S.R. 0202, Section 404
Intelligent Transportation System (ITS) Deployment

Final Report

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S.R. 0202, Section 404 ITS
Final Report

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EXECUTIVE SUMMARY

The Route 202, Section 404 Roadway Reconstruction Project included the installation of a new Intelligent Transportation System (ITS) along sections of S.R. 0202, S.R. 422, I-476 and I-76 in the Philadelphia metropolitan area. The ITS system design originally included a 12-camera Video Incident Detection (VID) system, a 46-camera Closed Circuit Television (CCTV) system, a Dynamic Message Sign (DMS) system consisting of 10 permanent and 4 portable signs, and a fiber optic communications system with short sections of spread spectrum and leased T-1 lines. During the construction phase of the project, two additional items were added to the project's scope: (1) installation of an additional five CCTV cameras, bringing the total number of new CCTV cameras to 51, and (2) work to make functional a part of the ramp metering system on I-476, including provision of a communications connection to the District 6-0 Traffic Control Center (TCC) and system activation and testing. This ITS project nearly doubled the number of ITS elements being managed from the District 6-0 Traffic Control Center (TCC) and represents the largest ITS deployment to date in the Philadelphia metropolitan area and the Commonwealth of Pennsylvania.

The construction and implementation of the ITS system was separated into two phases to allow for coordination with the overall roadway construction schedule. The separation of the ITS system into two phases also allowed PennDOT to test a newer type of CCTV camera on Phase I before fully deploying the Phase II CCTV cameras. All of the Phase I ITS elements were installed and tested at the TCC by November 2001. All Phase II ITS elements, including the five additional CCTV cameras and ramp metering activities, were completed and tested by October 31, 2004.

The deployment of this ITS Project was fully compliant with the Project Work Plan that was approved by PennDOT and FHWA in February 2000. All of the ITS elements that were listed in the Project Work Plan were successfully deployed and integrated into the existing Traffic and Incident Management System at the PennDOT District 6-0 Traffic Control Center without exceeding the federal earmark funds for the ITS Integration component of the ITS deployment or PennDOT's matching portion of those funds.

This project has provided a number of direct and indirect benefits to PennDOT and travelers in the Philadelphia region, including the following:

- Improved Traffic and Incident Management Capabilities – the project nearly doubled the number of CCTV cameras and DMS available for traffic and incident management, as well as providing the Department with its second automatic incident detection system, which will enhance the TCC operators' ability to detect and manage incidents.

- Provision of Traveler Information – through PennDOT's DMS system and Information Service Providers (ISPs) including Traffic.com and SmarTraveler, the traveling public has access to additional traveler information as a result of this ITS deployment.

- Provision of Fiber Optic Communications Backbone - the project deployed the first backbone of fiber optic cable that is directly connected from the field back to the TCC. This fiber backbone will provide the Department with a high-quality, reliable communications system that is free of the high recurring costs associated with dial-up telephone, leased T-1 lines and wireless communications via commercial providers. The fiber backbone also includes spare conduit and fibers for PennDOT's use during future system expansion.

- Economic and Environmental Benefits – there are a number of direct and indirect economic and environmental benefits associated with the reduction in delays, accidents and fatalities.

Although this project was successfully completed according to the Project Work Plan and within the budget, there were a number of design and construction challenges that needed to be resolved. The successful resolution of these challenges has allowed all parties involved to benefit from several "lessons learned" that will help with future ITS deployments. The major lessons learned from this deployment are the following:

- Effective, Ongoing Coordination is a Key to Success – ITS deployments are still relatively new and many contractors and engineers are not completely familiar with the details associated with constructing, integrating and testing advanced technologies. It is important to recognize this and maintain close coordination between ITS designers/installers and the remainder of the design and contracting team.

- Flexibility and Creativity is Important with ITS Deployments - ITS projects are unique and ever-changing, which requires designers, constructors and integrators to be flexible and creative with the deployments. For this project, this meant separating the ITS deployment into two phases to match the roadway reconstruction schedule and bring a number of ITS elements online earlier than would have been possible under a single phase deployment. The two phase deployment process also allowed for the evaluation of a newer CCTV technology before full deployment on the larger Phase II.

- Design-Bid-Build Contracting and Roadway Reconstruction Projects are not "ITS-friendly" – due to the rapidly evolving technologies associated with ITS deployments, the traditional design-bid-build contracting mechanism presents challenges to system designers and integrators. Often, the time between design and installation is a period of one or more years, which can represent a period of significant changes in the ITS field. The deployment of ITS systems as part of roadway reconstruction projects can also present challenges. The ITS portion of a roadway reconstruction project typically represents a small percentage of the work to be completed and the overall project cost. As such, the constraints related to the roadway design and construction schedule take priority over the ITS design and construction scheduling concerns. In addition, the bidding process for a major roadway reconstruction project focuses much more heavily on the qualifications and experience (and cost) of the general contractor, not the ITS subcontractor.

Overall, this project was successfully completed on time and within budget, and will provide a number of direct and indirect benefits to PennDOT and the travelers in the Philadelphia region.

1 INTRODUCTION

This document serves as FHWA's Final Report for the SR 0202, Section 404 ITS project. At the time of its deployment, this project represented the largest ITS deployment to date in the Philadelphia metropolitan area and the Commonwealth of Pennsylvania, and nearly doubled the number of ITS elements available for traffic management and traveler information purposes at the PennDOT District 6-0 Traffic Control Center (TCC).

This report will provide an overview of the project and a complete summary of the implementation process. It will also present an analysis of the project's compliance with the Project Work Plan. The direct and indirect benefits of the deployment will also be presented, as well as a section on Lessons Learned. Finally, photographs of key project elements are presented in Appendix A.

2 KEY PROJECT PARTICIPANTS

Participant	Role	Contact Person
FHWA	Project Oversight/Guidance	Carmine Fiscina
PennDOT 6-0 Traffic Unit	Project Oversight/Guidance	Dennis Tiley/ Emmanuel Anastasiadis
PennDOT Construction	Project Construction	Rex Mackey/Steve Laws
Urban Engineers	Construction Management	Al Alberts
URS	Prime Design Consultant	Tom Friel/Dave Littlewood
Gannett Fleming	Subconsultant – ITS	Miomir Ivanovic/Matt Schiemer
DMJM+Harris	Subconsultant – ITS	Ed Reagle

3 PROJECT DESCRIPTION

The Federal Highway Administration, together with the Pennsylvania Department of Transportation, initiated the Route 202, Section 404, Roadway Reconstruction Project, which includes the installation of a new ITS system along sections of S.R. 0202, S.R. 422, I-476 and I-76 in the Philadelphia metropolitan area. The ITS system design originally included a 12-camera Video Incident Detection (VID) system, a 46-camera Closed Circuit Television (CCTV) system, a Dynamic Message Sign (DMS) system consisting of 10 permanent and 4 portable signs, and a fiber optic communications system with short sections of spread spectrum and leased T-1 lines. The ITS system was designed to be constructed and implemented in two phases, to allow for the ITS system to be constructed in coordination with the overall roadway construction schedule. During the construction phase of the project, two additional items were added to the project's scope: (1) installation of an additional five CCTV cameras, bringing the total number of new CCTV cameras to 51, and (2) work was completed to make functional a part of the ramp metering system on I-476, including provision of a communications connection to the District 6-0 Traffic Control Center (TCC) and system activation and testing. This ITS project nearly doubled the number of ITS elements being managed from the District 6-0 Traffic Control Center (TCC) and represents the largest ITS deployment to date in the Philadelphia metropolitan area and the Commonwealth of Pennsylvania.

4 PROJECT IMPLEMENTATION SUMMARY

The design of the ITS system was completed by Gannett Fleming and DMJM+Harris, who worked together as subconsultants to the overall reconstruction project's prime consultant, URS. The ITS consultants worked closely with FHWA and PennDOT during the design process and remained actively involved in the project during the construction, integration and testing of the ITS system. Construction of the ITS system began in April 2001 and finished on October 31, 2004 (including all integration, testing, training and operational support periods).

The construction and implementation of the ITS system was separated into two phases to allow for coordination with the overall roadway construction schedule. Phase I of the ITS system included all of the ITS elements located along Route 422, beginning at Route 202 and extending west to Route 29. This section of the project includes ten CCTV cameras, two permanent DMS, one portable DMS and a fiber optic communications backbone that runs along Route 422 and is connected back to the TCC. All of the CCTV cameras and the two permanent DMS are connected to the TCC via the fiber optic system; the portable DMS is located beyond the limits of the fiber optic backbone and utilizes a hard-wired dial-up telephone connection for control from the TCC. All of the Phase I ITS elements were installed and tested at the TCC by November 2001.

In addition to providing coordination with the overall construction schedule, the separation of the ITS system into two phases also assisted in addressing an issue that is common with ITS systems that are implemented as part of large roadway reconstruction projects. With these types of projects, the ITS system design is often completed a year or more before equipment procurement takes place. While this time period does not normally pose a problem with traditional roadway elements such as steel sign structures or concrete pipes, a period of one year often means changes in the technologies that are utilized as part of the ITS system. Many times this results in the implementation of a system that does not represent the latest technologies available on the market. The Route 202 ITS project was faced with precisely this type of issue during the procurement of the CCTV cameras. The CCTV cameras that were submitted by the Contractor represented the latest technology, but were drastically different from the CCTV cameras that were specified in the contract. The CCTV cameras that the contractor submitted were relatively new off-the-shelf products that were only available as prototypes during the design of the ITS system. The two-phase nature of the Route 202 ITS project was utilized to test the CCTV cameras on Phase I (ten cameras) prior to selecting cameras for implementation throughout Phase II (36 cameras).

Three different types of CCTV cameras were chosen for implementation in Phase I - two newer CCTV cameras and one CCTV camera that PennDOT District 6-0 had already deployed on previous projects. In order to test the performance of the two newer types of CCTV cameras, the Department chose to install nine of the newer types and one of the older types for comparison purposes. This allowed the Department to evaluate the performance of the newer CCTV cameras for a period of several months before making a decision as to which camera(s) to procure for the 36 additional cameras in the Phase II CCTV system. Ultimately, the Department chose to implement one of the newer CCTV camera types throughout Phase II. The camera that was selected was a high-speed PTZ (pan-tilt-zoom) dome camera capable of operating as a color camera in daylight conditions and a black-and-white camera in low-light conditions at night.

Construction on Phase II of the ITS project began in early 2002. The original Phase II system included CCTV cameras and permanent and portable DMS units along Route 202, I-76 and I-476. In addition, there is a 12-camera VID system located along Route 202. Nearly all of these field elements are connected directly to the TCC via a fiber optic communications system that runs along Route 202, I-76 and I-476. The two easternmost CCTV cameras on I-76 are located outside of the limits of the fiber backbone and utilize a dedicated T-1 telephone line for communications. Three other CCTV cameras that are also outside of the fiber backbone utilize microwave communications for short segments before being connected into the fiber optic system for final connection to the TCC. The two portable DMS units utilize hardwired dial-up telephone communications for control from the TCC.

The video incident detection system deployed as part of this project represents the second type of vehicle detection system deployed in District 6-0. The first automatic incident detection system in the District was deployed on I-95 and utilizes radar-based vehicle detection technology. The Department chose to utilize video-based vehicle detection technology on Route 202 as a way of evaluating the performance of both types of vehicle detection systems. (Both systems utilize the same All Purpose Incident Detection (APID) algorithm). The VID system was configured, tested and put into operation in April 2004. Once it was tested, Gannett Fleming worked closely with the Department and the Contractor as the system was fine-tuned during an extended operational testing period of six months.

In addition to the ITS elements contained in the original system design, Gannett Fleming also worked with the Department and the Contractor for the installation of five additional CCTV cameras and additional work on the ramp metering system on I-476. Four of the new CCTV cameras were installed to monitor ramp metering operations at three interchanges on I-476. Specifically, these cameras have been deployed to monitor traffic operations on the I-476 mainline, ramp and ramp approaches at the interchanges with McDade Boulevard, Baltimore Pike and U.S. 1. Since these cameras are located several miles away from the fiber backbone they utilize dedicated T-1 telephone service for communications with the TCC. The design also includes the use of data channels on the same T-1 communications circuit to provide remote control of the ramp metering systems from the TCC; as well the additional work required to make the ramp metering system operational with control from the TCC. The fifth new CCTV camera was installed at the interchange with I-76, Route 202 and Route 422 to augment coverage of the numerous roadways and ramps at that interchange. This camera was provided with a fiber optic communications connection back to the TCC over spare fiber that was provided as part of the fiber optic communications backbone.

All Phase II ITS elements, including the five additional CCTV cameras and ramp metering activities, were completed and tested by October 31, 2004.

5 COMPLIANCE WITH PROJECT WORK PLAN

The deployment of the SR 0202, Section 404 ITS Project was fully compliant with the Project Work Plan that was approved by PennDOT and FHWA in February 2000. All of the ITS elements that were listed in the Project Work Plan were successfully deployed and integrated into the existing Traffic and Incident Management System at the PennDOT District 6-0 Traffic Control Center without exceeding the federal earmark funds for the ITS Integration component of the ITS deployment or PennDOT's matching portion of those funds. PennDOT obtained additional National Highway System (NHS) funding for the additional CCTV cameras and ramp metering work that was completed under this project without increasing or exceeding the federal earmark funds originally allocated for this project. The following provides a detailed review of the Project Work Plan goals for this deployment.

5.1 CCTV System

The Project Work Plan indicated that approximately 46 CCTV cameras would be deployed for: traffic monitoring, incident detection, incident confirmation, incident management activities, and that the system should ultimately allow for public access to the images and information produced from the images. Under this project, 51 CCTV cameras were successfully deployed and are currently integrated and operational from the TCC. These cameras are currently used for all of the operational purposes highlighted in the Work Plan, and for the provision of images to the public via local television stations, who have access to the CCTV video images. The information from the CCTV images is also provided to the public via information service providers (ISPs) such as Traffic.com and SmarTraveler. Traffic.com has 24-hour/7-day operations staff that actively reviews PennDOT's CCTV cameras and provides traveler information to the general public via the web (www.traffic.com), radio, satellite radio, television and in-vehicle telematics systems. SmarTraveler also has access to PennDOT's CCTV video images and provides traveler information in a similar manner on the web (www.smartraveler.com) and through a wide variety of television and radio stations in the Philadelphia area. While the direct provision of video images on PennDOT's webpage was not contained in the project's scope of work, the current implementation allows for such a service to be provided under a separate contract in the future.

5.2 Variable Message Sign (VMS) System

The Project Work Plan indicated that ten permanent and four temporary VMS would be deployed and controlled from the TCC. Under this project, ten permanent and four temporary VMS were successfully deployed and are currently integrated and operational from the TCC.

5.3 Automatic Incident Detection System

The Project Work Plan indicated that a video detection system with an incident detection system would be deployed under this project. This project successfully deployed, integrated and tested a video incident detection system that is currently operational from the TCC.

5.4 Communication System

As indicated in the Project Work Plan, this project included the successful deployment of a communications system that consists of a fiber optic network, as well as microwave, T-1, and dial-up telephone service. The only change from the original design was the use of hard-wired dial-up telephone communications for the four portable VMS units, which were originally planned to use CDPD communications. This change occurred due to the nationwide phasing out of CDPD service, which was not anticipated at the time the design was completed. All portable VMS units were successfully hardwired for dial-up communications and are completely operational from the TCC.

5.5 Integration with the TCC

The Project Work Plan indicated that a separate project was underway to relocate the District's TCC into the District Office where it is currently located. This relocation did occur and all elements deployed under the SR 0202, Section 404 ITS project were successfully integrated into the new control center. All CCTV cameras, DMS and Incident Detection control were integrated into existing desktop computers, operator consoles and the video switcher/control keyboard for full functionality alongside the existing systems that were already operational at the TCC before this project was deployed. Specifically, the 51 new CCTV cameras deployed under this project are fully integrated into the existing system and are controlled, like the rest of the CCTV cameras at District 6-0, from the CCTV control keyboards at the operators' consoles. The permanent and portable VMS units' control software was integrated into the existing desktop computers from where the other VMS units utilized in District 6-0 are controlled. The incident detection control software was deployed on new incident detection servers at the TCC, but is integrated into the operator's console for full control from an existing operator's position. Further, as indicated in the Project Work Plan, the purchase and installation of central computer software at District 6-0's TCC is currently integrating all DMS control from the desktop computers adjacent to the operators' consoles into the operators' consoles themselves. This integration was not part of the SR 0202, Section 404 ITS project scope of work.

5.6 Schedule

The Project Work Plan indicated that the ITS portion of the Route 202 reconstruction project was anticipated to take 40 months to complete. The actual construction of the ITS system was completed in 42 months, including the additional work required to design, install and test five additional CCTV cameras and activate and test a part of the ramp metering system for full functionality and remote operation from the TCC.

5.7 System Benefits

This project has provided a significant expansion of the ITS system in the Philadelphia metropolitan area. The project nearly doubled the number of CCTV cameras and DMS available for traffic and incident management, as well as providing the Department with its second automatic incident detection system, which will enhance the TCC operators' ability to detect and manage incidents. In addition, the project deployed the first backbone of fiber optic cable that is directly connected from the field back to the TCC. This fiber backbone will provide the Department with a high-quality, reliable communications system that is free of the high recurring costs associated with dial-up telephone, leased T-1 lines and wireless communications via commercial providers. Overall, this system will provide a number of direct and indirect benefits, including the following:

<u>Improved Traffic and Incident Management Capabilities</u>
The deployment of this system will allow PennDOT to provide traffic and incident management services on some of the most heavily utilized and congested roadways in the Philadelphia area. In this way, the system will allow PennDOT to provide better customer service to the users of the roadways. This will offer significant benefits to the traveling public in the form of reduced delays, accidents and fatalities, as has been shown with similar deployments elsewhere around the country. It will also allow for improved coordination with emergency service providers (police, fire, ambulance), which will result in faster response times to accidents and more accurate accident information being provided to emergency responders before they arrive on the scene. The DMS deployed under this project also provide the Department with the ability to provide Amber Alerts.

<u>Provision of Traveler Information</u>
The first type of traveler information available from the use of this ITS system is the provision of messages on the 14 DMS installed under this project. All of the DMS are located in and around the areas where TCC operators have real-time CCTV video images of roadway conditions and all of the DMS deployed under this project have communications connections with the TCC. This allows the TCC operators to provide actionable, real-time traveler information to drivers on the most congested roadways in the Philadelphia area.

The second type of traveler information available from this deployment is via media outlets and information service providers (ISPs), which reach travelers through a broad range of channels. PennDOT District 6-0 provides the images from all of its CCTV cameras to several local television stations and to ISPs including Traffic.com and SmarTraveler. The local television stations regularly utilize PennDOT's real-time CCTV camera images as part of their traffic broadcasts. Traffic.com maintains a private 24/7 operations center and its operators view all of PennDOT's CCTV cameras (in addition to other activities) to provide real-time traveler information via their website and to radio stations, XM and Sirius satellite radio, TV stations and in-vehicle telematics. SmarTraveler utilizes PennDOT's CCTV cameras in a similar manner, providing traveler information on its website and a number of TV and radio stations in the Philadelphia area. The traveler information provided by ISPs reaches a large number of Philadelphia area residents through all of these channels, and is based, in part, on the CCTV images provided by PennDOT. In this way, the CCTV cameras provide a great benefit to the general public for traveler information purposes.

<u>Provision of Fiber Optic Communications Backbone for Future System Expansion</u>
In addition to the traffic and incident management and traveler information capabilities provided by this system, there are additional benefits that will be realized in the future as system expansion utilizes the fiber optic communications backbone deployed under this project. The entire fiber optic backbone was deployed with spare (unused) fibers for use by future system expansion activities. Spare fibers were provided for expansion on Route 422 (west), Route 202 (north and south), I-76 (east) and I-476 (north and south).

Two projects that are currently being designed/deployed to expand the District's ITS system will benefit from these spare fibers. The first is the S.R. 0202, Section 300 ITS project, which will expand the District's ITS system further south on S.R. 0202 and will tie into existing spare fibers provided under this project. The second is the S.R. 0309, Section 104 ITS project, which will expand the District's ITS system onto Route 309 and tie in to existing fiber where I-476 meets the Pennsylvania Turnpike. Both of these projects will directly benefit from the existence of spare fibers that their systems can utilize for direct connection back to the TCC.

In addition to the provision of spare fibers to facilitate future system expansion, the S.R. 0202, Section 400 ITS project also deployed a multi-duct conduit along all of the roadways where the fiber backbone has been installed. The fiber optic cable currently being used, as well as all spare fibers, are currently occupying one of the four innerducts in this conduit. This leaves three unused conduits that are available to PennDOT for future expansion beyond what the spare fibers permit.

<u>Economic and Environmental Benefits</u>
The economic benefits that are anticipated from the deployment of this system have been identified based on similar ITS deployments around the country. The first economic benefit is the savings associated with the reduction of the duration and existence of delays. The deployment of Advanced Traffic Management Systems (ATMS) such as this one result in private and commercial travelers saving time due to less delays. An hourly rate is applied to the value of both private and commercial traveler's time, which yields economic benefits for reduced delay. Another economic benefit comes in the form of reduced fuel usage due to the same reduction in delays. This provides travelers, both private and commercial, with a direct benefit since the same amount of travel is completed while spending less on fuel. Similarly, the reduction in delay offers savings in non-fuel operating costs, which include items such as tires, brakes, and vehicle depreciation. There are also economic benefits associated with the reduction in injuries, property damage and fatalities from traffic accidents. While a quantitative analysis of the benefits was not completed for this project, it has been shown by previous analyses that the combined direct and indirect economic benefits of a system such as this can reach several million dollars per year.

The environmental benefit associated with ATMS deployments comes in the form of reduced emissions from vehicular traffic. This reduction in emissions provides a quality of life benefit for those who live in and around congested urban areas, as well as an indirect economic benefit associated with the cost to society of environmental pollution.

6 LESSONS LEARNED

Although this project was successfully completed according to the Project Work Plan and within the budget, there were a number of design and construction challenges that needed to be resolved. The successful resolution of these challenges has allowed all parties involved to benefit from several "lessons learned" that will help with future ITS deployments. The major lessons learned from this deployment are the following:

<u>Lesson: Effective, Ongoing Coordination is a Key to Success</u>
This project (like many others around the country) involved the deployment of an ITS system as part of a major roadway reconstruction project. In order to ensure success, both the design and construction phases of this project required significant coordination between all parties -- the ITS and roadway design consultants; FHWA; PennDOT; and the general contractor and ITS subcontractors. Although ITS projects have been deployed for the better part of ten years in most major metropolitan areas in the United States, it is still important to recognize that many highway engineers and contractors do not have experience with the unique nature of ITS deployments. Recognizing this, it is important that the consultant and public agency ITS designers work closely with the roadway designers during the design process and the contractors during the construction portion of the contract.

During the typical roadway reconstruction design process, roadway designers proceed with their designs and make a number of design decisions, changes and adjustments based on years of experience with traditional roadway design. Many aspects of roadway design have not changed much in the past few decades and the designers are very familiar with the impacts that even small design changes have on the rest of the deployment. Unfortunately, roadway designers do not typically have significant experience with ITS systems or the impact on the ITS systems from even the smallest roadway design changes. Similarly, many ITS designers are not familiar with the details of roadway design, and need to ensure that ITS design decisions do not negatively impact the roadway design in any way. For this reason, it is extremely important that the ITS system designers work very closely with the roadway designers through every step of the roadway and ITS system designs for projects where the ITS systems are being deployed as part of a roadway reconstruction project like this. Gannett Fleming and DMJM+Harris' ITS designers worked closely with FHWA, PennDOT and the roadway designers to ensure that the ITS and roadway designs were completed in the most effective manner without negatively impacting either design.

During the construction of the project, it is equally important that the ITS designers remain actively involved to ensure the successful installation, integration, testing and training for the ITS system. Just as many highway engineers are not familiar with ITS systems, many general contractors that perform large roadway reconstruction projects such as the Route 202 project are not familiar with the complexities associated with the deployment of ITS systems. Although PennDOT has worked to create a prequalification process for contractors that will perform ITS installations, it is still important to recognize that many contractors only have limited experience with the installation of ITS systems. Even when a prequalified contractor is used to deploy the ITS systems, that contractor is typically a subcontractor to the overall highway reconstruction general contractor.

This means that close coordination between the general contractor and ITS subcontractor needs to be facilitated as well. During the construction of this project, Gannett Fleming and DMJM+Harris' ITS designers continued to be actively involved, attending the bi-weekly construction meetings and maintaining close coordination with PennDOT's TCC personnel, the resident engineer, the construction manager, and the prime and subcontractors. This active participation ensured that the construction, integration, testing and training for all ITS systems was successful.

Lesson: Flexibility and Creativity is Important with ITS Deployments

Another lesson learned from this project is that the ever-evolving nature of technology and the deployment of ITS as part of roadway reconstruction projects require creativity and flexibility during the design and construction of ITS systems to ensure the highest quality, most cost-effective deployment. For this project, there were two areas where flexibility and creativity allowed PennDOT to realize benefits with the ITS deployment:

1. During the design phase, the ITS and roadway designers worked in close coordination to constantly monitor the construction schedule of the roadway so that the ITS deployment could be planned accordingly. During this process, the ITS designers recognized an opportunity to construct and integrate one segment of the ITS system (Route 422) before the remainder of the project area would be ready for ITS installations. This led to the creation of two different phases for the ITS deployment: Phase I and Phase II. Phase I involved the installation of ten CCTV cameras and three DMS signs, all connected back to the TCC via fiber optic cable. The ITS Contractor installed, integrated and tested all of the Phase I elements and provided the Department with a functional ITS system on Route 422 before the remainder of the project area was ready for deployment.

2. By the time the construction of Phase I was about to begin, it was apparent that the CCTV technology had advanced to a point where the latest in CCTV technology was drastically different from the CCTV cameras specified during design. The CCTV camera that the Contractor submitted for approval was only a prototype during the design phase of the project, and as such could not be specified during design. Rather than reject a CCTV camera that represented the latest in CCTV camera design, the ITS designers worked closely with FHWA and PennDOT to utilize the two-phase nature of the project to test the new cameras before they would be fully deployed throughout the project. It was decided to deploy a mix of two different types of the newer camera along with one CCTV camera with which the Department was familiar (to serve as a "control" for the test). This deployment of the Phase I test cameras allowed the Department to evaluate the performance of the newer camera type before deploying what would ultimately become 41 more CCTV cameras in Phase II.

The lesson learned from this project is that ITS designers should recognize the evolving nature of technology and the challenges associated with deploying ITS projects as part of major roadway reconstruction projects and use creative and flexible solutions to provide the best possible solution.

Lesson: Design-Bid-Build Contracting and Roadway Reconstruction Projects are not "ITS-friendly"

This ITS project was deployed using the traditional design-bid-build method of contracting and was part of a major roadway reconstruction project. As has been illustrated in several sections of this document, these two methods of deploying ITS projects are not "ITS-friendly". The lesson learned from this project is that this is indeed the case and other methods of deploying ITS systems should be evaluated for more effective ITS deployments in the future.

Design-Bid-Build deployment presents challenges for ITS projects due to the ever-evolving nature of technology. There is often a period of one or more years between the point where the ITS system design is substantially complete and when the Contractor begins to procure equipment for installation. Although one or two years between design and construction does not typically affect the procurement of traditional roadway construction materials such as concrete pipe or metal guiderail, it often represents a period of significant change in ITS elements. This was particularly true on this project with the CCTV camera system. As noted previously, the CCTV camera that was submitted by the Contractor was only a prototype during the design phase and, as such, could not be specified for use on the project. By the time the project progressed through the bidding, award, and letting phases and reached the point of equipment procurement, this particular CCTV camera had moved into full production and was already up and running at several locations around the country. Although FHWA, PennDOT, the designers and contractors were able to find ways to successfully deploy this new camera, there were significant challenges associated with its deployment, including negotiation of payment to the Contractor. Design-build contracting offers a particular advantage for ITS projects since the design-build team can more easily deploy state-of-the-art technology.

Roadway Reconstruction Projects also present challenges to the effective deployment of ITS systems. The ITS portion of a roadway reconstruction project typically represents a small percentage of the work to be completed and the overall project cost. As such, the constraints related to the roadway design and construction schedule take priority over the ITS design and construction scheduling concerns. In addition, the bidding process for a major roadway reconstruction project focuses much more heavily on the qualifications and experience (and cost) of the general contractor, not the ITS subcontractor. By deploying ITS projects as stand-alone contracts the full attention of the project will be on the ITS system, from the selection of the ITS contractor/integrator team to the schedule associated with the deployment.

The lessons learned during both the design and construction of this system will serve the Department well as it prepares to nearly double again the size and scope of its ITS system with the ITS projects that are currently under design or planned for design throughout the District.

7 CONCLUSION

This project represented a major effort on the part of a number of designers, contractors, system integrators and stakeholders to implement a significant expansion of the PennDOT District 6-0 ITS system. As discussed herein, the deployment of this ITS Project was fully compliant with the Project Work Plan that was approved by PennDOT and FHWA in February 2000. All of the ITS elements that were listed in the Project Work Plan were successfully deployed and integrated into the existing Traffic and Incident Management System at the PennDOT District 6-0 Traffic Control Center without exceeding the federal earmark funds for the ITS Integration component of the ITS deployment or PennDOT's matching portion of those funds. Although the project was successfully deployed on time and within budget, the design and construction teams were faced with a number of challenges that required close coordination, creativity and flexibility to overcome. The solutions to these challenges have provided several "lessons learned", which have been detailed in this report. Overall, this project has provided, and will continue to provide, a number of direct and indirect benefits to PennDOT and the travelers in the Philadelphia region.

APPENDIX A: PHOTOGRAPHS OF PROJECT ELEMENTS

CCTV Cameras

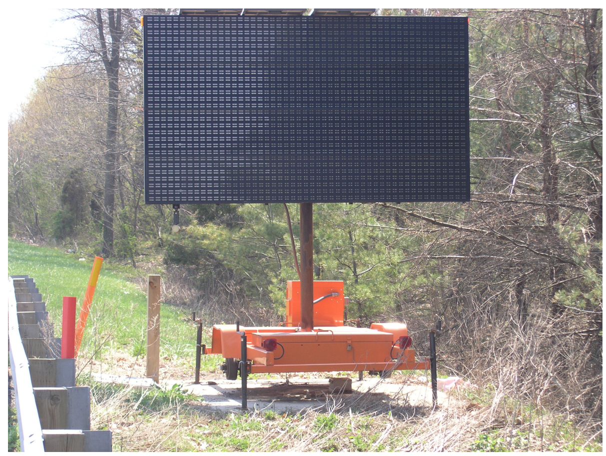
 Typical CCTV installation – 50-foot pole	 CCTV pole – structure mounted

Dynamic Message Signs (DMS)


VMS – Mounted over road on full-span structure


VMS – Center-mount roadside structure


Portable VMS – Trailer-mounted on concrete pad


Portable VMS – close up view

Video Incident Detection (VID) Cameras

VID Camera mounted on bridge parapet

VID Camera – close up view

VID Camera mounted on 65-foot pole

VID Camera mounted on full-span structure