quantity**	**Low**	**High**
Fiber Plowing	Foot	818,400	$1,023,000	$1,432,200
Total Bores		281		
Directional Boring - Rural	Foot	35,850	$215,100	$250,950
Directional Boring - Urban	Foot	5,600	$44,800	$56,000
Directional Boring - Rock	Foot	2,100	$89,250	$569,100
Conduit (2" HDPE)	Foot	1,636,800	$1,227,600	$1,309,440
Bridge Attachments	Foot	1,531	$153,100	$267,925
Handhole	Each	185	$106,375	$129,500
Handhole Installation	Each	185	$111,000	$148,000
SMFO Cable - 48 Count	Foot	818,400	$499,224	$654,720
Fiber Installation	Foot	818,400	$2,659,800	$4,092,000
Regeneration Building	Each	4	$1,120,000	$1,200,000
SUB TOTAL			**$7,249,249**	**$10,109,835**
Design	L.S.	1	$543,694	$1,010,984
Traffic Control	L.S.	1	$217,477	$707,688
Mobilization	L.S.	1	$217,477	$909,885
Construction Engineering	L.S.	1	$543,694	$1,010,984
Administration	L.S.	1	$362,462	$707,688
Contingency	L.S.	1	$579,940	$2,021,967
Estimated Cost for Future Value	L.S.	1	$906,156	$3,032,951
TOTAL			**$10,620,150**	**$19,511,982**

Table 6-9: Estimated Infrastructure Cost (Alabama)

Alabama				
Service/Product	**Units**	**Quantity**	**Low**	**High**
Fiber Plowing	Foot	1,135,200	$1,419,000	$1,986,600
Total Bores		489		
Directional Boring - Rural	Foot	62,400	$374,400	$436,800
Directional Boring - Urban	Foot	9,800	$78,400	$98,000
Directional Boring - Rock	Foot	3,600	$153,000	$975,600
Conduit (2" HDPE)	Foot	2,270,400	$1,702,800	$1,816,320
Bridge Attachments	Foot	6,400	$640,000	$1,120,000
Handhole	Each	236	$135,700	$165,200
Handhole Installation	Each	236	$141,600	$188,800
SMFO Cable - 48 Count	Foot	1,135,200	$692,472	$908,160
Fiber Installation	Foot	1,135,200	$3,689,400	$5,676,000
Regeneration Building	Each	5	$1,400,000	$1,500,000
SUB TOTAL			**$10,426,772**	**$14,871,480**
Design	L.S.	1	$782,008	$1,487,148
Traffic Control	L.S.	1	$312,803	$1,041,004
Mobilization	L.S.	1	$312,803	$1,338,433
Construction Engineering	L.S.	1	$782,008	$1,487,148
Administration	L.S.	1	$521,339	$1,041,004
Contingency	L.S.	1	$834,142	$2,974,296
Estimated Cost for Future Value	L.S.	1	$1,303,347	$4,461,444
TOTAL			**$15,275,221**	**$28,701,956**

Table 6-10: Estimated Infrastructure Cost (South Dakota)

South Dakota				
Service/Product	**Units**	**Quantity**	**Low**	**High**
Fiber Plowing	Foot	2,180,640	$2,725,800	$3,816,120
Total Bores		165		
Directional Boring - Rural	Foot	21,000	$126,000	$147,000
Directional Boring - Urban	Foot	3,400	$27,200	$34,000
Directional Boring - Rock	Foot	1,200	$51,000	$325,200
Conduit (2" HDPE)	Foot	4,361,280	$3,270,960	$3,489,024
Bridge Attachments	Foot	6,100	$610,000	$1,067,500
Handhole	Each	404	$232,300	$282,800
Handhole Installation	Each	404	$242,400	$323,200
SMFO Cable - 48 Count	Foot	2,180,640	$1,330,190	$1,744,512
Fiber Installation	Foot	2,180,640	$7,087,080	$10,903,200
Regeneration Building	Each	9	$2,520,000	$2,700,000
SUB TOTAL			**$18,222,930**	**$24,832,556**
Design	L.S.	1	$1,366,720	$2,483,256
Traffic Control	L.S.	1	$546,688	$1,738,279
Mobilization	L.S.	1	$546,688	$2,234,930
Construction Engineering	L.S.	1	$1,366,720	$2,483,256
Administration	L.S.	1	$911,147	$1,738,279
Contingency	L.S.	1	$1,457,834	$4,966,511
Estimated Cost for Future Value	L.S.	1	$2,277,866	$7,449,767
TOTAL			**$26,696,593**	**$47,926,833**

Table 6-11: Estimated Infrastructure Cost (Minnesota)

Minnesota				
Service/Product	**Units**	**Quantity**	**Low**	**High**
Fiber Plowing	Foot	1,457,280	$1,821,600	$2,550,240
Total Bores		374		
Directional Boring - Rural	Foot	47,700	$286,200	$333,900
Directional Boring - Urban	Foot	7,400	$59,200	$74,000
Directional Boring - Rock	Foot	2,850	$121,125	$772,350
Conduit (2" HDPE)	Foot	2,914,560	$2,185,920	$2,331,648
Bridge Attachments	Foot	1,100	$110,000	$192,500
Handhole	Each	320	$184,000	$224,000
Handhole Installation	Each	320	$192,000	$256,000
SMFO Cable - 48 Count	Foot	1,457,280	$888,941	$1,165,824
Fiber Installation	Foot	1,457,280	$4,736,160	$7,286,400
Regeneration Building	Each	6	$1,680,000	$1,800,000
SUB TOTAL			**$12,265,146**	**$16,986,862**
Design	L.S.	1	$919,886	$1,698,686
Traffic Control	L.S.	1	$367,954	$1,189,080
Mobilization	L.S.	1	$367,954	$1,528,818
Construction Engineering	L.S.	1	$919,886	$1,698,686
Administration	L.S.	1	$613,257	$1,189,080
Contingency	L.S.	1	$981,212	$3,397,372
Estimated Cost for Future Value	L.S.	1	$1,533,143	$5,096,059
TOTAL			**$17,968,439**	**$32,784,644**

Table 6-12: Estimated Infrastructure Cost (Wisconsin)

Wisconsin				
Service/Product	**Units**	**Quantity**	**Low**	**High**
Fiber Plowing	Foot	575,520	$719,400	$1,007,160
Total Bores		257		
Directional Boring - Rural	Foot	32,700	$196,200	$228,900
Directional Boring - Urban	Foot	5,200	$41,600	$52,000
Directional Boring - Rock	Foot	1,950	$82,875	$528,450
Conduit (2” HDPE)	Foot	1,151,040	$863,280	$920,832
Bridge Attachments	Foot	6,800	$680,000	$1,190,000
Handhole	Each	220	$126,500	$154,000
Handhole Installation	Each	220	$132,000	$176,000
SMFO Cable - 48 Count	Foot	575,520	$351,067	$460,416
Fiber Installation	Foot	575,520	$1,870,440	$2,877,600
Regeneration Building	Each	4	$1,120,000	$1,200,000
SUB TOTAL			**$6,183,362**	**$8,795,358**
Design	L.S.	1	$463,752	$879,536
Traffic Control	L.S.	1	$185,501	$615,675
Mobilization	L.S.	1	$185,501	$791,582
Construction Engineering	L.S.	1	$463,752	$879,536
Administration	L.S.	1	$309,168	$615,675
Contingency	L.S.	1	$494,669	$1,759,072
Estimated Cost for Future Value	L.S.	1	$772,920	$2,638,607
TOTAL			**$9,058,626**	**$16,975,041**

7.0 Environmental Considerations

This section presents various regulatory and permitting requirements for construction in each Corridor with respect to environmental disruptions and the recommended and/or mandated treatments that should be considered during construction of HST backbone infrastructure.

Trenching and other excavation required for duct bank installation tends to create vegetation disturbance and generally produces large amounts of sediment in runoff that eventually makes its way to local streams and rivers. Strict mitigation is required to control this runoff. Directional boring produces manageable amounts of runoff, but such runoff is heavily silt laden. State DOTs have policies regarding the treatment of runoff from construction sites for protection of waterways. Generally, sediment fencing and ditch checks are required if the disruption to the surface vegetation is significant. Other environmental issues to consider include the disturbance of wetland areas and the timing of construction activities that may interfere with nesting periods of certain bird species.

Federal Government regulation will apply to all Corridors. These include:

- Section 10/404 and 103 permits from U.S. Army Corps of Engineers may be required.
  - Section 10 of the Rivers and Harbors Act governs placement of structures in navigable waters and covers issues such as location of federal navigation channels, access of adjacent users to their waterfront, and safe navigation.
  - Section 404 of the federal Clean Water Act ensures that any fill placed in the waters of the U.S. (wetlands are also considered waters of the U.S.) will not harm the quality of the water or the plants and animals in it, including impacts to wetlands, eelgrass, shellfish, sediment transport, and water quality.
- If a project will alter more than five acres of land, a National Pollution Discharge Elimination System (NPDES) Construction Storm Water General Permit is required.

State and federal regulatory agencies have made a significant effort in recent years to develop permits that have similar review thresholds and resource definitions. This effort has resulted in a more streamlined review process. For example, federal agencies now usually require minimal review of impacts that have already been conditioned and mitigated by the state permitting process. For projects of little or no environmental impact, the permitting process is minimal. These and other environmental considerations are discussed below.

Obtaining permits and performing environmental assessments can take from several months to several years and a State's regulatory process will need to be taken into consideration when developing project budgets and schedules. If extensive mitigation measures need to be taken during construction, these should be factored into the budget and schedule as well. The schedules noted in Section 5 should be adjusted to reflect unusually long permitting and clearance processes.

7.1 I-20 Corridor

States along the I-20 Corridor have enacted regulations for the protection of the environment during the construction process. In Louisiana, the Department of Environmental Quality (LDEQ) provides the overall environmental monitoring and permitting function within the state. In Mississippi, the Department of Environmental Quality (MDEQ) provides the overall environmental monitoring and permitting function within the state. In Alabama, the Department of Environmental Management (ADEM) provides the overall environmental monitoring function within the state.

7.1.1 Environmental Permitting

States along the I-20 Corridor have similar environmental review and permitting processes. Each state adheres to the Federal review NEPA process which includes the following permits at a minimum:

- Construction Storm Water Discharge Permit
- Section 401 water quality certification
- Federal Coastal Zone Management (CZM) consistency concurrence
- Section 10/404 permit issued by the U.S. Army Corps of Engineers

7.1.2 Corridor Considerations

Erosion control and storm water management measures are required on all construction projects in States along the I-20 Corridor. In Louisiana, if more than more than one-half acre of soil will be disturbed, a Notice of Intent (NOI) detailing how the contractor will manage runoff to prevent water pollution is required. Alabama requires silt fencing and other erosion control measures if more than one acre of soil is disturbed. Directional boring is generally allowed under streams or wetlands, however, a minimum of four feet of clearance is required below the bottom of a stream bed.

Each state along the I-20 Corridor maintains a list of endangered and threatened species. These lists will require careful consideration. PCB contamination has been confirmed in the Calhoun, Alabama area.

States along this Corridor have similar requirements in their Utility Accommodation Policies for aesthetic considerations for scenic strips, overlooks, rest areas, recreation areas, public parks, and historic sites. In general, surface or aerial installations are discouraged or in some areas prohibited. New underground facilities can only be constructed if they will not require extensive removal or alteration of trees.

7.2 I-90 Corridor

States along the I-90 Corridor have well defined regulations concerning the protection of environment during the construction process. In Minnesota, the environmental review process is detailed under the Minnesota Environmental Review Program (MERP), while permitting is handled by the Minnesota Department of Natural Resources (MDNR). In South Dakota, the Department of Environment and Natural Resources (DENR) provides the overall environmental monitoring and permitting function within the state. Within the DENR "One Stop Permitting" is provided by the Division of Environmental Services (DES). In Iowa, the Department of Natural Resources (DNR) provides the overall environmental monitoring function within the state. In both South Dakota and Iowa, the NEPA environmental review process is used.

7.2.1 Environmental Permitting Process

In Minnesota, the installation of privately owned conduits or communication towers on the right of way that would destroy a wetland is prohibited unless a permit is obtained from the DNR. The MERP requires projects to undergo review prior to obtaining approvals and permits. The program assigns a Responsible Governmental Unit (RGU) to conduct the review. The program has no enforcement authority. Rather, the review is a source of information and must be integrated with other permitting and approval processes to protect the environment. When completed, the review gives government units information to determine whether the project is environmentally acceptable and what mitigation measures are needed. Projects are screened for their potential to have significant environmental impacts. The MERP works in conjunction with the Minnesota Pollution Control Agency (MPCA) and the Minnesota Board of Water and Soil Resources to ensure that the permitting process helps to protect Minnesota's environment. The following permits are required by all States along this Corridor:

- Construction Storm Water Discharge Permit
- Section 401 water quality certification
- Federal Coastal Zone Management (CZM) consistency concurrence
- Section 10/404 permit issued by the U.S. Army Corps of Engineers

In addition, local permissions, other state statutory considerations, and federal permits must be taken into consideration.

7.2.2 Corridor Considerations

Erosion control and storm water management measures are required on all construction projects in all States along the I-90 Corridor. The contractor is responsible for providing erosion control and storm water management measures to protect all restored areas upon completion of the project until the replacement vegetation is established.

Each state along the I-90 Corridor maintains a list of endangered and threatened species. In Iowa nine species of freshwater mussels are protected in the Mississippi River and other freshwater rivers. In southern Iowa the Indiana bat is protected. In Minnesota several species of migrating turtles are protected and greater prairie chicken nesting areas are protected. In South Dakota, the Topeka Shiner (fish) is protected in waterways. In Wisconsin, the Butler's Garter Snake and the Karner Blue Butterfly are protected. Also many species of protected migrating birds cannot be disturbed in spring.

The States along the I-90 Corridor have similar requirements in their Utility Accommodation Policies for aesthetic considerations for scenic strips, overlooks, rest areas, recreation areas, public parks, and historic sites. These policies are in place to maintain and enhance the visual qualities along State freeway corridors. Utility installations (above ground) are not allowed adjacent to areas of scenic enhancement and natural beauty. Exceptions may be made if:

- Underground installation is not technically feasible
- Underground installation is unreasonably costly
- The aesthetic quality of the lands being traversed is not impaired
- Extensive removal or alteration of trees or vegetation is not required
- The design and materials of above ground facilities is compatible with the scenic quality of the I-90 Corridor and blends in with the ground contours and scenery

Trees, wildflowers, and other vegetation should be maintained along the I-90 Corridor. This includes the planting of new trees if the project allows it. New underground facilities can only be built if they will not require extensive removal or alteration of trees.

7.3 I-91 CORRIDOR

Both Vermont and Massachusetts have well defined regulations concerning the protection of environment during the construction process. The Massachusetts Department of Environmental Protection (MassDEP) is the primary environmental permit issuing agency in Massachusetts. However, any project that requires a state environmental permit or that will be constructed with state funds must be reviewed under the Massachusetts Environmental Policy Act (MEPA) Unit to ensure compliance with the requirements of the MEPA law. In

Vermont, the Agency of Natural Resources (ANR) and the Department of Environmental Conservation (DEC) are primarily charged with project review, the issuance of environmental permits, and the administration of environmental regulations.

7.3.1 Environmental Permitting Process

In general, the Commonwealth of Massachusetts requires the following construction certifications and environmental permits:

- Secretarial Certificate issued by the Massachusetts Environmental Policy Act (MEPA) Unit
- Order of Conditions issued by the local Conservation Commission
- 401 Water Quality Certification issued by the Massachusetts Department of Environmental Protection (MassDEP)
- Chapter 91 license issued by MassDEP
- Federal consistency concurrence issued by the Massachusetts Office of Coastal Zone Management (CZM)
- Section 10/404 permit issued by the U.S. Army Corps of Engineers

In addition, local permissions, other state statutory considerations, and federal permits must be taken into consideration.

A MEPA review gives state permitting agencies and the public an opportunity to comment on a proposal while it is still in the planning stages, so that environmental concerns and permitting problems can be brought to the applicant's attention and remedied before significant investment is made into a proposal that may require considerable alteration to meet permitting requirements. Anyone proposing a state permitted or state funded project that has potential impacts above certain thresholds is required to file an Environmental Notification Form (ENF) with the MEPA Unit. If significant environmental problems are identified at the ENF stage, or if the project impacts are such that it is automatically required, the MEPA Unit may determine that an Environmental Impact Report (EIR) is necessary. In addition, certain projects, generally those with significant environmental impacts, may be reviewed under the federal National Environmental Policy Act (NEPA). Analysis of alternatives and impacts are conducted through the preparation of an Environmental Impact Statement (EIS). MEPA and the lead federal permitting agency make every effort to combine the reviews into a single process.

Concurrent with or right after the MEPA review, a Notice of Intent (NOI) should be filed with the town or city's Conservation Commission, which administers the Massachusetts Wetlands Protection Act. The Conservation Commission will issue an Order of Conditions, which specifies construction methods that will avoid or minimize and mitigate damage to wetland areas. Either the applicant or people that object to the Orders can appeal local Orders to MassDEP. MassDEP will consider the issues raised by the appeal and issue a Superseding Order of Conditions.

The State of Vermont uses a statewide land use planning tool commonly referred to as Act 250. Act 250 establishes a mechanism for review of certain land use activity at the state level. Specifically, Act 250 complements existing local zoning and subdivision control legislation, and ultimately requires development projects meeting certain criteria to gain state approval, in addition to that normally required at the local level before being carried out. Act 250 establishes a permitting process that requires a developer to demonstrate that a proposed development project meets ten specified criteria, as part of an effort to "ensure economic growth without environmental catastrophe."

While primarily aimed at controlling subdivision development, Act 250 does come into play on this type of project because it is "construction for a governmental purpose which disturbs more than 10 acres, or is part of a larger project that will involve more than 10 acres of land". The applicant will be required to demonstrate compliance with the following Act 250 criteria:

- The project will not result in undue water or air pollution. This criterion deals with water and air pollution generally and such specific matters relating to water pollution as:
  - Headwaters;
  - Waste disposal (including wastewater and storm water);
  - Water Conservation;
  - Floodways;
  - Streams;
  - Shorelines; and
  - Wetlands.
- The project will not cause unreasonable soil erosion or affect the capacity of the land to hold water.
- The project will not cause unreasonably dangerous or congested conditions with respect to highways or other means of transportation.
- The project will not create an unreasonable burden on the municipality in providing governmental services.
- The project will not have an undue adverse effect on aesthetics, scenic beauty, historic sites, or natural areas, and will not imperil necessary wildlife habitat or endangered species in the immediate area.
- The project will conform with the Capability and Development Plan which includes the following considerations:
  - The impact the project will have on the growth of the town or region;

- Primary agricultural soils;
- Productive forest soils;
- Earth resources;
- Extraction of earth resources;
- Energy conservation;
- Private utility services;
- Costs of scattered developments;
- Public utility services;
- Development affecting public investments; and
- Rural growth areas.

7.3.2 Corridor Considerations

In recent years the Wetlands Protection Act has been revised to include the Rivers Protection Act. In most communities, an area 200 feet wide on each side of a river is specially protected to limit impacts to resources such as water supplies, storm damage and flood control, and fisheries. In densely developed areas, the protected river corridor is 25 feet wide. The Act is administered by the local Conservation Commission along with its Wetlands Protection Act responsibilities.

If a construction project requires dredging more than 100 cubic yards of material, or will result in the loss of more than 5,000 square feet of wetlands, alter any salt marsh, or will discharge dredged material or fill to an Outstanding Resource Water (which includes public water supplies, Areas of Critical Environmental Concern (ACECs), and certified vernal pools) a 401 Water Quality Certification for dredging is required from MassDEP. Conditions of the Certification may include requirements to use silt curtains, "environmental buckets" for certain sediment types, dewatering methodologies, and time-of-year restrictions to protect spawning fish.

To place structures in the water and on adjacent land, and to allow dredging to take place, a license must be obtained under the Public Waterfront Act (Chapter 91). The Chapter 91 or Waterways program regulates activities on filled and flowed tidelands of the Commonwealth. To comply, an engineer will have to prepare stamped drawings of the project layout, which will eventually be filed at the Registry of Deeds along with the deed to the property. Because tidelands are "public trust" lands, (i.e., they are owned in common by the citizens of the state), public benefits must be offered in exchange for private use of this land. The license itself will include conditions that ensure that public benefits, such as public walkways, are constructed.

The Massachusetts also requires a Federal Consistency Review by CZM. Any project that requires a federal permit must be consistent with state coastal policies, as administered by CZM. CZM has worked with both the Corps and the U.S. Environmental Protection Agency (EPA) to develop general permits for projects of minimal environmental impact. If a project is eligible for one of these general permits, it does not generally have to undergo a separate CZM federal consistency review.

Each state along the I-91 Corridor maintains a list of endangered or threatened species. In Massachusetts, it is the Division of Fisheries and Wildlife (MassWildlife). In Vermont it is the Vermont Department of Fish and Wildlife. In all, these lists contain over 80 threatened or endangered species. Massachusetts conforms to the Massachusetts Endangered Species Act (MESA).

8.0 Utility Accommodation Policies

This section presents the various utility accommodation policies of each State and determines how these policies either facilitate a shared resource project or discourage the trading of ROW access for telecommunications infrastructure in a Corridor deployment of a communications backbone.

8.1 Utility Accommodation Policies in the I-20 Corridor

Within the I-20 Corridor, there is great variance in the policies of the three States with regard to allowing the use of Interstate highway rights-of-way for the installation of telecommunications infrastructure. In general, the States of Alabama and Mississippi do not currently allow private utilities to construct communications infrastructure within Interstate highway rights-of-way. Louisiana does allow the use of Interstate highway ROW and encourages installations through the use of barter or shared resource projects to gain infrastructure for the state. In order to promote the development of contiguous and Corridor-wide communications infrastructure along I-20, the policies of both Mississippi and Alabama would require modification.

In order for a contractor or private sector partner to complete construction along the Corridor, they would need to adhere to the specific policies of each state. If one standard were adopted Corridor-wide to satisfy all of the States, the following conditions would apply that would meet all state policies:

- Minimum depth for construction is 40”
- The utility must be located within 10’ of the ROW line
- Traffic control must be provided
- Bridge attachments are to be avoided, unless extreme circumstances require attachment
- Bridge attachments need to be encased in protective conduit and grounded
- Erosion control must be used during construction
- The construction area must be restored afterwards
- Access to the infrastructure should be from outside the ROW or from an interchange
- All wetlands permits are the responsibility of the contractor

The following sections provide specific details about each State's utility accommodation policies.

8.1.1 Alabama DOT

Specifically within Alabama, their Utility Accommodation Policy prohibits the installation of utilities within Interstate highway rights-of-way. The following is from Section 2.14.2 of the Alabama DOT Utilities Manual[3]:

New utilities will not be permitted to be installed longitudinally within the control-of-access lines for any interstate or other controlled access highway.

In an effort to look forward, some of the specifics of Alabama's utility regulations will be noted here as if the above policy prohibiting utility installations were to be amended to allow communication infrastructure to be installed. The information presented here is what may be of use to a utility contractor seeking to install communications infrastructure. These regulations are for non-Interstate highway ROW, but would possibly be applicable to Interstate highway ROW.

Of note is that utilities are required to be outside of the clear zone. That is 30 feet for Interstate highway ROW in Alabama. Installation depth for conduit is 40" and it is to be placed as near to the ROW line as practicable. All traffic control required for installation is the responsibility of the contractor. Alabama DOT prohibits attachment to bridge structures except in extreme cases where no other alternative is available. Attachment requests are reviewed rigorously by the Alabama DOT to make sure there is no alternative. Where communications facilities are allowed on structures, they must be insulated, grounded, and carried in a protective conduit. Disturbed areas may require the use of temporary erosion control and restoration after construction.

8.1.2 Mississippi DOT

The Mississippi DOT by policy prohibits the installation of utilities on Interstate highway ROW, except in special cases as defined below. The following is taken from the Mississippi DOT Rule 941-7501-06001, Accommodation of Utilities on Freeway Rights of Way[4]:

Installation of new utilities will not be permitted longitudinally within the control of access lines of any freeway, except that in special cases such installations may be permitted under strictly controlled conditions. The location of such installations, if permitted, will generally be restricted to the outer ten (10) feet of the right of way. Installation of utilities will not be allowed longitudinally within the median area.

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[3] Http://www.dot.state.al.us/NR/rdonlyres/CB214C69-D6BF-48EC-A28B-C61E7119B998/0/ALDOT_Design_utman.pdf accessed on 4/11/2008.

[4] Http://www.gomdot.com/apa_data/apa_rules/PDF_Record/maintenance/941-7501-06001/941-7501-06001.pdf accessed on 4/11/2008.

Some special cases, referenced above, that may warrant accommodation on the right of way are (1) significantly undesirable social, economic, or environmental effects on adjacent property, (2) prohibitively excessive right of way costs on areas adjacent to the freeway, (3) unique nature of adjacent property (irreplaceable historical, parkland, recreational or other function), (4) temporary, short-term emergency needs, or other circumstances that the Mississippi Transportation Commission may specifically authorize.

Where such longitudinal installations are requested, the utility owner must in each case show that:

A. The accommodation will not adversely affect the safety, design, construction, operation, maintenance or stability of the freeway;

B. The accommodation will not be constructed and/or serviced by direct access from the through traffic roadways or connecting ramps;

C. The accommodation will not interfere with or impair the present use or future expansion of the freeway; and

D. Any alternative location would be contrary to the public interest. This determination would include an environmental evaluation of the direct and indirect environmental and economic effects covering on and off right of way alternates.

Although the policy notes that installations are allowed under special circumstances, it has been reported by representatives of Mississippi DOT that the practice of allowing such installations is almost never allowed. The DOT does install its own infrastructure for communications on Interstate highway ROW.

If this policy were to be reversed at some point in the future, there are several requirements of Mississippi's utility construction rules of which a contractor should be aware. These requirements include a minimum 36" depth for underground installations; the utility should be located within the outer 10' of ROW and as close as possible to the ROW line; no median or shoulder installations are allowed; and access for maintenance should be via a frontage road or interchange. Wetlands permits must be obtained when working in or around wetland areas and restoration of the area must be performed after construction. Traffic control is to be provided by the contractor. No bridge attachments are allowed unless the owner can show that there are special circumstances that make the attachment the best alternative.

8.1.3 Louisiana DOTD

The Louisiana DOTD has by far the most accommodating utility policy of the three Corridor States along I-20. They have fully embraced the shared resource concept and accept applications for use of the Interstate highway ROW for most utility types, including wireless towers. Neither Alabama nor Mississippi has wireless tower siting policies. Louisiana does have specific regulations regarding the use of their ROW and they do charge fees or accept barter arrangements. Their Utility Accommodation Policy is contained within the Louisiana

Administrative Code, Title 70 (Transportation), Section II (Utilities), dated December 2005.

Specific to the policy of Louisiana is the provision to charge an access fee. There is a fee of $5,000 per mile for Interstate or access-controlled highway ROW, or the utility can offer shared resource barter in exchange for the fee. There is also a fee associated with bridge attachments. Although bridge attachments are to be avoided by policy, they are allowed where no alternative exists and the attachment will not damage the structure or create a hazard. There is both a lump sum fee and an annual rent associated with bridge attachments that vary depending on the structure length and the weight of what is to be attached.

Other requirements of the Louisiana DOTD include requirements for 36" burial depth of conduit, placement of conduit in the outside 10' of ROW or as close as possible to the ROW limits; no median installations; and bridge attachments need to be grounded and encased in protective conduit. Traffic control is the responsibility of the contractor, and access to the infrastructure must be from outside the ROW, an interchange, or lastly, from the roadway. The ROW must be restored to its previous condition upon completion of construction.

Louisiana DOTD allows wireless towers and wireless equipment to be located on State ROW or property in exchange for a fee, co-location, and/or bartered services. Primary locations where towers or fixtures are allowed include rest areas, weigh stations, power poles or light standards, existing state-owned towers, crossing structures, and at interchanges. Where space permits, towers can be up to 350' lattice type towers or up to 195' monopole towers. Providers are also allowed to strengthen existing towers in order to place equipment, or to replace existing towers completely in order to make them more suitable to their needs. The fees charged range from $1,500 to $3,500 per year, but these can be waived if the provider offers shared resources in exchange. Overall, the Louisiana DOTD wireless policy is fairly liberal and allows many concepts and ideas to be forwarded for review.

8.2 Utility Accommodation Policies in the I-90 Corridor

Of the three Corridors studied, the I-90 Corridor States have the most consistent and progressive Utility Accommodation Policies with regard to shared resource projects and bartering of ROW access in exchange for infrastructure. The I-90 Corridor States provide the best opportunity for the creation of a Corridor-wide telecommunications backbone that can be shared between multiple States as the accommodation policies of the three States along I-90 are similar. South Dakota, Minnesota, and Wisconsin all allow access to Interstate highway ROW for communications infrastructure installation in exchange for fees, shared resource compensation, or in the case of South Dakota, for free.

For the most part, the ROW is free of other utilities at this time and presents a very clean installation opportunity. The most restrictive construction specifications of the States would include:

- Burying the conduit at a depth of 48”
- Using protected and grounded conduit for bridge crossings
- Ensuring that endangered plants and animals are taken into consideration before beginning construction
- Providing traffic control
- Initiating erosion control measure
- Restoring the ROW to pre-construction condition

Minnesota and Wisconsin vary on the fees charged, which will need to be resolved. Probably the largest impediment to a Corridor-wide contract is the requirement in Minnesota that the contractor selection must be done in a competitive manner and that additional conduit should be installed for future users or installed for a competitor at fair market value. Although this seems onerous, it will likely not be much of an issue as there have been few companies interested to date in having communications infrastructure installed along I-90. The Minnesota Department of Administration will be heavily involved in this process.

Specifics of each State’s utility accommodation polices are presented below.

8.2.1 South Dakota

South Dakota’s Administrative Rule, Article 70:04:05.01:01, Utility Accommodations on Interstate Rights-of-Way[5] states the following:

> ***Construction and maintenance of utility facilities within interstate right-of-way.*** *All longitudinal installations within the interstate right-of-way are prohibited except for longitudinal installations of fiber-optic telecommunications cable if the facility is located as near the right-of-way line as practicable. However, the department may approve longitudinal utility attachments to structures over major bodies of water where other utility crossings are impractical, result in excessive costs, or are otherwise unique and unusual. The department may also approve longitudinal installations if the permittee is a governmental entity, the utility facility is a gravity flow sewer line or a water line, and other locations would result in excessive costs or are impractical as determined by the region engineer.*

[5] Http://legis.state.sd.us/rules/DisplayRule.aspx?Rule=70:04:05.01:01 accessed on 4/11/2008.

This rule allows for any provider to apply for a permit and, if approved, install communications infrastructure within South Dakota's Interstate highway ROW without compensation to the state. This is generally the case for typical non-access controlled ROW, but rarely the case for access-controlled ROW.

With the exception of the open policy for access to Interstate highway ROW, South Dakota's utility accommodation rules are very similar to most States. The utility should be installed as near to the ROW line as possible; installation should be done without extensive removal of trees or natural features; the area needs to be restored after construction; access is from a side road or interchange; and traffic control needs to be provided. The depth of installation is 48" in rural areas and 36" in other areas. Bridge attachments are allowed, but only if an alternate is difficult or unreasonably costly. Bridge attachments need to be grounded and encased in protective conduit.

8.2.2 Minnesota

The Minnesota DOT has developed an extensive policy regarding the accommodation of wireline communications infrastructure on Interstate highway ROW. Their policy does allow for installation on Interstate highway ROW, but it must be done in an open and competitive manner and the contractor must allow competitors to install their infrastructure at the same time if they so desire. In general, utility installations are allowed on Interstate highway ROW for highway purposes such as lighting or ITS by the DOT or by a private entity if there is a need shown by the DOT for infrastructure and it is a shared resource arrangement where the State is compensated. The compensation must be fair market value for the ROW and access, and paid monetarily or as a shared resource in the form of infrastructure or services.

Minnesota DOT's policy statement[6], Highways No. 6.6, allowing installations on Interstate highway ROW, is dated November 20, 2006 and reads as follows:

> ***Minnesota and federal laws permit the accommodation of utility facilities on highway right-of-way, including all federal-aid highways.*** *Minnesota law also authorizes Mn/DOT to develop reasonable rules pertaining to placing and maintaining such facilities. Mn/DOT's policy is that wireline facilities may be accommodated within freeway right of way when such use and occupancy does not adversely affect traffic safety, roadway operations, roadside vegetation function or visual quality and does not conflict with federal or state laws, rules, regulations or this policy.*
>
> *This policy applies to longitudinal installation of wireline facilities used for the transmission of voice, data, and/or video communications.*

[6] Http://www.dot.state.mn.us/utility/policy/index.html accessed on 4/11/2008.

The utility construction policies of Mn/DOT are similar to those of other States. Bridge attachments are allowed only if a separate structure or path is infeasible. The attachment cannot adversely affect the structure in terms of maintenance, structural capacity, aesthetics, or safety. The conduit used must be steel. Access to infrastructure along the ROW must be made from a side road, frontage road or adjacent property and traffic control is to be provided by the contractor. The installation depth shall be 36" in open ROW and installed outside the clear zone as close to the ROW edge as possible.

For wireless tower installations, Minnesota has a State statute, 174.70, which allows the DOT to enter into a contract for the development of wireless tower locations with a private provider in exchange for compensation. The statute provides for great latitude in negotiating a shared resource agreement and what the state may receive in compensation.

8.2.3 Wisconsin

The Wisconsin DOT also allows for the installation of communications infrastructure on Interstate highway ROW. The specific policy allowing this is Policy 96.30 from the State Highway Maintenance Manual[7]. It states as follows:

> *Longitudinal installations on freeway right-of-way shall be limited to communications facilities only. The installation of cellular antennas and its associated equipment shall be defined as a longitudinal occupation. Other types of utility facilities may be allowed to longitudinally occupy freeway right-of-way, but only under certain circumstances. See policy 96.31(C) for details.*
>
> *On highways which are not presently constructed as freeways but the right-of-way has been acquired for the construction of such a facility, the requirements for utility installations shall be the same as for freeways.*
>
> *Utility facilities may be limited to underground installations, except as provided for crossings or special cases.*
>
> *Longitudinal utility installations on freeways may be charged a fee for the right to occupy. The Department may also opt for access to communications or other types of services, or a combination of fees and services. If this is warranted, agreements shall be negotiated with each company on a case by case basis, and are aimed at providing mutual benefits to all parties involved.*

Wisconsin does charge a fee for access to Interstate or access controlled highways by communication companies. These fees vary between $5,000 and $20,000 per mile depending on the length of the installation and the AADT of the route being considered. They are applicable to a 20-year period. Although it is not explicitly stated in the Utility Accommodation Policy, Wisconsin does allow for the installation of wireless communication facilities on state ROW. To date, only two

[7] Http://www.dot.wisconsin.gov/business/rules/property-96.htm accessed on 4/11/2008.

such agreements have been negotiated and it is done on an as-needed basis. A negotiated fee is charged for wireless infrastructure access as well.

Wisconsin's utility construction policies are similar to those of other States. Access to the ROW should be from frontage roads, side roads, or trails adjacent to the ROW. Access is allowed from the roadway, but only by special permit. Utilities need to be placed as near as practicable to the ROW line and no median installations are allowed. Environmentally, permits are required to trim or otherwise damage any trees or shrubs on the ROW, and the contractor is responsible for being aware of and avoiding endangered species. Erosion control measures are required and the contractor must provide traffic control as per MUTCD rules. The depth of the utility line is Wisconsin is shallower than other States, only 24".

Bridge attachments are to be avoided, but they are allowed as long as they do not affect the structural design, appearance, maintenance, or safe operations of the bridge.

8.3 Utility Accommodation Policies in the I-91 Corridor

The I-91 Corridor is the most advanced of the Corridors studied in that the States along I-91, Vermont and Massachusetts, have progressed farther then the other Corridor States in securing a contract to have communications infrastructure installed. MassHighway has a solicitation whereby they are installing the infrastructure themselves, but then offering up use of that infrastructure in exchange for fees. Vermont is in the design stage of their shared resource project and expecting to solicit for a partner within the next year.

Both Vermont and Massachusetts allow and encourage shared resource arrangements along I-91 as evidenced by their impending projects. For this study, copies of utility accommodation polices were requested. In this instance, only information on the MassHighway Utility Accommodation Policy was supplied. It was noted by MassHighway that the policy from 1988 is being updated. Vermont also noted that their policy is being updated, but it was not available at the time this report was published nor was a copy of their current policy.

For the purposes of this report, only specifics of the Utility Accommodation Policy of Massachusetts will be presented. This policy is currently under revision and will likely change in the near future. However, for the purposes of this report, the 1992 version of the Utility Accommodation Policy is used.

8.3.1 Massachusetts

The latest Utility Accommodation Policy for Massachusetts is dated 1988. In that policy, it does allow for the accommodation of multiple types of utilities, including communications, on freeway ROW. In 1992, Massachusetts clarified the 1988 UAP regarding communication utilities on Interstate highway ROW in response to the FHWA changing their policy on the accommodation of utilities on Interstate highways and to gain approval from the FHWA for the State's UAP. The 1992 amendment states as follows with regard to longitudinal accommodation of utilities of freeways:

> *This policy applies to all applications for permits for longitudinal accommodation of utilities on freeways. The policy addresses the recent change in Federal Highway Administration regulations codified at 23 CFR Section 645.201, et seq. (subpart B) regarding accommodation of utilities on rights-of-way of freeways. This policy also complies with federal standards (23 U.S.C. Section 109) and agreements relating to access to rights-of-way (23 U.S.C. Section 111)*
>
> *The Massachusetts Highway Department's primary concern is to maintain safe standards on our highways. Our goal is to strike a balance between keeping work on Freeways to a minimum and assuring that the accommodations of longitudinal utilities are safe, while at the same time accommodating utilities on Freeways where it may be in the public interest. Accordingly, permits for the installation of utilities longitudinally will be issued on a case by case basis for underground utilities, and may be issued for above-ground utilities only under unusual circumstances as provided in Part 5.6.*
>
> *In addition, the provisions of the Massachusetts Highway Department's "Utility Accommodation Policy – 1988", as it has been or may be amended, is applicable to the accommodation of the longitudinal utilities on Freeways.*

In general, MassHighway's Utility Accommodation Policy is similar to that of other States in that it requires installations to be as near the ROW line as possible, contractor provided traffic control, and access to the ROW restricted to be only from frontage roads, side roads, or trails. Mainline access is allowed in emergency or otherwise unusual circumstances where no other access is available. Traffic control is to be provided by the contractor and erosion control measures must be used. Bridge attachments should be avoided, but are allowed if it does not impair the structure in any way and it is deemed in the public's best interest.

There are, however, some unique characteristics of the MassHighway UAP of which a contractor should be aware. Of note is that median installations are allowed on freeways if the median is large enough. No specifics are provided, so this approval would be on a case-by-case basis. The depth of installation ranges from 18" to 33" depending on whether the communications cable is for a toll operation (33") or not (18"). Visual aesthetics are emphasized heavily in the MassHighway UAP. Trees are not allowed to be removed, especially in rest areas, scenic overlooks and other recreation areas. If they are removed, a replacement tree must be planted by the contractor. All disturbed areas need to have a revegetation plan developed so that the construction area is restored to its natural state. Lastly, in the 1992 amendment, MassHighway required that the contractor submitting the application demonstrate that approval is in the public's best interest. This is unique amongst accommodation policies studied as part of this project.

In 2006, MassHighway amended their UAP to provide for the accommodation of wireless utilities on state-owned property where there is a desire to install tower facilities or co-locate on existing structures. The MassHighway Wireless Telecommunications Asset Management Policy provides a mechanism for private companies to request the use of various property owned by MassHighway for the purposes of installing wireless towers or equipment. In exchange, MassHighway receives compensation in the form of fees, equipment, or services. Once sites have been identified, providers must bid on the sites through an open and competitive process.

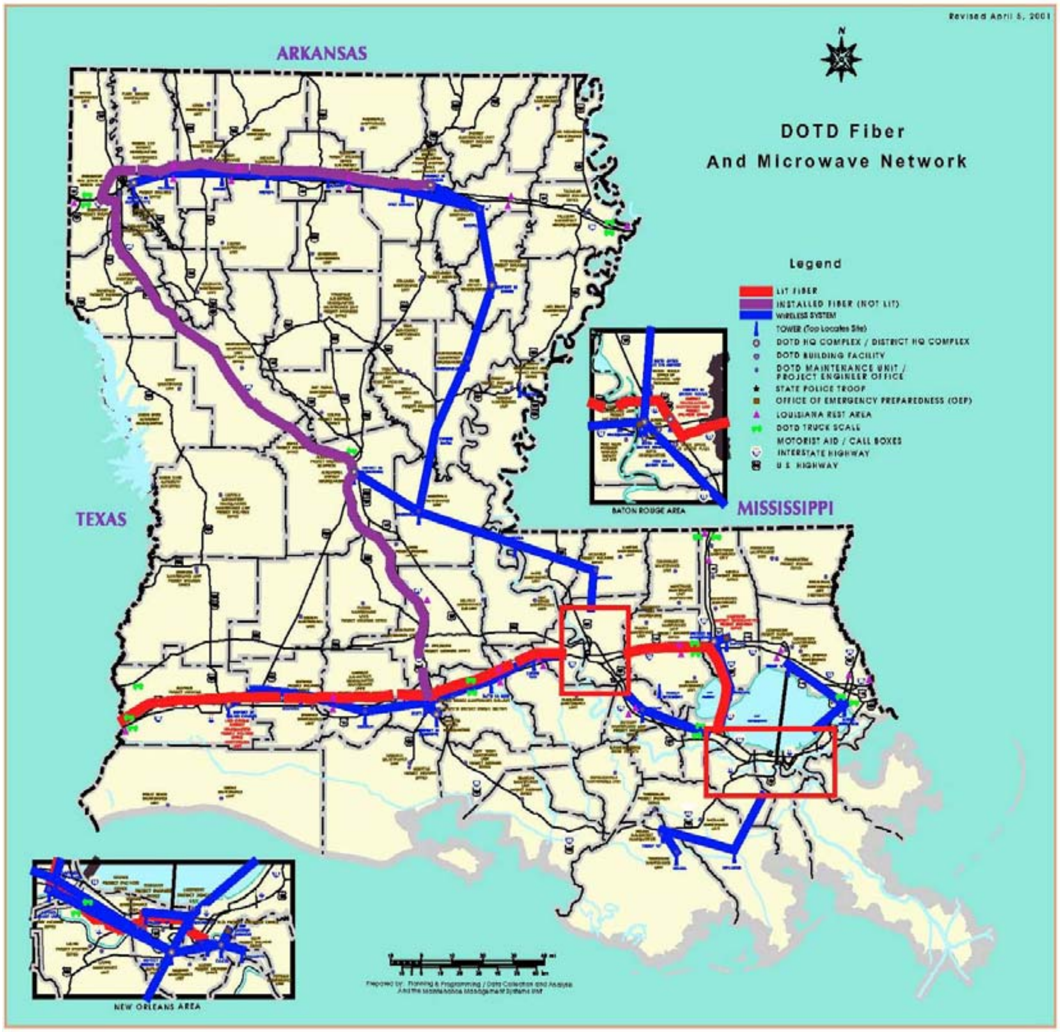
Appendix

Appendix A – State Telecommunication Information

Figure A-1: Fiber Optic Cable Installations in Louisiana (2001)

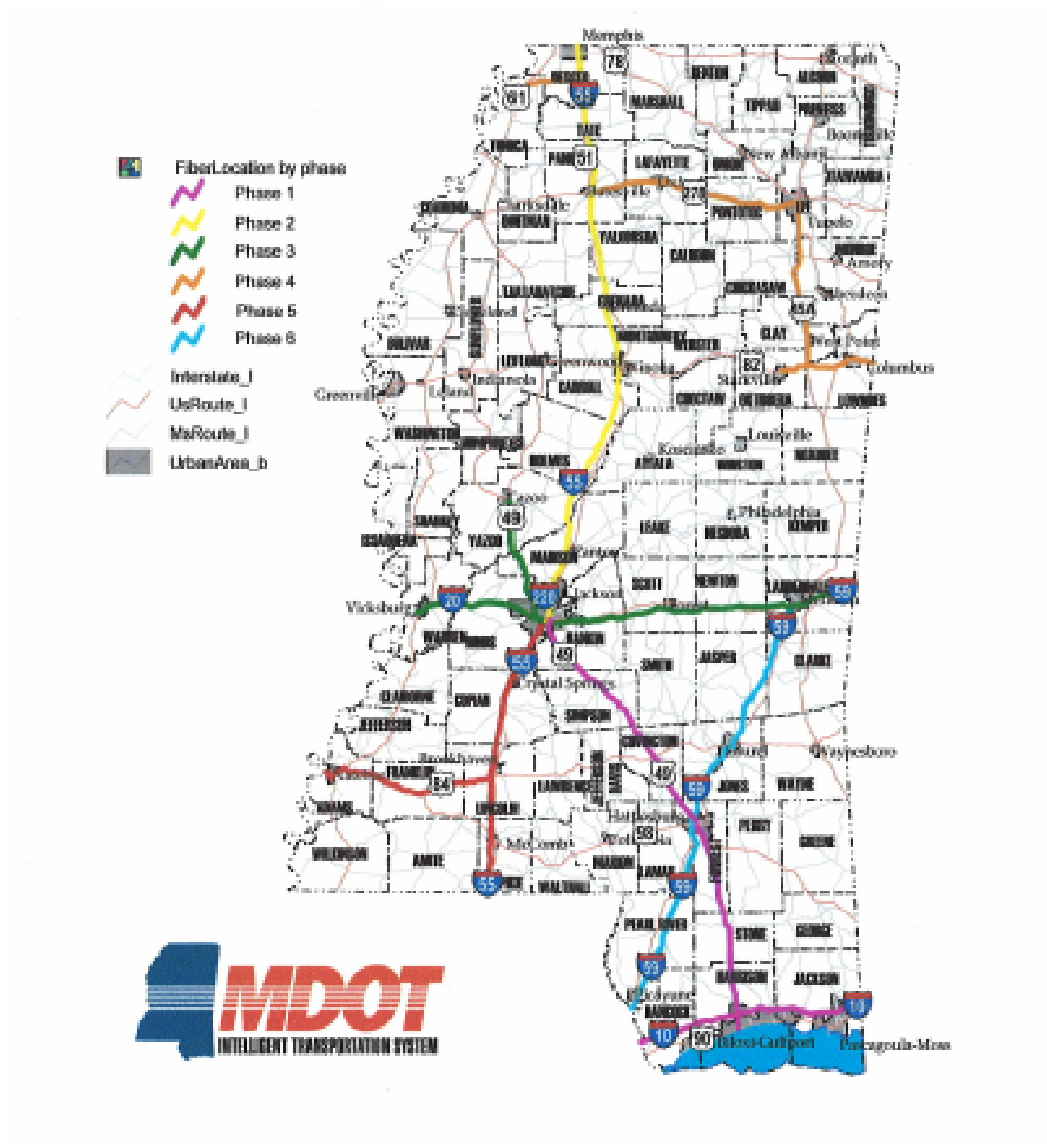
Source: LADOTD, http://www.dotd.louisiana.gov/highways/maintenance/fiberoptic/all_fiber_in_la.pdf. (Accessed on 4/11/2008.)

Figure A-2: Louisiana DOTD Fiber and Microwave Tower Locations (2001)



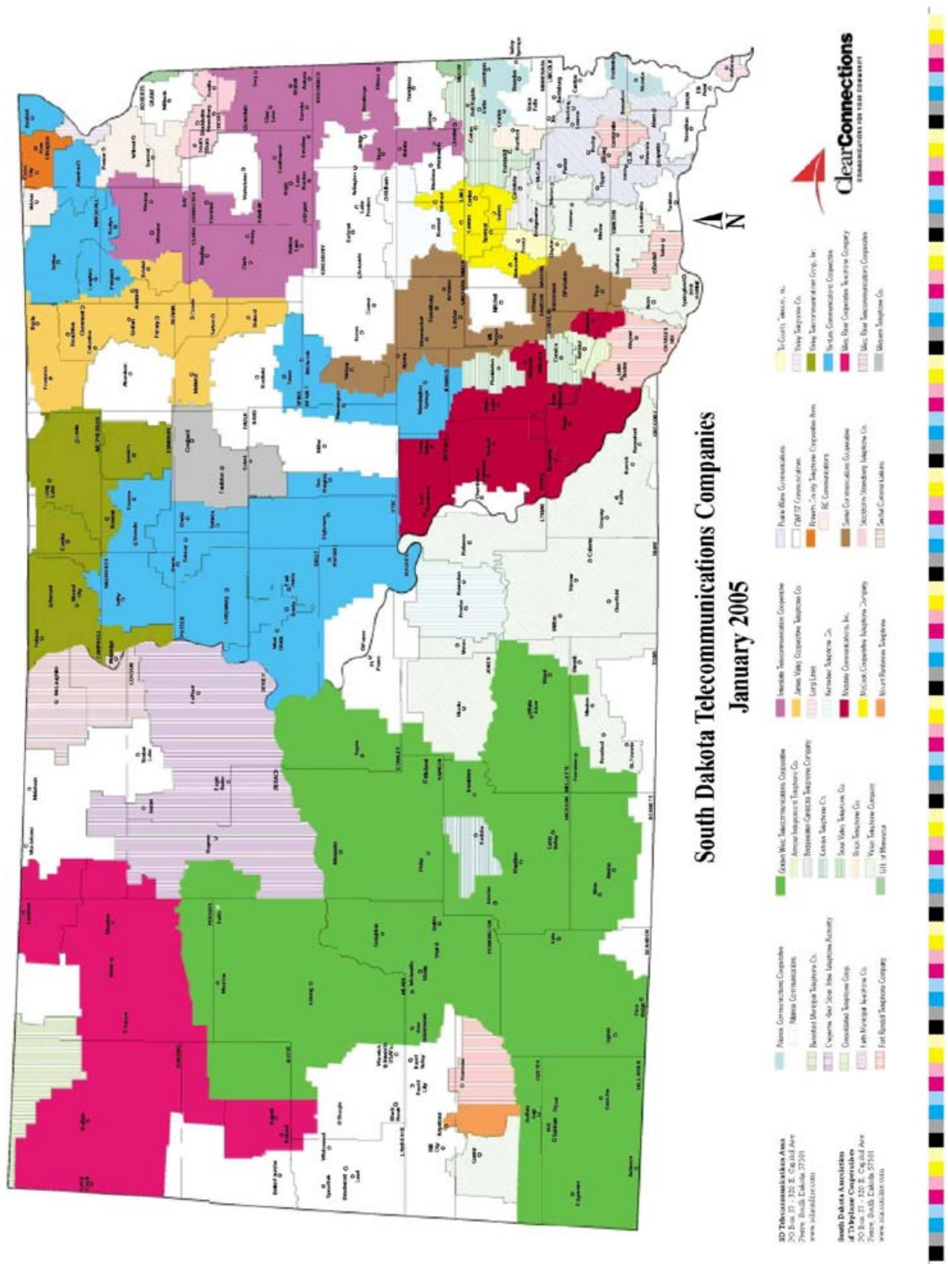
Source: LADOTD, http://www.dotd.louisiana.gov/highways/maintenance/fiberoptic/dotd_fiber_basemap.pdf. (Accessed on 4/11/2008.)

Figure A-3: Mississippi DOT Statewide Fiber Optic Infrastructure Plan



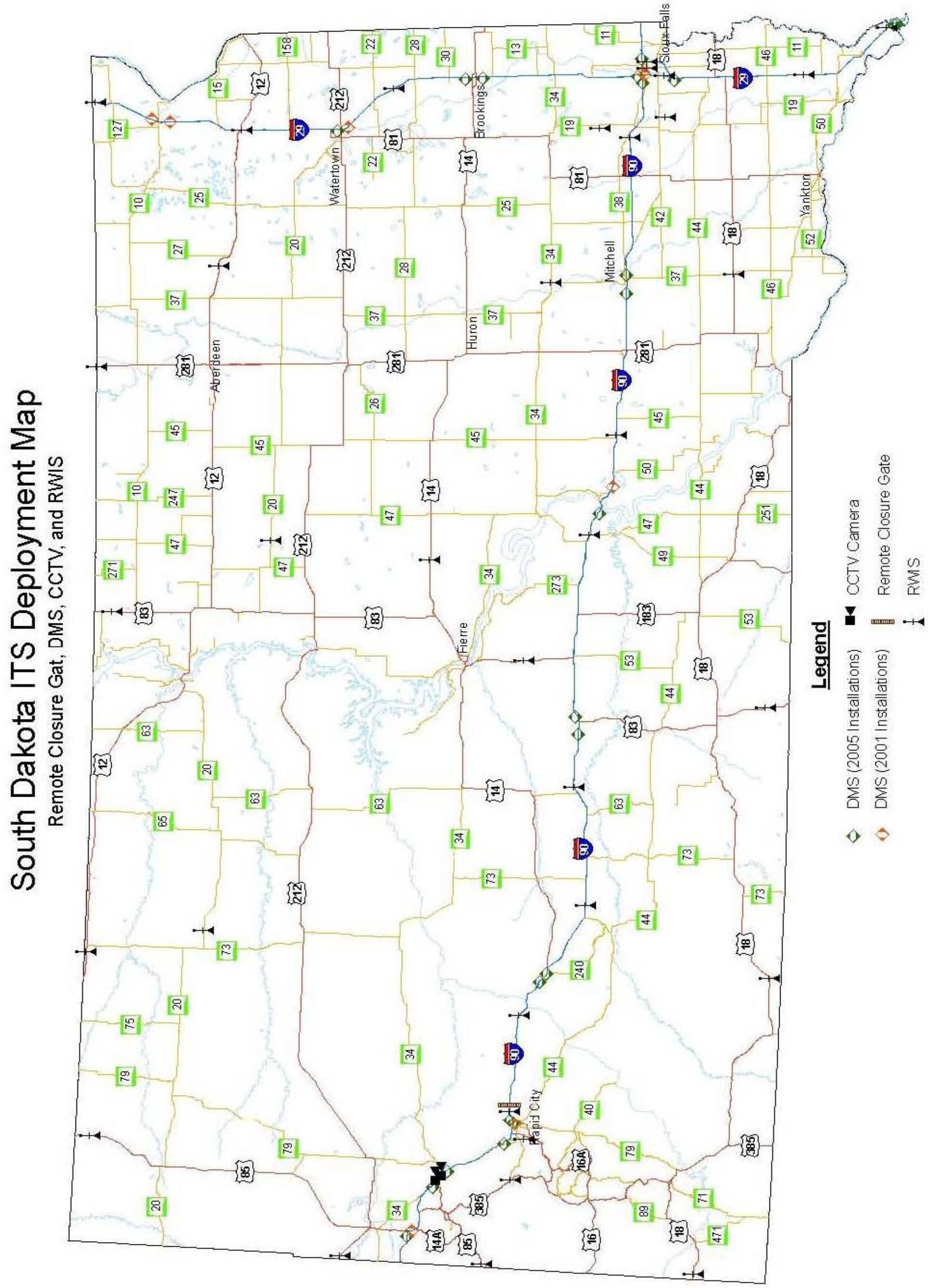
Source: Mississippi Department of Transportation.

Figure A-4: South Dakota Telecommunications Providers (January 2005)



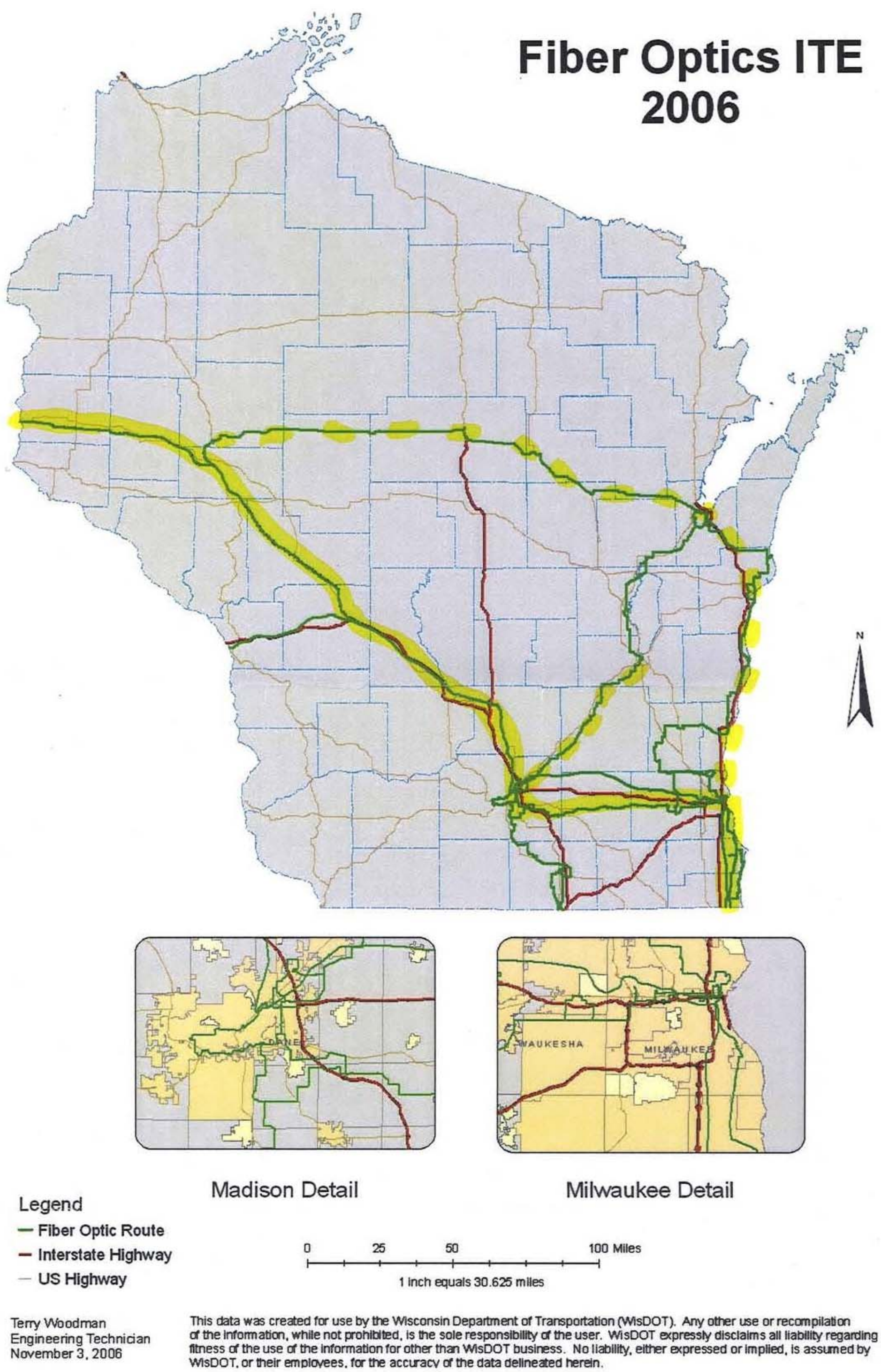
Source: South Dakota Telecommunications Association.

Figure A-5: South Dakota ITS Deployments (2007)



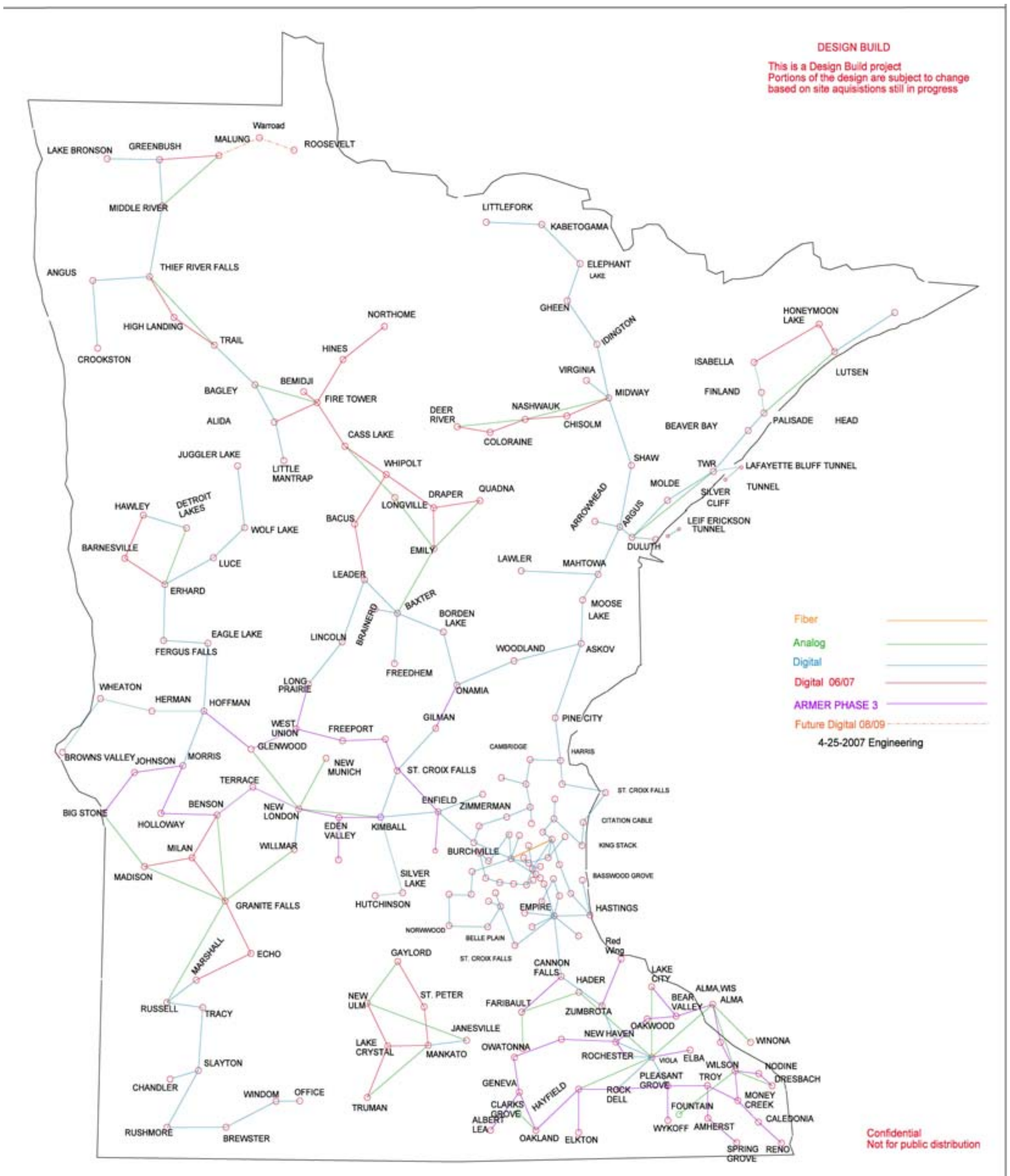
Source: South Dakota Dept. of Transportation.

Figure A-6: Wisconsin's Fiber Optic Cable Installations (2006)



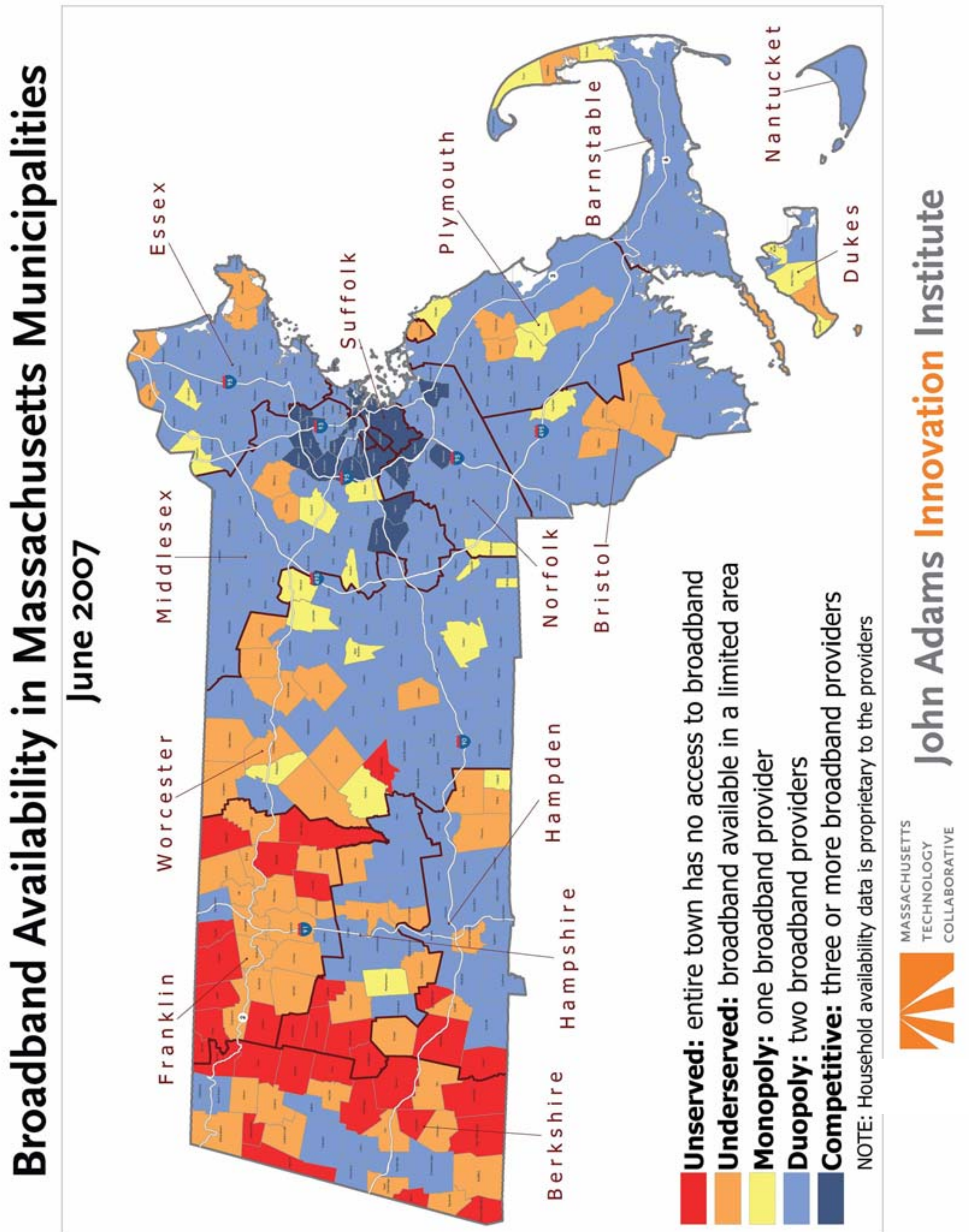
Source: Wisconsin Department of Transportation.

Figure A-7: Minnesota State Microwave System (2007)



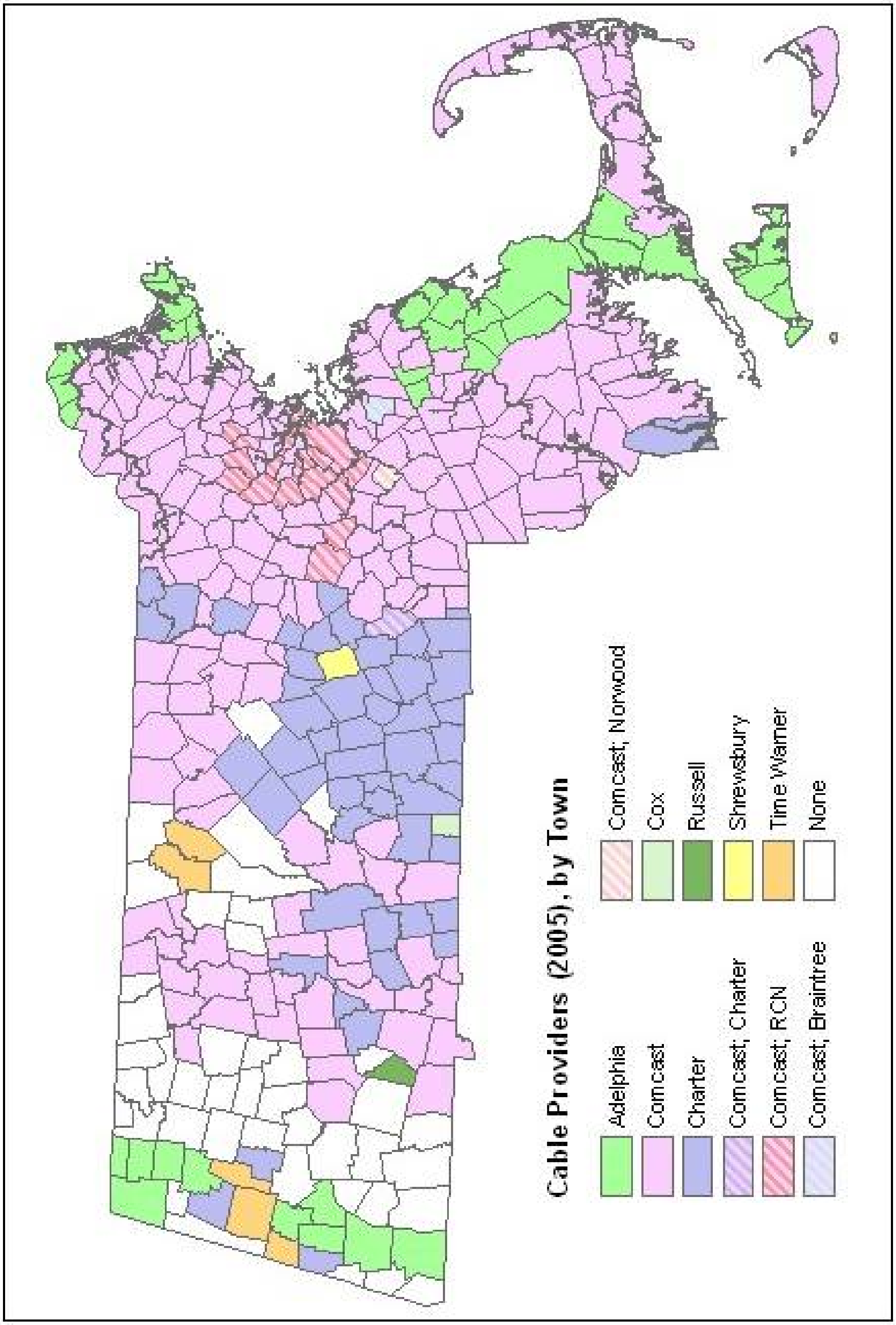
Source: Minnesota Department of Transportation.

Figure A-8: Broadband Availability in Massachusetts Map (June 2007)



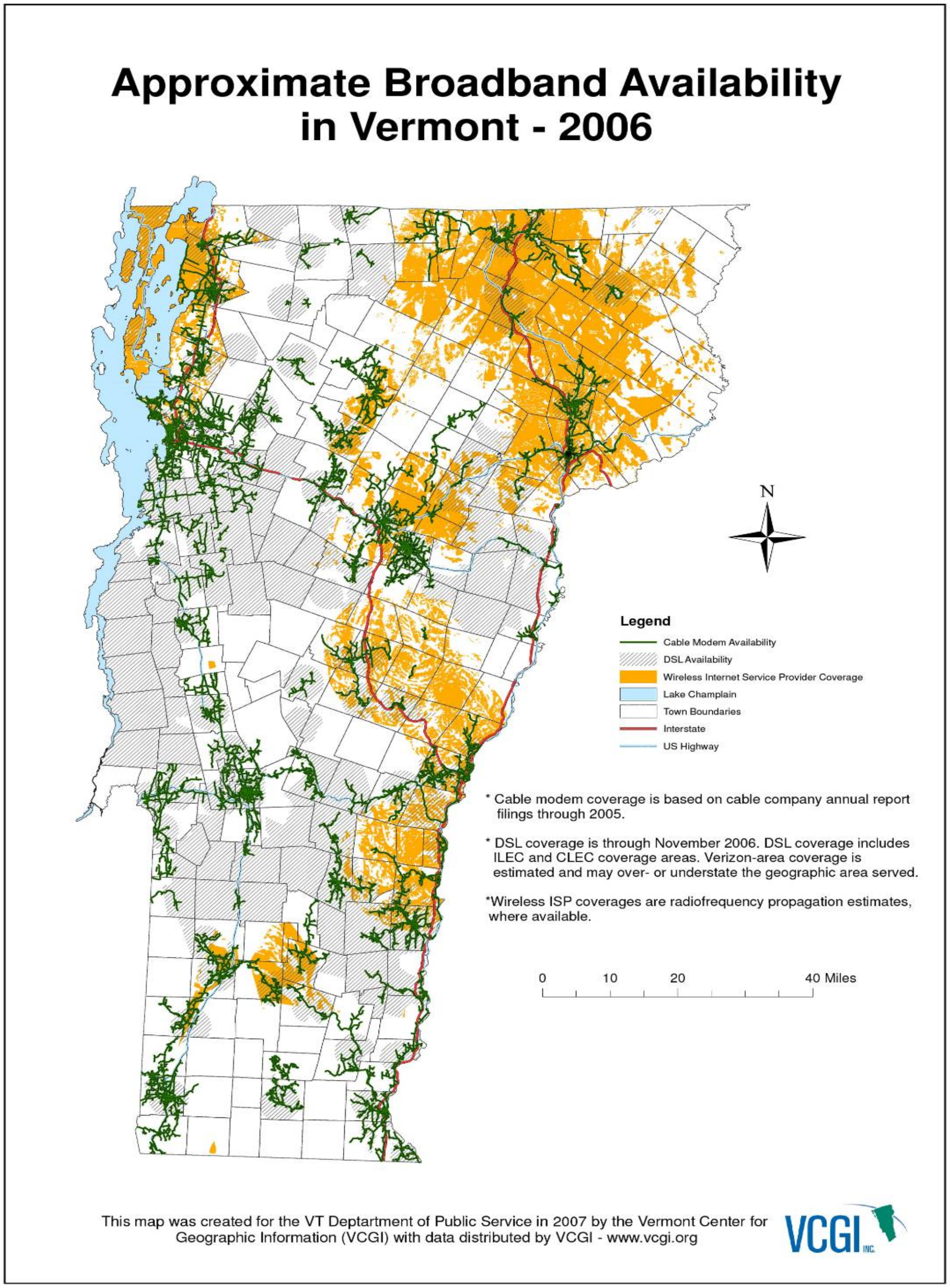
Source: John Adams Innovation Institute.

Figure A-9: Massachusetts Cable Providers Map (2005)



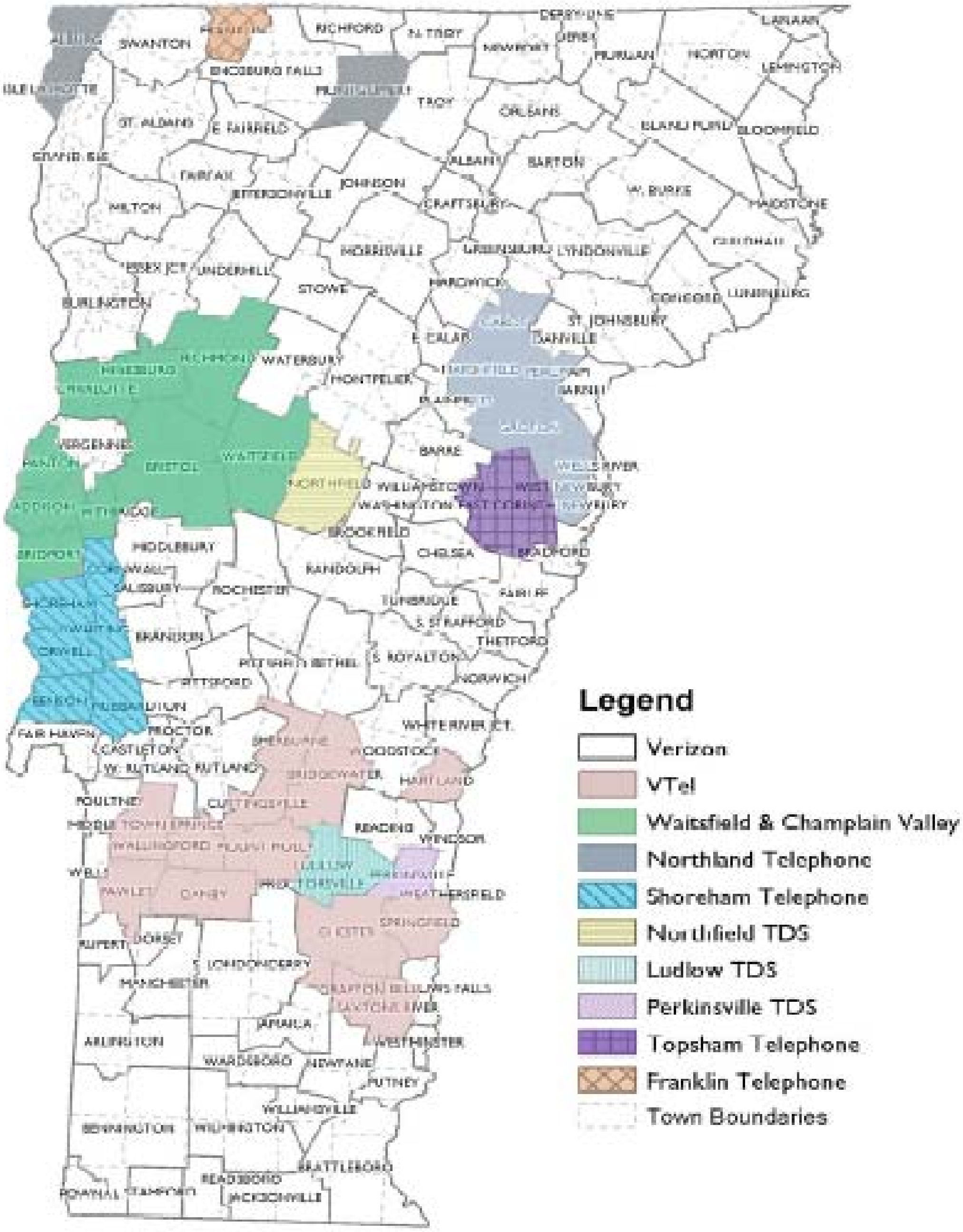
Source: MassGIS.

Figure A-10: Broadband Availability in Vermont (2006)



Source: Vermont Department of Public Service, http://www.publicservice.vermont.gov/cable/broadband_availability_map.html.pdf. (Accessed on 4/11/2008.)

Figure A-11: Vermont Telecommunications Providers (c.2003)



Source: Vermont Department of Public Service, http://www.publicservice.vermont.gov/images/telcoservicemap.gif. (Accessed on 4/11/2008.)

B. Using the SVG Viewer

B.1 Overview

An Internet mapping application was developed to support the corridor profiling aspect of the Rural Interstate Corridor Communications Study. The original application developed in 2007 was later enhanced to add several capabilities to maximize the use and visualization of collected data.

The Mapping System was developed using Scalable Vector Graphics (SVG) technology, an innovative technology based entirely on open standards and open source components, for producing two-dimensional graphics and graphical applications. The application includes a generic map application with one map view for each of the three corridors along with several map manipulation, navigation and visualization functions. It uses data in a standard GIS format such as ESRI shapefiles as its input, which will then be converted into an SVG format using customized scripts in ESRI GIS software.

B.2 Accessing the Application

The application is easily accessible through a standard web browser and preferably using Internet Explorer. The users can access the application using the following web URL – http://camims01.camsys.com/svg/FHWARR_2/mainpage/view.htm

Figure B.1 Components on the Main Page

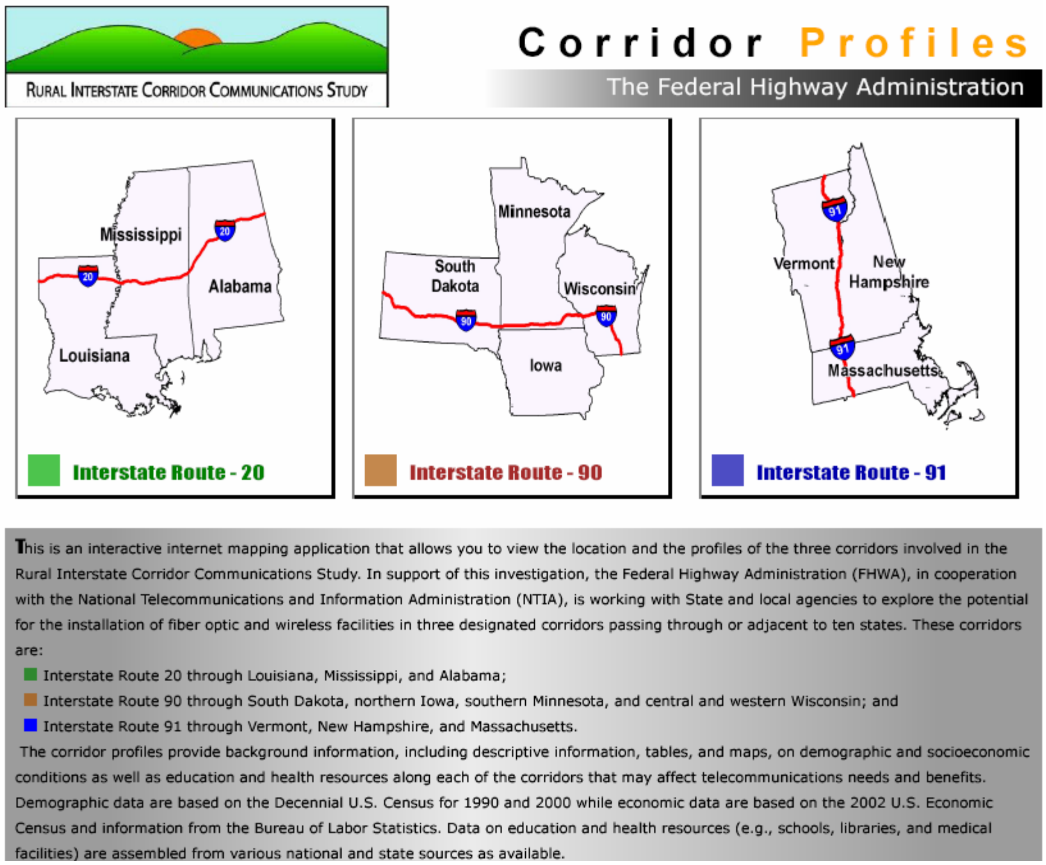


Figure A.1 shows the layout of the main page in the application. From this page, the user can click on any of the maps or their corresponding texts to navigate to the map views of individual corridors. The main page also provides a brief description regarding the study. By clicking the “Rural Interstate Corridor Communication Study” logo, the user can navigate to the overall project web site.

Figure B.2 Sample Corridor Map View (I-20)

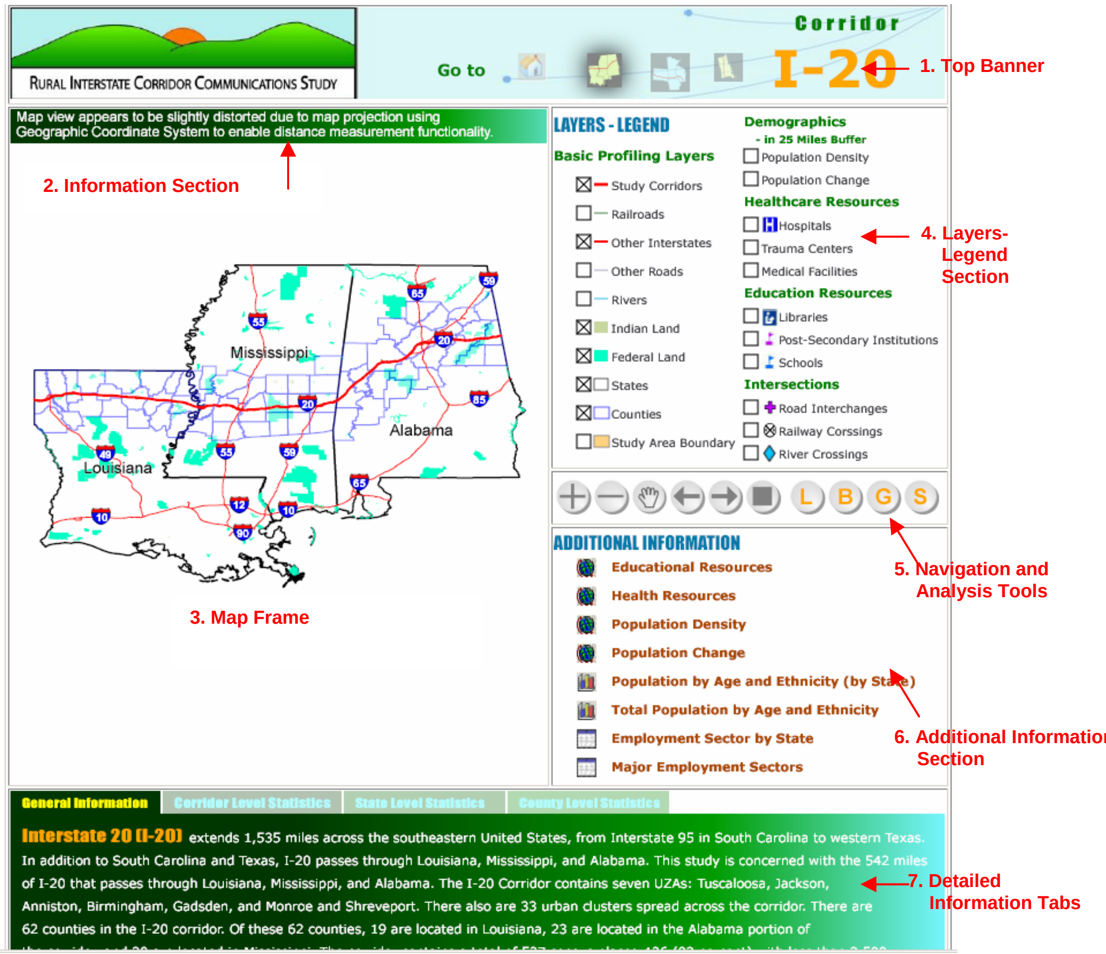
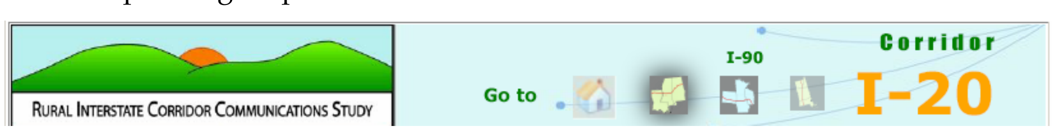


Figure A.2 shows a snapshot of a sample corridor map view (I-20) in the application. The entire view can be divided into 7 different elements.

1. **Top Banner –** The top banner consists of the project logo along with several icons that help the user to navigate to either the main page or to other corridor map views. The user can place the mouse cursor over each of the icons to see the corridor name and then click on these icons to navigate to the corresponding map view.



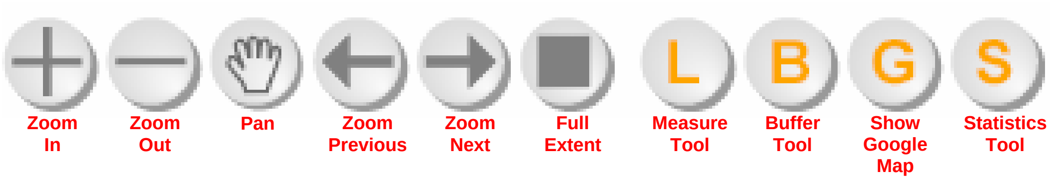
2. **Information Section –** The information provides important information regarding the map view and the attributes that relate to the "Measure Tool" and the "Buffer Tool." More details on this section will be provided while describing each of these tools.

3. **Map Frame –** The map frame consists of the initial extent of the corridor provides an interactive environment for the user to visualize, navigate, and

select several features on the map interface. The exact behavior of this interactive environment is dependent upon the tool that the user selects. For example, if the user chooses the "Pan Tool" the map frame enables user to drag and point the mouse cursor to locate the new extent to pan to. This map frame is the primary interactive area for the user to geographically visualize the corridor data.

4. **Layers-Legend –** Several layers of geographic data are included as a part of this interactive mapping application. This section enables the user to identify all these layers on the map interface and also to turn on/off any of these layers in an interactive manner. In order to turn a layer on (to display a layer on the map frame), the user can simply clicks on the check box to show the check symbol. Similarly, in order to turn the layer off, the user clicks again on the check box to turn off the check symbol. Please note that the initial display has only a few layers checked on and other layers can be turned on as required.

5. **Navigation and Analysis Tools –** The following are the Navigation and Analysis Tools provided in the application.



Any tool can be activated by simply clicking on the corresponding tool. Tools like Zoom in, Zoom out, Measure, Buffer and Statistics require the user to perform certain interaction in the map frame. Also, when the user clicks on these tools, the corresponding tool icon turns into blue color indicating that a selection has been made.

- **Zoom In and Zoom Out Tools –** Allows the user to zoom in and out in the map area. To use these tools, the user selects the tool and draws a rectangle on the map frame, using the mouse, indicating the area the user wishes to zoom in/out. Upon releasing the mouse button the map frame adjusts its extent to show the user specified extent.

- **Pan Tool –** Allows the user to pan across the map by holding down the left mouse button and dragging the cursor.

- **Previous Extent –** Zooms to the last extent chosen by panning or zooming. This tool allows the previously accessed extents to be displayed.

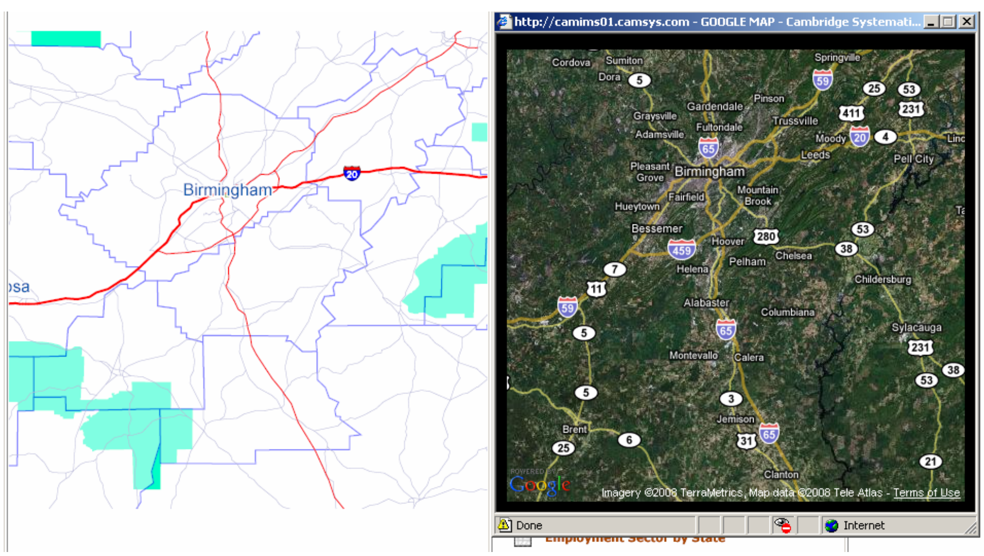
- **Next Extent –** Zooms to the next extent chosen by panning or zooming. This tool allows access to the subsequent extents while using Previous Extent tool.

- **Full Extent –** Zooms out to the full extent of the map.

- **Measure Tool –** Enables users to measure the distance between a set of points. The user clicks at a point on the map, then successively on other points and a line is drawn from the first clicked point to the next clicked point and so on, and the accumulated distance to each point is displayed on the map inside the 'Information Section', as shown in the figure below.

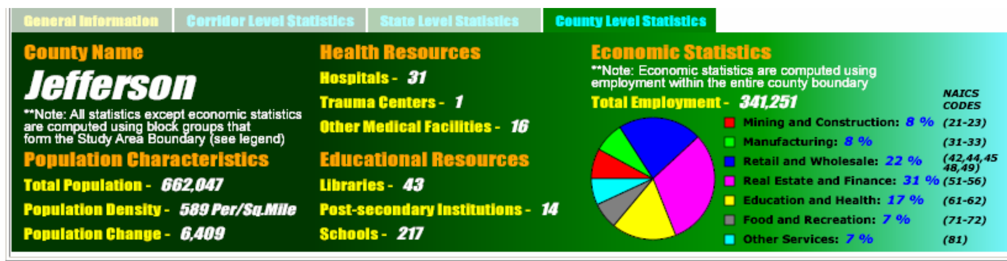
- **Buffer Tool –** Enables users to create a point buffer overlay of specified size on the map interface. To use this tool, the users clicks anywhere on the map and specifies the buffer distance in the 'Information Section' and clicks on the "Go" button to show the cirular buffer transperant overlay on the map view. The user can then click anywhere on the map view and move the overlay freely to any location on the map.

- **Show Google Map –** Ties the current SVG map view with a Google map view and enable users to view Google's maps and satellite imagery for the current SVG map extent. Upon clicking on this tool, the application opens a new window showing similar extents of the Google map view as in the Map frame.



- **Statistics Tool –** Shows statistics at three geographic levels such as the entire corridor, State level and the county level. Different kinds of demographic, economic, health and educational statistics can be viewed using this tool.

In order to obtain the corridor level statistics, upon activating the tool, the user clicks on the "Corridor Level Statistics" tab in the "Detailed Information Tabs" section and then should click on the corridor in the map frame. Doing so would select the corridor (turns into a yellow shade) and updated the statistics for the entire corridor. Similarly, to obtain the State level statistics, the user clicks on the "State Level Statistics" tab and selects a particular State on the map view. As the user selects different States, their corresponding statistics get updated. Similarly, to obtain county level statistics, the user clicks on the "County Level Statistics" tab and select a county on the map interface (the user should make sure the 'Counties' layer is checked on in the 'Layers-Legend' section). Upon selecting a county, the user can navigate onto State or corridor levels and compare corresponding statistics.



6. **Additional Information Section –** Provides access to previously compiled static maps and tables related to a particular corridor. The user can simple click on the required map/table in the interface and a new window opens with the corresponding information.

7. **Detailed Information Tabs –** Provides general description of the corridor and the tabs provide statistical information at various geographic levels while using the "Statistics Tool."

C. Typical Installation Details

- **Junction Box Details 1**
  - Installation Cross Section
  - Cable Vault/Cable Racking Scheme
- **Junction Box Details 2**
  - Fiber Optic Service Box Details
  - Initial Box Installation Details
  - Plan (Conduit Position) Directional Change
  - Plan (Conduit Position) Straight Through Run
- **Junction Box Details 3**
  - Fiber Optic Pullbox (Typical) Details
  - Fiber Optic Splice Closure Type B Pullbox
  - Fiber Optic Closure Type A Pullbox
- **Junction Box Details 4**
  - Junction Box
- **Fiber Optic Underground Entrance Details**
  - Underground Entrance into Base Mounted Cabinet (Internal Splice – Max 12 Fiber Splices)
  - Underground Entrance into Base Mounted Cabinet (External Splice)
  - Typical Underground Splice
  - Underground Entrance for Embedded Steel, Concrete, or Wood Pole into Pole Mounted Cabinet (External Splice)
  - Underground Entrance for Steel Pole into Pole Mounted Cabinet (External Splice)
- **Underground Boring Details**
  - Detail "A" – Jacking, Boring, and Directional Bore – Uncurbed Typical
  - Quad-Duct – Typical Jacked, Drilled, or Bored Fiber Optic Trunkline Conduit Installation Section
- **Underground Conduit Trenching Details 1**
  - Detail "B" Open Cut Excavation Across Bituminous Concrete Pavement
  - Detail "C" Open Cut with Portland Cement Concrete Pavement

  - Quad-Duct Typical Trenched Fiber Optic Trunkline Conduit Installation Section
- **Underground Conduit Trenching Details 2**
  - Conduit Trenching
  - In Existing Pavement Behind Curb
  - Fiber Optic Conduit Above Ground Marker Detail
  - In Existing Pavement
  - In Earth
- **Underground Conduit Trenching Details 3**
  - Typical Conduit Cross Section
    - Option 1
    - Option 2
- **Conduit Routing Details**
  - Conduit Installation at Interchange
- **Bridge Attachment Details 1**
  - Typical Deck Section – I-Beam Girder Bridge
  - Typical Deck Section – Box Girder Bridge
- **Bridge Attachment Details 2**
  - Typical Conduit Sweep Detail
  - Typical Bridge Cross Section
  - Hanger Detail
- **Bridge Attachment Details 3**
  - Typical Attachment of Conduit to Bridge Abutment
- **Regeneration Building**
  - Perspective View
  - Building Plan Details

D. Utility Accommodation References and Best Practice

A Policy on the Accommodation of Utilities Within Freeway Right-of-Way, 5th Edition; AASHTO, 2005:
https://bookstore.transportation.org/item_details.aspx?ID=93

A Guide for Accommodating Utilities within Highway Right-of-Way, 4th Edition; AASHTO, 2005:
https://bookstore.transportation.org/Item_details.aspx?id=95

AASHTO Guidance on Sharing Freeway and Highway Rights-of-Way for Telecommunications, 1997:
https://bookstore.transportation.org/item_details.aspx?ID=97

AASHTO Subcommittee on Right of Way and Utilities:
http://rightofway.transportation.org/?siteid=61

FHWA Subsurface Utility Engineering Site:
http://www.fhwa.dot.gov/programadmin/sueindex.cfm

FHWA Program Guide – Utility Relocation and Accommodation on Federal Aid Highway Projects, 2003: http://www.fhwa.dot.gov/reports/utilguid/index.cfm

Guidance on Longitudinal Telecommunications Installations on Limited Access Highway Right-of-Way, December 22, 2000:
http://www.its.dot.gov/telecom/tele_srguide.htm

Background Guidance on Longitudinal Telecommunications Installations on Limited Access Highway Right-of-Way, December 20, 2000:
http://www.its.dot.gov/telecom/tele_srbackground.htm

North Dakota Policy for Accommodation of Utilities on State Rights of Way:
http://www.dot.nd.gov/manuals/environmental/policy-utilities-state-row.pdf

Oregon Highway/Utility Guide, 2003:
http://joancsymons.com/RUSTools/highway_utility_guide.pdf

FHWA Survey: Compensation for Telecommunications in Controlled Access Right-of-Way (23 states) :
http://www.fhwa.dot.gov/REALESTATE/aashto2006/comtelcoacrow.htm
Utility Corridor Structures And Other Utility Accommodation Alternatives In TXDOT Right Of Way; 2002: http://tti.tamu.edu/documents/4149-1.pdf

Longitudinal Occupancy of Controlled Access Right-of-way by Utilities
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