Research Report
KTC-10-21/RSF28-09-1F

KENTUCKY TRANSPORTATION CENTER

LOCAL EVALUATION FOR THE CUMBERLAND GAP TUNNEL REGIONAL ITS DEPLOYMENT

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Local Evaluation for the Cumberland Gap Tunnel Regional ITS Deployment

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16. Abstract

This report is the local evaluation of an Intelligent Transportation System deployment for the Cumberland Gap Tunnel and U.S. 25E corridor in Tennessee and Kentucky. This report examines the planning for the deployment and the systems and components used to achieve the goals of the deployment. The goals and expectations of the ITS deployment were to provide updated travel information to drivers in the vicinity of the Cumberland Gap Tunnel and along the U.S. 25E corridor; to improve the integration of the tunnel systems; to improve incident detection, verification, and response times along the U.S. 25E corridor; and to develop, use, and maintain a Regional ITS Architecture. A Regional ITS Architecture, a Strategic Plan, and an ITS Integration Plan were developed and used as the basis to upgrade and expand existing systems, to deploy regional signage, and to enhance communication. The report includes discussions of institutional involvement and the use of a project champion, along with lessons learned from the deployment.

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EXECUTIVE SUMMARY

The Cumberland Gap Tunnel is a twin bore tunnel on U.S. 25 E located in the Cumberland Gap National Historical Park. The facility carries a four-lane highway through the Cumberland Mountains between Kentucky and Tennessee. The Tunnel was opened to traffic in October 1996. The original facility included some ITS components, such as: closed-circuit television (CCTV), message signs, magnetic loop detectors, and a traffic control system.

In 1999, Congress provided Highway Trust Funds to upgrade the ITS components and deploy new technologies at the Cumberland Gap Tunnel. The Federal Highway Administration (FHWA) and Kentucky Transportation Cabinet (KYTC) partnered to improve traveler mobility along the U.S. 25E corridor through the Cumberland Gap region. The funding was used to develop an ITS regional architecture, strategic plan, and integration plan, and to deploy and upgrade ITS technologies at and around the Tunnel.

As planning of the project got underway, a technical advisory committee (TAC) was established to provide guidance and oversight for the planning of the ITS deployment. The TAC consisted of representatives from: KYTC, Tennessee Department of transportation (TDOT), FHWA, Cumberland Gap National Historical Park, Cumberland Gap Tunnel Authority (CGTA), and the Cumberland Valley Area Development District. After significant delays through the procurement process, a private consultant with valuable related experience was hired to lead the planning process and complete the regional ITS architecture, strategic plan, and integration plan. The planning process and documentation cost $818,936.

Stakeholders were engaged at local workshops to help identify local and regional needs. A local project champion, Mr. Lewis Melton, P.E., was identified who served as the information liaison between the stakeholders and the general public. Mr. Melton was involved in the original construction and operation of the Tunnel and was able to provide much information during the planning process. Several legal agreements were put in place throughout the duration of the project that helped to solidify the partnerships and ensure long-lasting relationships.

KYTC identified a project manager who had prior experience with ITS deployment projects. Leveraging this past experience, the project manager pursued a single system integrator for the CGT ITS deployment. The procurement process for the deployment was lengthy and experienced many delays.

The ITS deployment cost more than $4.8 million dollars and included the following: 1) expansion and upgrade of the CCTV system and upgrade of the multiplexer; 2) installation of the radio rebroadcast system; 3) design and upgrade of the local dynamic message signs (DMS); 4) regional deployment of DMS and CCTV for I-75 and I-81; and 5) upgrade of the tunnel facility control room. Installation of these systems occurred in phases between July of 2002 and September of 2007.

The goals of the deployment were to: 1) provide updated traveler information; 2) improve integration of the tunnel systems; and 3) improve incident detection, verification, and response times along U.S. 25E. It was also expected that this deployment would meet other general ITS goals area such as: traveler safety, traveler mobility, transportation system efficiency, and conservation of energy and protection of the environment.

The purpose of this local evaluation report is to provide documentation on the planning and installation of the ITS components and to determine how well the deployment met the intended goals. This evaluation involved the review of project documentation, interview of stakeholders, and analysis of additional data that would serve as measures of effectiveness. This evaluation focused on whether the ITS deployment met the following objectives:

1) Provide Up-to-Date Traveler Information to Local and Regional Travelers
2) Improve Integration of the Tunnel Systems
3) Improve Incident Detection, Verification, and Response Times
4) Improve Traveler Safety
5) Improve Traveler Mobility
6) Improve Transportation System Efficiency
7) Conserve Energy and Protect the Environment

Based upon the goals of the deployment and the ITS goal areas, the following hypotheses were established for the evaluation:

H1. The implementation and integration of the ITS components would facilitate the passage of increased traffic through the tunnel corridor.

H2. The implementation and integration of the ITS components would improve safety around the Tunnel by reducing rear end collisions during hazardous material escorts.

H3. The implementation and integration of the ITS components would improve the operations and maintenance procedures within the Tunnel.

H4. The implementation and integration of the ITS components would facilitate an increase in the average number of hazardous material vehicles per escort through the CGT.

H5. The implementation and integration of the ITS components would provide a mechanism to enhance traffic and weather information to travelers in the region surrounding CGT.

H6. The implementation and integration of the ITS components would help personnel to detect, verify, and respond to incidents in and around the Tunnel more quickly.

Based on interviews of the stakeholders, the ITS deployment served to provide additional information in the control room which allowed for improved traffic flow and improved safety at the Tunnel. The equipment also provided improvements in traveler information both locally and regionally. The upgrade of the equipment led to efficiency in operations and maintenance since there were fewer technical and integration problems.

Additional measures of effectiveness were analyzed to determine if these stakeholder findings could be substantiated with quantitative data. Traffic volume data was unreliable and spotty and therefore could not be used to make any conclusions about the deployment. Data did show a significant increase in hazardous material vehicles through the Tunnel (from 2000-2001 to 2007-

2008) which could be an indication of increased traffic through the Tunnel. The information on hazardous material vehicles also showed that the average number of vehicles escorted per closure had increased from 1.27 to 1.41. Crash data indicated a reduction in crashes when comparing the four years before and the four years after the implementation of ITS.

Based on the findings, the deployment met most of the objectives that were established, including the improvement of: traveler information; integration of systems; incident detection, verification, and response time; traveler safety and mobility, and transportation system efficiency. All of the identified hypotheses were found to be either fully or partially true.

Technical and institutional issues were also identified as part of the evaluation. Those issues included such things as: lack of expertise; difficult and lengthy procurement processes; and lack of traffic volume data.

The evaluation found that the ITS deployment at the CGT was a successful demonstration of the usefulness of ITS technologies. The stakeholders were pleased with the deployment and found value in the technology. The key lessons learned and recommendations for future ITS deployments include:

- **Engage Stakeholders** – Local and regional stakeholders should be engaged early in the project.
- **Identify a Project Champion** – A local project champion should be identified who is committed to seeing the project succeed and can assist with engaging and communicating with stakeholders.
- **Plan for the Project** – Set aside proper funding to plan for the project, making sure to establish clear goals and performance measures for the project.
- **Establish Institutional Agreements** – Formal partnership agreements should be established in an effort to garner long-term commitment to the project.
- **Find Expertise Within –** A project manager who has significant experience with ITS deployment should be chosen for the project.
- **Find Expertise Outside** – ITS deployment projects can be very technical and complicated. If expertise is not available within the organization, the proper expertise should be obtained from consultants or other outside organizations.
- **Prepare for a Lengthy Procurement Process** – Prepare stakeholders for a lengthy procurement and investigate procurement options at the start of the project.
- **Utilize a System Integrator for the Duration of the Project** – Make use of a system integrator to ensure that accountability rests with a single firm and with that firm’s subcontractors.

In addition, a recommendation specific to the Tunnel is the implementation of traffic count systems. This would allow stakeholders to measure the flow of traffic through and around the Tunnel and would provide valuable data to the stakeholders.

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CHAPTER ONE: INTRODUCTION

1.1 Overview of the Project

This study provides an evaluation of the Cumberland Gap Tunnel (CGT) Intelligent Transportation System (ITS) deployment along the U.S. 25E Corridor from I-81 near Morristown, Tennessee to I-75 near Corbin, Kentucky. This report reviews the activities undertaken for determining the necessary components for installation, documents the technical and institutional issues encountered throughout the project, and identifies the best practices and recommendations that resulted from these activities. This evaluation is intended to assess how well the ITS components performed in meeting the goals established at the onset of the deployment. This documentation of activities, lessons learned, best practices, and recommendations will provide valuable information to the Kentucky Transportation Cabinet (KYTC) when faced with similar projects in the future. The information contained in this report will also be useful to other states that are considering similar types of projects.

1.2 Objective

The objective of this evaluation was to provide a clear understanding of the value, effectiveness, and impact of the ITS deployment at the Cumberland Gap Tunnel. The results of the evaluation will have implication for future ITS deployments and will also provide valuable information to the transportation community.

1.3 Methodology

The information for this evaluation was collected using two mechanisms: (1) an extensive review of project documentation and (2) interviews with key players involved throughout the implementation process. The research team developed the evaluation plan for this project by combining the specific evaluation goals (provided in the original partnership agreement between the Federal Highway Administration and KYTC) and a sample evaluation plan provided by the Research and Innovative Technology Administration (RITA), the official coordinator of the U.S. Department of Transportation's research programs. Recommendations and lessons learned were developed based on findings of the evaluation.

1.4 Structure of the Report

This report is organized into six chapters. Chapter 1 provides an introduction to the evaluation including the objective of the project and the methodology utilized to accomplish the objective. Chapter 2 provides some background on the CGT facility, the planning and funding for the ITS upgrade, stakeholder involvement, and institutional agreements. Chapter 3 provides information on the evaluation plan, including the purpose, objectives, and hypotheses. Chapter 4 provides detailed information about the planning, procurement, and deployment of ITS at the CGT. Chapter 5 summarizes the project outcomes, including a discussion of technical and institutional issues. Chapter 6 discusses the lessons learned from this ITS deployment project.

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CHAPTER TWO: BACKGROUND ON THE CUMBERLAND GAP TUNNEL

2.1 The Cumberland Gap Tunnel Facility

The CGT facility carries a four-lane highway under the Cumberland Mountains between Kentucky and Tennessee. The tunnel facility consists of office, operational, and control areas, as well as twin bores carrying traffic on U.S. 25E between Kentucky and Tennessee. The facility lies within the Cumberland Gap National Historical Park located in the tri-state area of Kentucky, Tennessee, and Virginia. The highway portion of each bore includes two traffic lanes and a limited shoulder. Figure 1 shows the Kentucky portal looking south on U.S. 25E.

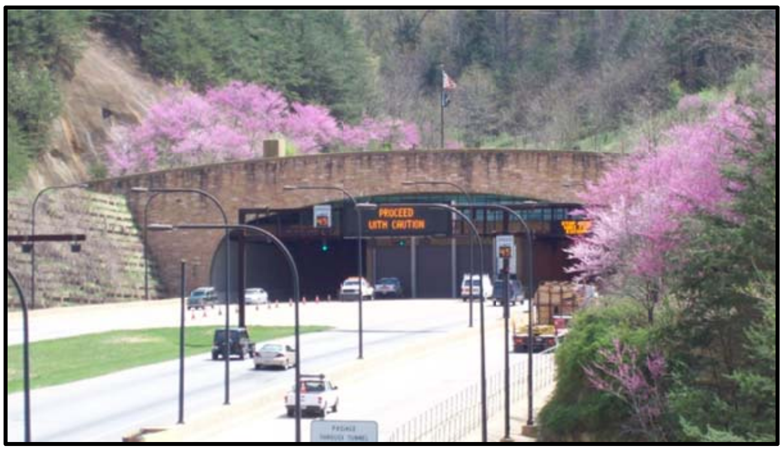

Figure 1. Cumberland Gap Tunnel - A View of the Kentucky Portal

When the Tunnel opened for traffic in October 1996, the tunnel facility had state-of-the-art ventilation, lighting, and communications equipment. The Tunnel also included several ITS devices, such as closed-circuit television (CCTV) cameras, several message signs, and magnetic loop detectors for traffic surveillance. KYTC contracted with Tunnel Management, Inc. (TMI) to provide management and operations of the facility.

2.2 Funding and Planning for the ITS Upgrade and Deployment

In 1999, the Cumberland Gap region was selected to participate in the ITS Integration component of the ITS Deployment Program as designated through the U.S. Department of Transportation's Fiscal Year 1999 Appropriations Bill. Funding was provided through the ITS Deployment Program as defined in Section 5208 of the Transportation Equity Act for the 21st Century (TEA-21). The U.S. Congress provided Highway Trust Funds for projects ITS-9821(001) and ITS-9921(001) to deploy and upgrade ITS components at the CGT facility. The partnership agreements between the Federal Highway Administration (FHWA) and KYTC were focused on improving traveler mobility along the U.S. 25E corridor through the Cumberland Gap region. These agreements provided KYTC with funding to develop an ITS regional architecture, deploy and upgrade the necessary ITS technologies as identified in the regional architecture, and evaluate those technologies.

The portion of U.S. 25E targeted for the ITS upgrade and deployment covers approximately 100 miles, extending from I-81 in Morristown, Tennessee to Corbin, Kentucky near I-75. This corridor is listed as a High Priority Corridor in section 1105(c) of the Intermodal Surface Transportation Efficiency Act (ISTEA) (PL 102-240) as amended through PL 109-59. Both Kentucky and Tennessee consider the corridor a valuable tourism area, as there are a number of recreational and historic sites along the corridor. Figure 2 shows the corridor.

Figure 2. U.S. 25E Corridor from I-81 in Tennessee to I-75 in Kentucky

A Technical Advisory Committee (TAC) was established to provide general guidance and oversight for the planning of the CGT ITS deployment. Members of the TAC included representatives from the following:

- Kentucky Transportation Cabinet (KYTC)
- Tennessee Department of Transportation (TDOT)
- Federal Highway Administration (FHWA)
- Cumberland Gap National Historical Park
- Cumberland Gap Tunnel Authority (CGTA)
- Cumberland Valley Area Development District

KYTC's project manager served as the chairman of the committee. The TAC provided recommendations to KYTC, TDOT, and FHWA throughout the course of the project.

2.3 Stakeholder Involvement

As with any ITS deployment, stakeholder involvement was critical. The federal aid projects that funded the ITS deployment were high visibility earmarks with congressional involvement. This deployment involved management decisions from two states (Kentucky and Tennessee) and a national park. The planning process and installation of the CGT ITS components involved procurement issues, system engineering, and technology standards. Installation of the CGT ITS components took place on the National Park Service (NPS) property in the Cumberland Gap National Historical Park and in two states along a corridor with Scenic Byway designation. Congressional liaisons provided information on the legislative intent. This information provided federal, state, and local decision-makers with the primary basis to develop the initial work plans. Federal officials provided fundamental information concerning the earmark, the ITS partnership agreement, and funding allocation.

Senior level state officials involved in this project included those inside KYTC and in Kentucky state government. KYTC General Counsel provided review and advice concerning the ITS partnership agreements and the bi-state agreement and was consulted on procurement issues. Senior management within KYTC provided information on the various procedural steps and documents required for FHWA programming.

Kentucky's Chief Information Officer (CIO) provided an overview of the possible involvement of the CIO's office. The CIO was aware of ITS activities in Kentucky and was a strong supporter of the use of advanced technologies and communications in transportation. The CIO updated Kentucky's Computing Architecture to allow for the systems and components that were typically used in ITS deployments. The Cumberland Gap National Historical Park's superintendent and deputy provided advice and guidance concerning NPS regulations and mandates. Senior TDOT officials were very supportive of KYTC's efforts for the CGT. TDOT officials provided the procedures for the approval agreements, permits and inspections, and for processing payments.

The TAC continued to meet during the development of the planning documents. The TAC recommended implementation of sections in the Strategic Plan. Senior management from both states and the NPS decided on the systems and components to initially deploy. A local project champion was identified who was familiar with the region and stakeholders and had a strong desire for the project to succeed. This person also provided strong leadership for the project and remained very active during this period, advising senior management in both states and the NPS. The initial installation and upgrade was undertaken by FHWA's Eastern Federal Lands Highway Division (EFLHD).

2.4 Institutional Agreements

There were several legal agreements in place at the initiation of the regional architecture development. In 1986, a Memorandum of Understanding between the US Department of the Interior, the Commonwealth of Kentucky, and the State of Tennessee identified responsibilities for CGT. This Memorandum of Understanding assigned responsibility for construction of CGT to the EFLHD. The responsibility for the management and operations of the completed facility was placed upon the states. A 1995 bi-state agreement established a bi-state oversight committee and established Kentucky as the lead state to secure management and operations of the CGT. In 1996, TMI was awarded a four year contract to manage and operate CGT.

In 1998 and 1999, KYTC and FHWA signed partnership agreements granting funds to KYTC to develop an ITS regional architecture and other planning documents. These agreements also provided funds to deploy ITS systems and components. In 1999, KYTC and TDOT agreed to deploy ITS systems and components in both states and maintain them. In 2000 and 2001, TMI was awarded contracts to continue managing and operating the CGT. Table 1 provides a summary of the key agreements.

Existing agreements and new agreements solidified the NPS, Kentucky, and Tennessee in their desire to see the deployment of technology at the Tunnel and along the U.S. 25 E corridor. The use of agreements transcends senior leadership changes and enables project managers to complete multi-year deployment without continual re-authorization.

Table 1. Legal Agreements

Legal Agreement		Parties to the Agreement			Summary of Items Included
Date	**Type**	**First**	**Second**	**Third**	
21-Feb-86	Memorandum of Understanding	U.S. Department of the Interior/NPS	Tennessee	Kentucky	*U.S. 25E is Federal Highway *EFLHD is responsible for construction of the CGT *Management and operations by Kentucky and Tennessee -States will produce a plan
20-Jan-95	Bi-state Agreement	Kentucky	Tennessee		*Kentucky lead state for management of the Tunnel *Oversight committee established
6-Aug-96	Contract Agreement	Kentucky	Tunnel Management Inc. (Cumberland Gap Tunnel Authority)		*Third party contractor responsible for operation and management of the Tunnel
3-Oct-98	Partnership Agreement	FHWA-9821	Kentucky		*Traveler information along U.S. 25E corridor *Decrease response times along the U.S. 25E corridor
29-Oct-99	Bi-state Agreement	Kentucky	Tennessee		*Kentucky lead state to run the project *Part of the work will be done in Tennessee *Tennessee will maintain Tennessee components
5-Nov-99	Partnership Agreement	FHWA-99211	Kentucky		*Traveler Information along U.S. 25E corridor Decrease response times along the U.S. 25E corridor
1-Jul-00	Contract Agreement	Kentucky	Tunnel Management Inc. (Cumberland Gap Tunnel Authority)		*Third party contractor responsible for the operation and management of the Tunnel
1-Jul-10	Contract Agreement	Kentucky	Tunnel Management Inc. (Cumberland Gap Tunnel Authority)		*Third party contractor responsible for the operation and management of the Tunnel

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CHAPTER THREE: THE EVALUATION PLAN

The goals and objectives of the ITS deployment were established within the ITS Partnership Agreement at the onset of the project. The parties involved agreed to work toward accomplishing the following:

1) Provide updated traveler information to drivers in the vicinity of CGT and along the U.S. 25E corridor;
2) Improve the integration of the tunnel systems; and
3) Improve incident detection, verification, and response times along U.S. 25E.

In addition, it was expected that the deployment of ITS infrastructure would have an impact on at least some of the traditional ITS goal areas, such as:

- traveler safety;
- traveler mobility;
- transportation system efficiency; and
- conservation of energy and protection of the environment.

3.1 Purpose and Objectives of the Evaluation

The purpose of this evaluation was two-fold. First, this evaluation was intended to provide documentation of the planning and installation of ITS components at CGT. This information is summarized in Chapter 4. By going through the documentation process, which required substantial interaction with stakeholders, lessons learned could be derived.

The second component of this evaluation was to determine how well the TAC and KYTC met the goals of the CGT ITS deployment. In other words, did the deployment do what it was intended to do? Also, did the deployment of ITS infrastructure have a positive impact on any of the traditional ITS goal areas listed above? In consideration of the goals of the deployment and the ITS goal areas, this evaluation focused on whether the ITS deployment met the following objectives:

1) Provide Up-to-Date Traveler Information to Local and Regional Travelers
2) Improve Integration of the Tunnel Systems
3) Improve Incident Detection, Verification, and Response Times
4) Improve Traveler Safety
5) Improve Traveler Mobility
6) Improve Transportation System Efficiency
7) Conserve Energy and Protect the Environment

To accomplish these tasks the project team thoroughly reviewed the project documentation provided by the project champion and project manager for CGT. Stakeholders were also asked to provide input regarding the planning and deployment process. In addition, other types of data, serving as measures of effectiveness, were collected and analyzed in an effort to evaluate the benefits of the ITS deployment. Such data included: traffic volume, number of incidents, number of hazardous material vehicles, and number of hazardous material vehicles escorted per closure.

3.2 Hypotheses

The following hypotheses were offered by the evaluation team based upon the project documentation:

- **H1. The implementation and integration of the ITS components would facilitate the passage of increased traffic through the tunnel corridor.**
- **H2. The implementation and integration of the ITS components would improve safety around the Tunnel by reducing rear end collisions during hazardous material escorts.**
- **H3. The implementation and integration of the ITS components would improve the operations and maintenance procedures within the Tunnel.**
- **H4. The implementation and integration of the ITS components would facilitate an increase in the average number of hazardous material vehicle per escort through the CGT.**
- **H5. The implementation and integration of the ITS components would provide a mechanism to enhance traffic and weather information to travelers in the region surrounding CGT.**
- **H6. The implementation and integration of the ITS components would help personnel to detect, verify, and respond to incidents in and around the Tunnel more quickly.**

CHAPTER FOUR: THE CUMBERLAND GAP TUNNEL REGIONAL ITS DEPLOYMENT

This chapter documents the process of planning and implementation of the ITS infrastructure at the CGT. Information for this chapter was collected from project documentation and stakeholder interviews.

4.1 Planning Process

The ITS regional architecture was developed to serve as a blueprint or framework for the various ITS systems and the interactions among them. KYTC and TDOT expressed a strong interest in including a broad array of state and local stakeholders in the development of the ITS regional architecture. KYTC designated a project manager who had experience in ITS deployment. The TAC served as the core element of the stakeholder advisory group, and various local, regional, and state level stakeholders were added.

The TAC also determined that a project champion would be integral to the overall success of the development of the ITS regional architecture and the CGT ITS deployment. A project champion would be instrumental in engaging other stakeholders for both the architecture development and the ITS deployment. Lewis Melton, P.E., with Vaughn and Melton Consulting Engineers, Inc., was identified as the project champion and ultimately served as the information liaison among the TAC, the stakeholders, and the general public. TMI had a long-term contract through KYTC's competitive bidding process to manage and operate the Tunnel, and that work involved considerably more than just the ITS components. Mr. Melton had a thorough understanding of the Tunnel, the local area, and the stakeholders. He helped to maintain open lines of communication with the various stakeholders throughout the entire CGT ITS deployment and provided much-needed institutional knowledge about the original planning and construction of CGT. He was, of course, very knowledgeable concerning the management and operation of the CGT.

In November of 1999, the project manager proceeded to procure a pre-qualified firm to develop the Regional ITS Architecture and the Strategic and Integration Plans. The procurement was carried out through provisions of the Kentucky Revised Statutes (KRS) 45A and Kentucky Administrative Regulations (KAR) 600. A Professional Services Bulletin was prepared. Firms were asked to respond to the bulletin indicating their approach to the project, their relevant expertise, and their ability to complete the work in a timely manner. TRW, Inc., a pre-qualified firm, was selected, and contract negotiations were initiated. While this method was successful, the pace of the deployment was slowed considerably due to the change-order process and the length of the procurement phase. TRW was officially under contract by July of 2001. This delay in getting TRW in place resulted in some loss of interest in the deployment by the senior management of KYTC and TDOT, as well as by local supporters.

The Kentucky Transportation Center (KTC) at the University of Kentucky assisted TRW with the stakeholder involvement and established a website to provide information to the stakeholders and the public concerning the ITS planning for the deployment. Updates on the architecture development process and other information were added periodically. This occurred between 2001 and 2003. This website provided an innovative method to disseminate information quickly and economically. However, many of the stakeholders were not versed in the use of the World Wide Web, so the effectiveness of the website was limited.

Over the course of several stakeholder workshops, local and regional ITS needs were identified. The needed CGT ITS components were detailed, and an ITS regional architecture was defined. The original ITS regional architecture was published in June 2002. The architecture was consistent with the national ITS architecture and was reviewed and accepted by FHWA in December 2002.

In addition to the ITS regional architecture, two other planning documents were developed. An ITS strategic plan was generated to guide the deployment of the various CGT ITS technologies. An ITS integration plan was also produced, as a companion to the ITS regional architecture, to aid in the procurement and deployment of the various components. These documents were also completed by TRW in June 2002. The costs associated with the planning process and documents are shown in Table 2 below.

Table 2. Costs of the Planning Process and Documentation

ITS Planning Tasks	**Costs**
Deployment Planning, Stakeholder Involvement, Web Site Development and Maintenance	$ 103,183
ITS Regional Architecture, Strategic Plan, and Integration Plan development	$ 715,753
Total Planning Costs	**$ 818,936**

Drawing from the planning documents, the project manager and the project champion developed a schedule for deploying the various technologies and systems. Table 3, on the following page, shows the planned deployment. As the project proceeded, some of the planned tasks were not carried out for various reasons. In some cases, certain tasks were deemed to be inappropriate or unnecessary.

4.2 Procurement of the ITS Equipment

The TAC held public meetings on several occasions in Middlesboro, KY to review the various contracts and agreements integral to the CGT ITS deployment. One of the first tasks of the TAC was to determine the contracting method to be followed for the deployment of the CGT ITS components. Specifically, they discussed whether traditional consultant and low-bid construction contracts would be used or whether alternative methods such as design/build or system integrator could be used.

KYTC staff members were familiar with the management and implementation of ITS projects because of their involvement with the traffic management center deployments in the Northern Kentucky region and Louisville (ARTIMIS and TRIMARC). This past experience led KYTC to pursue a single system integrator for the CGT ITS deployment.

Table 3. Planned Deployment Schedule

Planned Task	**Route/Location**	**Anticipated FY Installation**
CCTV (6 or more)	Approaches to Tunnel	2002
Road Weather Information Station (RWIS) (2 or more)	Around Tunnel and on I-75 near Jellico, Tennessee	2002
Dynamic Message Sign (DMS) - permanent (6 or more)	Tunnel Approaches and I-75 and I-81 Interchanges	2002
Highway Advisory Radio (6)	U.S. 25E Corridor	2002
Radio Re-broadcast	Tunnel Control Center and Speakers in Tunnel	2003
Expansion of Tunnel Control Center	Tunnel Control Center	2003
Multiple Communication Devices (prototype)	To be Determined by Stakeholders	2003
Hazardous Material Truck Identification Monitoring System (prototype)	Tunnel Approaches	2003
Automatic Vehicle Location and Computerized Dispatching	Located on Regional Public Transit Vehicles and Tunnel Control Center	2003

In 1998, Kentucky's CIO implemented the Strategic Alliance Services (SAS) master contract. KYTC reviewed the SAS administrative methods and regulations to consider if it could be useful for the CGT project. After consulting the CIO's staff, a Strategic Alliance Service Request (SASR) was developed and proposed in the spring of 1999. The SASR was reviewed and accepted by the CIO's staff. Nevertheless, the CIO requested that KYTC withdraw the SASR. The CIO indicated that while the use of a system integrator was appropriate under SAS, she was concerned that the amount of hardware purchased by the system integrator would exceed the limit allowed by law. The idea of using SAS was abandoned, and the project manager proceeded to procure a consultant through the professional services procurement process (as described in KRS 45A and KAR 600). A professional services bulletin was prepared announcing that services were needed. A consultant was selected and placed under contract to provide an ITS regional architecture, a strategic plan, and an integration plan for CGT and the U.S. 25E corridor. While this method of procurement was successful, the pace of the deployment was slowed considerably due to the time required for the procurement and for change orders.

The project manager developed the necessary documentation for the programming staff to advance the CGT ITS deployment funding through the various state and federal agencies. This documentation was coordinated with both NPS and TDOT. Funds were programmed with FHWA. The CGT ITS deployment was included in Kentucky's Statewide Transportation Improvement Program. Documentation was shared with the Kentucky Division of Air Quality, the Kentucky Division of Water, and other groups interested the CGT ITS deployment project.

4.3 ITS Upgrade and Deployment

The funding for the deployment of ITS technologies at CGT was used to (1) upgrade the existing technologies operating in the Tunnel, (2) add additional technologies to expand local and regional area coverage, and (3) ensure that all ITS technologies operating in the Tunnel and the regional area were interoperable. Upgrading the original systems was necessary due to the limitations of those technologies.

The installation of the CGT ITS systems and components took place between July of 2002 and September of 2007. The timetable of the installations is outlined in Table 4 on page 19. Not all planned elements were actually deployed. This was mainly due to some components being deemed as not appropriate or not a priority after additional investigation.

ITS deployment at the CGT can be grouped into the following categories: (1) expansion and upgrade of the CCTV System and upgrade of the multiplexer; (2) installation of the radio rebroadcast system; (3) design and upgrade of the local DMS; (4) regional deployment of the DMS and CCTV for I-75 and I-81; and (5) the upgrade of the Tunnel facility control room. The costs associated with the deployment are shown in Table 5 on page 20.

Additional detail about the deployment and the expected benefits follows.

4.3.1 CCTV Upgrade and Expansion

The CCTV coverage was originally limited to the Tunnel area and a short distance beyond. Additional coverage was needed beyond the facility to better improve control of traffic along the corridor. The original CCTV multiplexor was an older model that had limited capacity. Moreover, the cameras were several years old, and routine maintenance was proving increasingly difficult.

A design was completed to replace the existing analog CCTV cameras with digital cameras from an established manufacturer. Additional CCTV cameras were installed to assist with management of the hazardous material vehicle escort system and to extend coverage to the U.S. 25E corridor. The upgraded system was intended to increase the incident detection and verification range of the CGT operators. In addition, it allows operators to identify oncoming hazardous material vehicles so that they many combine escorted vehicles. The new digital cameras are rarely out of service and do not require as much maintenance as the previous analog system.

In concert with the expansion and upgrade of the existing CCTV system, the existing CCTV multiplexor was upgraded and a digital video recorder (DVR) was installed. The digital storage provided verification for the various events occurring at the CGT for use by the CGTA and the NPS.

Table 4. Yearly ITS Deployment Summary

Fiscal Year	ITS Deployment Tasks and Milestones
2002-2003	• Radio-rebroadcast system was installed • 19 analog cameras replaced with digital cameras • Two additional cameras to view outbound hazardous material carriers • Install a digital video recorder with 320 gigabyte storage • 21 digital cameras in operation • 51,800 feet of fiber and power cable was added to network
2003-2004	• Installed all wiring for DMS • Installed traffic control scenarios specific to CGTA • Installed 30 DMS, 2 changeable message signs (CMS), 12 variable speed limit signs, 13 traffic signals, and 28 lane usage signs
2004-2005	• Control room monitors 24 digital cameras • Addition of one security camera at the Tennessee equipment enclosure • Expansion of the emergency power circuits at DMS N-9 and N-10 CMS • Installed the DMS and CCTV cameras on I-75 near Corbin, KY
2005-2006	• Control room now monitors 26 cameras • Expansion of emergency power circuits in Kentucky at DMS S-3 and S-4, and a hazardous material truck lane CMS • Commissioned DMS on I-75 • Installed DMS and CCTV cameras I-81 near Morristown, TN
2006-2007	• Commissioned DMS on I-81 • Improved DMS control system network and the message library
2007-2008	• New video wall and console with 110” diagonal panel and two 67” diagonal LCD panels • Two 45” diagonal LCD panels • Software upgrade to SCADA • Digital radio equipment upgrade for agency interoperability • New rebroadcast antennas • Established communication to I-81 DMS • Web-server upgrade for I-75 DMS • Installed new multiplexer upgrading storage to two terabytes
2008-2009	• Installed digital radio upgrade for federal P-25 compliance and multi-agency patch capability

Table 5. Costs of the ITS Deployment

Components of the ITS Deployment	**Costs**
CCTV Upgrade and Expansion	$ 228,860
CCTV Multiplexor	$ 34,159
Radio Rebroadcast System	$ 226,000
Planning and Design of Local DMS Upgrade and Expansion	$ 50,696
Deployment of Local DMS Upgrade and Expansion	$ 2,514,345
Design and Deployment of Regional DMS on I-75 near Corbin, KY	$ 734,450
Design and Deployment of Regional DMS on I-81 near Morristown, TN	$ 705,600
Planning, Design, and Deployment Upgrade and Expansion of CGT Facility Control Room	$ 383,973
Total Deployment Costs	**$ 4,878,083**

4.3.2 Radio Rebroadcast System

The installation of a radio re-broadcast system was intended to be part of the original construction of the CGT, but financial constraints prevented the project from being implemented. Stakeholders identified the radio rebroadcast system as an important component, and so it was included in the ITS upgrade. The voice/message override system added the capability for TMI employees to communicate instructions to motorists during an emergency or other events such as lane closures, bore closures, and adverse weather conditions.

The new digital radio equipment meets the public safety industry standard known as "P-25". It allows different agencies using different radio systems to communicate with each other. The NPS and some mutual aid partners have transitioned to digital radio. CGTA is now compatible with partnering agencies. With the radio rebroadcast system in place, CGTA has a greater range for NPS dispatch and can patch together multiple agencies for emergency response communications. CGTA thus expanded the radio range for NPS Ranger contact and dispatch and has enhanced its ability to integrate multiple agencies for coordinated emergency response communications.

4.3.3 Upgrade of Local DMS

There were several issues with the original message signs at the CGT. By 1999, the message signs had become outdated, and basic repair modules were no longer available from the manufacturer. Various other components of the message signs had to be repaired in-house multiple times. A replacement for the message signs was needed. New signs were procured from a stable modern vendor whose sales and operations included a wide range of customers. This upgrade was intended to allow CGTA to more efficiently communicate real-time information to drivers and more easily maintain the DMS.

The new DMS system includes the following signs:

- eight three-line signs on the approaches to the Tunnel
- four two-line signs on the portal faces
- fourteen one-line signs in the Tunnel
- four one-line doubled faced signs in the Tunnel
- two two-line signs in the hazardous materials lanes

Other associated technologies include:

- 12 variable speed limit signs
- 28 lane usage signs
- 13 traffic signals
- Daktronics Vanguard NTCIP Compliant control software
- 22 digital cameras

4.3.4 Regional Deployment of DMS and CCTV

An expansion beyond the coverage area of the existing message signs was needed. A regional DMS system would allow traveler information to be communicated to motorists on I-75 near Corbin, Kentucky and I-81 near Morristown, Tennessee. These are locations where no regional signage had previously existed. Additional DMS with CCTV cameras were deployed at four locations in the area:

- I-75 Northbound near mile 23.5
- I-75 Southbound near mile 35.5
- I-81 Northbound near mile 3
- I-81 Southbound near mile 13.5

CGTA maintains all four signs and establishes a message on the DMS in Kentucky at the request of the transportation operations center (TOC) in Frankfort. Messaging responsibilities for the DMS in Tennessee are shared with the Knoxville Transportation Management Center. CGT operators utilize the regional DMS to inform drivers of incidents or weather events of interest to the travelling public.

The purpose of installing the additional CCTV cameras was to provide TMI operators with a tool for monitoring the two major interstates near CGT. The purpose for installing the additional DMS was to provide motorists with current regional travel information. Installation of the new CCTV cameras required an upgrade of the technologies in the tunnel control room to facilitate the monitoring of the additional cameras. A digital video recorder was needed to store the incoming images. The original Traffic Surveillance Control Software (TSCS) contractor was unable to upgrade the software to meet the requirements of the newer operating systems.

Therefore, the system upgrade necessitated new software, as described in section 4.3.5 of this report.

4.3.5 Upgrade of the Control Room

The upgrade to the CGT Control Room occurred in phases. The original CGT control room was planned and designed in the 1990s. Figure 3 shows the original control room in 1997. By the time most of the systems were installed, the control room hardware and software were already becoming outdated. Older hardware was wearing out and interim replacements were obtained. The Regional Architecture development included a plan for a systematic remodeling of the control room. Figure 4 shows an interim remodeling of the control room. This remodeling, completed in 2003, included Cathode Ray Tube (CRT) technology and limited flexibility in layout and work arrangement. A stable platform was needed for expanding and modernizing the control room.

Figure 3. CGT Control Room Circa 1997

Figure 4. CGT Control Room Circa 2003

The original TSCS, which controlled the local signage, was subcontracted in the original construction to a vendor with limited resources. Software patches and updates were slow in coming or nonexistent, and the vendor became unreliable. The new software allowed for improved control of the signs prior to the Tunnel and inside the Tunnel. Various traffic patterns were programmed into the software and could be used to direct traffic according to the conditions.

The Supervisory Control and Data Acquisition (SCADA) software was functional and used by the staff to monitor and control many of the tunnel facility's power, environmental, and access systems, such as:

- Ventilation fans
- Lighting
- Water valves
- Fire alarms
- Security system
- Power distribution system in Kentucky and Tennessee
- Other miscellaneous equipment.

The power distribution system was one of SCADA's main functions. Power came from both Tennessee and Kentucky; SCADA monitors the power distribution and can manipulate some breakers.

In September 2007 a new video wall and console were installed in the control room that included a 110" diagonal panel with two 67" diagonal LCD panels on either side. Two 45" diagonal LCD panels complemented the console. This new video display system improved image quality. The work surfaces were redesigned with the intent of providing a more open and flexible design. Figure 5 shows the control room following the upgrade in 2007.

Figure 5. CGT Control Room Circa 2007

CHAPTER FIVE: PROJECT OUTCOMES

This chapter presents the project outcomes based upon the objectives and hypotheses identified in Chapter 3. Both quantitative and qualitative data are included in these findings.

5.1 Findings of the Deployment

The research team gathered feedback from the stakeholders and collected data to assess the effectiveness of the CGT ITS components installed and to determine if the components installed met the original goals set forth in the FHWA-KYTC partnership agreement.

5.1.1 Stakeholder Findings

According to the stakeholders, the ITS deployment accomplished several things. First, the CCTV upgrade and expansion provided for additional information in the control room. The south camera provided the ability to observe breaks in the traffic, which allowed operators to stop traffic when there was a reduced chance for a rear-end collision. With the Cumberland Avenue camera, the control room operators could see hazardous material trucks approaching, and the operators could more easily escort two or more trucks at a time. The information from the cameras helped to identify and verify incidents more quickly. As a result, incident response was also improved. With the upgrade of the multiplexer, CGTA could store images and retrieve video of incidents. These upgrades to the equipment also led to increased efficiency in operations and maintenance, since there were fewer technical and integration problems.

The radio rebroadcast system served as an additional way to communicate with the public. Although this method has been rarely used, it is extremely important to have this capability in the event that motorists are stopped within the Tunnel. This component has improved traveler information and traveler safety within the Tunnel. It allows Tunnel personnel the ability to "patch" the radio systems of other emergency service providers in the area.

The upgrade of the local DMS has improved traveler information by allowing greater use of each sign and the placement of additional signs. This upgrade has also led to increased efficiency in operations and maintenance, since the newer technology has led to fewer technical and integration problems. The new DMS also provided easier access for repair, preventing CGTA from having to stop traffic for maintenance on the DMS.

Regional deployment of DMS and CCTV has improved traveler information within the region. These signs and cameras are in critical locations to allow traffic to be detoured away from the Tunnel if necessary. This deployment also provided critical regional traffic information to the Control Room. Traveler information on the interstate highways can also be given through messages on the signs.

The upgrade of the Control Room allowed operators to more efficiently and safely open and close the Tunnel for hazardous material vehicle escorts. This is another instance where the upgrades increased efficiency of operations and maintenance, since the newer technology led to fewer technical and integration problems. From the stakeholders' view, it appears that the ITS deployment served to meet several objectives as identified in Chapter 3:

- ✓ Improved Traveler Information
- ✓ Improved Integration of the Tunnel Systems
- ✓ Improved Incident Detection, Verification, and Response Time
- ✓ Improved Traveler Safety
- ✓ Improved Traveler Mobility
- ✓ Improved Transportation System Efficiency

5.1.2 Quantitative Indicators

Quantitative indicators were also used to assess the effects of the ITS components that were installed. Stakeholders perceived that motorists' safety would be improved by installing detection, verification, and information systems in the vicinity of the CGT and along the U.S. 25E corridor. These systems operated by the CGTA would afford operators the ability to verify incidents and provide the necessary information to travelers so they can make the best travel decisions to avoid the incident. This would help to reduce traffic congestion and reduce the likelihood of secondary crashes. The small number of crashes occurring in this vicinity makes it difficult to make many conclusions about improvements to safety around the Tunnel. However, looking at total crashes for four years before installation and upgrade of the ITS began (1999-2002) and four years after (2003-2006), there are some significant findings. Kentucky's total crashes dropped from 86 to 49 and Tennessee's dropped from 18 to 17. This is a total decrease in crashes from 104 to 66. Table 6 below shows crash and traffic volume data supplied by both TDOT and KYTC. The crashes are broken down into three categories: property damage only (PDO), injury, and fatal.

Table 6. Crash and Volume Data Around CGT

Year	PDO	Injury	Fatal	Total	Volume	PDO	Injury	Fatal	Total	Volume	Grand
Kentucky Data						Tennessee Data					Total
1999	12	9	0	21	24100	6	2	0	8		29
2000	11	7	0	18		2	2	1	5		23
2001	18	3	0	21		1	0	0	1		22
2002	25	1	0	26	24500	3	1	0	4	22736	30
2003	8	5	0	13		3	0	0	3		16
2004	12	1	0	13		1	3	0	4		17
2005	5	2	0	7	20000	3	1	1	5	22670	12
2006	13	3	0	16		3	2	0	5		21
2007	10	4	0	14		3	2	0	5		19
2008	13	1	0	14	20100	3	0	0	3	21543	17
2009	23	1	0	24	21600				0	21117	24

Notes: Kentucky Crash Data for U.S. 25E from MP 0.00 to MP 1.8 in Bell County
Tennessee Crash Data for U.S. 25E from MP 19.30 to MP 20.96 in Claiborne County

Unfortunately, complete traffic volume records were not available, so there are several gaps in the data. Volumes appear to decrease in both Kentucky and Tennessee over the period presented in the table. CGTA personnel and NPS management believe there has been a substantial increase in traffic volume since the Tunnel opened. They do not trust that the available volume data is accurate. Therefore it is also difficult to make any conclusions using the volume data.

Data does exist, however, on the number of hazardous material vehicles escorted through the Tunnel. Hazardous material vehicles must receive a visual inspection and wait for the Tunnel to be closed to public traffic so they can be escorted through the Tunnel. Very thorough records are kept on these escorts through the Tunnel.

Table 7 reveals the rising use of the Tunnel by hazardous material vehicles. In the 2000-01 fiscal year, 24,708 hazardous material vehicles were escorted trough the Tunnel. The peak year for such vehicle escorts was 2005-06, when 31,308 were escorted. The number of hazardous material vehicles escorted has declined somewhat since then with 28,900 being escorted in 2007-08, the most recent year for which this information is available. The table also shows an increase in the number of vehicles per escort. One of the specific objectives of tunnel management was to escort more than one hazardous material vehicle at a time. The six years of data show slow, consistent improvement over time. In 2000-01 the average number of vehicles per escort was 1.27 and in 2007-08 the average number was 1.41. This is an increase of more than 11%. This is an indication that tunnel operators are being more efficient about closing the Tunnel for hazardous material escorts. This also has safety implications, since traffic is being stopped more efficiently resulting in fewer opportunities for closure-related incidents. Lastly, another indicator of the effectiveness of the CGT ITS systems is the low number of hazardous material incidents. There have been no crashes involving hazardous material carriers in the Tunnel area. Despite the increase in hazardous material vehicle traffic, the number of incidents was five in fiscal year 2000-2001 and five in 2007-2008. The number has varied between two and six over the six year period, with no indication of an increasing trend.

Table 7 also shows information on incidents around the Tunnel. An incident could be anything from a serious accident, a suitcase falling off the roof of a car, or a motorist running out of gas. The total number of incidents is provided by year, but also included are the number of emergency incidents (with ambulance response), the number of motor vehicle emergency incidents (including crashes), and other emergency incidents (which are mostly medical). The data indicates that there was a significant increase in incidents from 2000-01 to 2007-08, more than 70%. This data alone, however, does not help to make any conclusions about the improvements in safety at the Tunnel. Without accurate volume data, it is difficult to say what this incident data indicates. It could be an indication of decreased safety (which seems unlikely) or it could be an indication of increased volumes of traffic at the Tunnel (which is expected although not supported). The limited data on the specific types of incidents makes it very difficult to make any conclusions based on this information.

Table 7. Tunnel Statistics on Incidents and Hazardous Material Activities

Year	# of Incidents	# of Emergency Incidents (ambulance response)	Motor Vehicle Emergency Incidents including crashes	Other Emergency Incidents—mostly medical	HazMat Vehicles Escorted	# of Vehicles per Escort	HazMat Spills/ Incidents
2000-2001	718	20	15	5	24,708	1.27	5
2001-2002	760	24	14	10	28,804	1.27	6
2002-2003	866	20	9	11	27,555	1.27	2
2003-2004	1199	27	25	2	27,872	1.28	2
2004-2005	1205	27	19	8	30,435	1.36	5
2005-2006	1208	25	21	4	31,308	1.35	3
2006-2007	1147	35	24	11	30,985	1.39	3
2007-2008	1230	23	19	4	28,900	1.41	5

From the quantitative data that was examined as part of this evaluation, it appears that the ITS deployment served to meet the following objectives:

- ✓ Improved Traveler Safety
- ✓ Improved Traveler Mobility
- ✓ Improved Transportation System Efficiency

5.1.3 Evaluation of Hypotheses

All of the identified hypotheses for this study were evaluated based on input from the stakeholders and analysis of available data. The following summary identifies each hypothesis as true, partially true, false, or undetermined. Also included for each hypothesis is evidence to support the finding.

H1. The implementation and integration of the ITS components would facilitate the passage of increased traffic through the Tunnel corridor.

PARTIALLY TRUE. There was insufficient data to determine if traffic volume increased through the Tunnel. However, the hazardous material records did reflect increases in the number of hazardous material escorts through the Tunnel.

H2. The implementation and integration of the ITS components would improve safety around the Tunnel by reducing rear end collisions during hazardous material escorts.

PARTIALLY TRUE. There were no records on the number of rear end collisions at the Tunnel. However, there was a substantial drop in the total number of crashes in the vicinity of the Tunnel. Also Tunnel operators reported an increase in safety with the ability to monitor traffic more closely using the CCTV and to select optimal times to stop traffic.

H3. The implementation and integration of the ITS components would improve the operations and maintenance procedures within the Tunnel.

TRUE. There were several updates that allowed for improved efficiency in operations and maintenance. The multiplexer allowed for more storage of images and the ability to retrieve video. The radio rebroadcast system gave operators the ability to communicate with motorists within the Tunnel. New and additional DMS and CCTV helped to expand coverage. The new DMS were also easier to access for maintenance and eliminated the need to stop traffic for maintenance to be performed. In general, the newer technology led to fewer technical and integration problems as well.

H4. The implementation and integration of the ITS components would facilitate an increase in the average number of hazardous material vehicles per escort through the CGT.

TRUE. Data on hazardous material escorts showed that there has been a slow, but steady increase in the number of hazardous material vehicles escorted per closure. In 2000-01 the average number of vehicles per escort was 1.27 and in 2007-08 the average number was 1.41.

H5. The implementation and integration of the ITS components would provide a mechanism to enhance traffic and weather information to travelers in the region surrounding CGT.

PARTIALLY TRUE. The installation of DMS on I-81 and I-75 has enhanced traveler information in the region. The signs and cameras are in critical locations that allow traffic to be detoured away from the Tunnel if necessary. Previously, there was no effective way to detour traffic around the Tunnel. There have been no enhancements to weather information as a result of this project.

H6. The implementation and integration of the ITS components would help personnel to detect, verify, and respond to incidents in and around the Tunnel more quickly.

TRUE. Although the time to identify, verify, and respond to incidents is not recorded by CGT, the operators do believe that the added camera coverage has greatly enhanced their ability to detect and verify an incident. This also allows the operators to request assistance from responders more quickly and should decrease response time.

5.2 Technical and Institutional Issues

This section identifies stumbling blocks and describes the steps taken to avoid or overcome them. This was a complex ITS deployment involving many partners and stakeholders as well as the integration of several new technologies. The following technical and institutional obstacles were identified.

5.2.1 Lack of Expertise

ITS deployments were relatively new in 1998, and KYTC did not have sufficient staff to develop a Regional ITS Architecture for the Cumberland Gap Tunnel area. Although the Project Manager was familiar with the National ITS Architecture and was experienced in the development of ITS Regional Architectures for two Traffic Management Centers, outside expertise was needed.

5.2.2 Difficult and Lengthy Procurement Process

The Project Manager procured a pre-qualified firm to develop the Regional ITS Architecture, the Strategic Plan for the corridor, and the Integration plan for the field deployment. This was done through provisions of the Kentucky Revised Statutes (KRS) 45A and Kentucky Administrative Regulations (KAR) 600. The project manager prepared a Professional Services Bulletin to announce the need for ITS services.

A pre-qualified firm with the requisite expertise (TRW) was selected and placed under contract. While this method was successful, the pace of the deployment was slowed considerably due to the length of the procurement process. The Architecture and Strategic and Integration Plans took one year to complete after the consultant was authorized to start.

The process took two years and created concerns for senior management and the local project champion. As a result of this delay, some stakeholders lost interest in the project. Kentucky's concerns with the institutional issues regarding the procurement of ITS technologies were reported in a 2007 analysis of Kentucky's procurement processes. (3)

5.2.3 Lack of Traffic Count Data

An issue that presented itself in the course of this evaluation was the lack of accurate continuous traffic count data at the Tunnel. Such data was needed to gain a more precise estimate of the impact of ITS on traffic management and safety. Had the Project Manager foreseen the impact, automated count and classification stations could have been installed early on in the deployment.

Both Kentucky and Tennessee lack a continuous traffic counting system near the CGT. Staff at the CGT believe the traffic volumes are much higher than the volumes reported by the respective state agencies. Continuous traffic counting systems could be installed in Kentucky and Tennessee with remaining funds in order to provide data for future decisions.

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CHAPTER SIX: LESSONS LEARNED AND RECOMMENDATIONS

This chapter describes the lessons learned from the ITS deployment at the CGT. The ITS deployment for the CGT and U.S. 25E corridor was a successful demonstration of the usefulness of ITS technologies. The following are some of the key lessons learned from this ITS deployment and also serve as recommendations for future deployment:

- **Engage Stakeholders –** Local and regional stakeholders were engaged early and made significant contributions during the planning process. This input was foundational for the project and resulted in the implementation of a well-received, valuable project for the region. Identification and engagement of stakeholders should be an early activity for all ITS projects.

- **Identify a Project Champion -** A local project champion was identified who was committed to seeing the project succeed. The project champion was instrumental in engaging stakeholders and communicating with them throughout the deployment. He had a thorough understanding of the CGT region and project and was a valuable resource.

- **Plan for the Project –** Proper planning for an ITS project is critical. Sufficient funding was set aside for the planning and architecture development for the CGT project. This allowed the project team to incorporate input from the stakeholders and have a clear goal for the deployment. However, thought should have also be give to performance measures. How will the success of the project be measured and what tools need to be in place to measure that performance? Traffic count systems at the Tunnel would have been helpful in measuring the volume of traffic accommodated by the ITS deployment. Future ITS deployments should start with good planning and identification of performance measures.

- **Establish Institutional Agreements** - Formal partnership agreements should be established early in the project. This helps to ensure that even when key agencies experience leadership changes, there is still commitment to the project.

- **Find Expertise Within –** A project manager who has had significant experience with ITS should be chosen for the deployment. The planning, procurement, and deployment of ITS can be lengthy and complicated. Having a project manager with prior experience with ITS deployments can make the process proceed more quickly and smoothly.

- **Find Expertise Outside -** When the expertise for the project (or some component of the project) is not available in-house, the needed expertise should be obtained from consultants or other outside organizations. An expert consultant was hired to develop the ITS Regional Architecture, Strategic Plan, and Integration Plan. This was an area where KYTC did not have the necessary expertise in house. This was a critical part of the planning process for the project.

- **Prepare for a Lengthy Procurement Process** - The procurement process for an ITS deployment project can be difficult and lengthy. Delays in this process can reduce stakeholder interest for the project. Prepare stakeholders for a lengthy procurement, and investigate procurement options at the start of the project.

- **Utilize a System Integrator for the Duration of the Project** - The ability to work with a single system integrator over the life of the CGT ITS deployment was an important aspect of the project's success. The use of a system integrator can help to ensure that accountability rests with a single firm and with that firm's subcontractors.

One recommendation specific to the Tunnel is the **implementation of traffic count systems**. This would allow stakeholders to measure the flow of traffic through and around the Tunnel and would provide valuable data to the stakeholders.

REFERENCES

1. ITS Partnership Agreements between FHWA and KYTC dated October 3, 1998 and November 5, 1999.
2. CGT ITS Regional Architecture developed by TRW for KYTC dated June 11, 2002.
3. "Analysis of Procurement Processes and Development of Recommendations for Intelligent Transportation Systems (ITS) Procurements" September 2007, KTC-07-28, J.D. Crabtree, C.W. Frost, J.R. Walton, J.M. Crossfield

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APPENDIX A: GLOSSARY

Bi-State Agreement - The supplement agreement between KYTC and TDOT spelling out each state's responsibilities with the ITS deployment.
CCTV - Closed-circuit television: a video camera system designed for monitoring highway traffic.
CGT - The Cumberland Gap Tunnel: a twin-bore tunnel through the Cumberland Gap National Historical Park's Cumberland Mountains.
CGTA - Cumberland Gap Tunnel Authority: the public face name of the company that manages the CGT.
CIO - Chief Information Officer: Kentucky state government's senior technology and communications officer
CRT - Cathode Ray Tube: a vacuum tube video technology developed in the early 1920s that provides a crisp bright display. CRTs are generally large, heavy, and cube-like.
DMS - Dynamic Message Sign: an electronic highway traffic sign providing traveler information to motorists. The DMS may be stationary or portable and may be a part of a system of signs.
DVR - Digital Video Recorder: an electronic device that records images in digital form from multiple CCTV cameras used for detection and documentation.
EFLHD - Eastern Federal Lands Highway Division: The Eastern Federal Lands Highway Division part of the Federal Lands Highway Program of FHWA administered the construction of the Cumberland Gap Tunnel construction.
ESS - Environmental Sensor Station: a roadway location consisting of one or more sensors measuring atmospheric, pavement, soil, or hydrologic conditions.
FHWA - The Federal Highway Administration: the national level transportation agency administering federal Highway Trust Funds.
FHWA, Kentucky Division - The local office in Kentucky for FHWA administering federal Highway Trust Funds.
HAR - Highway Advisory Radio: a licensed low-power radio station to provide traveler information to motorists.
HazMat - Hazardous Material: materials or goods in various forms capable of causing ill health effects and/or damage to property.
ISTEA - Intermodal Surface Transportation Efficiency Act: a 1991 US federal law which instituted an intermodal approach to transit/highway funding.
ITS - Intelligent Transportation Systems: the use of modern communications and technology to solve transportation problems.
ITS Partnership Agreement - A supplemental agreement to award a grant of Federal assistance to KYTC for the specific ITS activities authorized by TEA21.
KTC - Kentucky Transportation Center: a grant-funded transportation research organization which operates through the University of Kentucky in Lexington, Kentucky.
KYTC - The Kentucky Transportation Cabinet: the state level transportation agency in Kentucky.
LCD - Liquid Crystal Display: an electronic video technology, using liquid crystals, that provides a clearer and brighter display that is lightweight and has low power consumption.
NGC - Northup Grumman Corporation: the consulting firm that bought out TRW and finished plans for the deployment.

NPS - The National Park Service: the agency of the US Department of the Interior responsible for the national parks.
Project Champion - A regional stakeholder with a vested interest in the outcome of the deployment.
Project Manager - The KYTC engineer assigned to coordinate/administer the ITS deployment associated with the two agreements.
PS&E - Plans, Specifications, and Estimate: the various documents prepared by an engineer that provide the construction plans, the material specifications, and the estimated cost to deploy the project.
RITA - Research and Innovative Technology Administration: the agency of the US Department of Transportation that coordinates research programs including ITS research and evaluation.
RWIS - Road Weather Information Station: an ESS in the field near a roadway, designed to gather and transmit weather and roadway status to a central source.
SAC - Study Advisory Committee: the committee formed to advise and guide the research team.
SCADA - Supervisory Control and Data Acquisition: the software that monitors and controls many of the tunnel facility's power, environmental, and access systems.
TAC - Technical Advisory Committee: a working group established to provide general guidance and oversight to the ITS deployment.
TDOT - The Tennessee Department of Transportation: the state level transportation agency in Tennessee.
TEA-21 - The Transportation Equity Act for the 21st Century: enacted June 9, 1998 as Public Law 15-178 authorizing the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003.
TMI - Tunnel Management, Inc.: the firm holding the contract for managing the tunnel operations.
TRW - Thompson Ramo Woolridge, Inc.: the consulting firm that developed the ITS Regional Architecture for the CGT area.
TSCS - Traffic Surveillance Control System: software that coordinates the deployment of messages on the DMS.

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