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PENNSYLVANIA ROAD SAFETY AUDIT PILOT PROGRAM

Prepared for

Commonwealth of Pennsylvania
Department of Transportation and
the Mid-Atlantic Universities Transportation Center

by

M. T. Pietrucha
P. M. Garvey

The Pennsylvania Transportation Institute
The Pennsylvania State University
Transportation Research Building
University Park, PA 16802

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16. Abstract

The road safety audit is a process wherein a team of experts attempts to identify features of the highway operating environment that could be potentially dangerous and works to eliminate or change these features during the different phases of design. The Pennsylvania Department of Transportation (PennDOT) is in the process of formulating a safety audit process for use in the Commonwealth. Prior research produced guidance and information on how a safety audit could be incorporated into PennDOT's current design function. As a follow on to this prior work, PennDOT launched a pilot safety audit program to determine if the safety audit process is a valuable tool, and if so, how to expand its use in Pennsylvania.

Based on the observations of the implementation teams and the research team, it is recommended that PennDOT expand the road safety audit process in the Department. It is recognized that given the size, complexity, and organizational structure of the Department, the type of safety audit review program that can be implemented must reflect practical considerations. An expansion of the pilot program or a staged implementation of the process might be warranted before a fully executed program can be realized.

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INTRODUCTION

Historically, highway safety measures have been developed in response to the occurrence of accidents. These countermeasures to accidents are based on the identification of contributing factors in the operating environment, which can be eliminated or changed, so that the accidents caused by this element of the system will no longer occur. If it is possible to identify these contributing factors in a post hoc analysis, it would seem that these same deficient features could also be identified before any accidents occur.

The road safety audit is a process wherein a team of experts attempts to identify features of the highway operating environment that could be potentially dangerous and works to eliminate or change these features during the different phases of design. This process is also applicable to existing highway facilities. The key elements in this process are an interdisciplinary review team; use of a comprehensive audit list, which is used as a prompt and not as a mechanical check list; and access to the design through all phases of the design process.

The Pennsylvania Department of Transportation (PennDOT) is interested in formulating a safety audit process for use on roads in the Commonwealth. In cooperation with PennDOT, the Pennsylvania Transportation Institute (PTI) conducted research on the piloting of the application of a road safety audit process for PennDOT. Prior research project was conducted for PennDOT on the development of a road safety audit process. This project produced a final report (Kuhn, Pietrucha, and Garvey, 1996) that provided guidance and information on how a safety audit could be incorporated into PennDOT's current design function.

As a follow-on to this prior work, PennDOT decided to pilot the safety audit process in two districts (6-0 and 10-0), utilizing the information from the previously mentioned final report. This pilot effort is to be used to determine if the safety audit process is a valuable tool, and if so, how to expand its use to additional districts. Three key areas were considered as part of the pilot efforts are:

- Does the safety audit process "add value?"
- Does the safety audit process slow down the design process?
- Can the safety audit process be implemented with existing resources?

The work was conducted through the performance of several different tasks. The research project staff provided technical assistance and support to the department personnel implementing the pilot program in Districts 6-0 and 10-0 and is documenting the pilot project efforts by means of this final assessment report so that PennDOT can decide whether the safety audit process should be expanded to additional districts, and if so, what recommended changes might be made to the process.

BACKGROUND

Safety has always been at the forefront of transportation. Engineers have always worked toward creating a transportation network that serves the needs of its users both efficiently and safely. For example, guidelines and standards used by transportation engineers for the design, operation, and maintenance of transportation facilities consider safety so that the public is protected from harm. However, strict adherence to these guidelines and standards might not always be sufficient. Care should be taken so that they are not used as a substitute for experience and ability in the appropriate and effective application of these principles to minimize safety risks. A strategic process for reviewing projects from a safety perspective can help reduce the likelihood of safety deficiencies and improve the effectiveness of a design.

Various countries have developed national road safety audit processes and strategies in the past several years, each rising out of an increased awareness of safety issues and the role of safety in transportation. However, such processes are not really new. Most state and local transportation agencies in the United States have conducted some sort of technical safety check in the design process for years, though these checks were rarely formalized with specific emphasis on safety issues and design features. Today, as with other countries, transportation agencies in the United States are working to improve safety and help reduce the frequency and severity of accidents. Safety audits are part of this movement. The safety audit process formalizes the procedure for safety reviews to ensure consistency so that safety is built into the transportation facility from the beginning.

DEFINITION

Many definitions of a safety audit exist, all of which encompass the idea that safety should be an ongoing concern of transportation agencies. In short, a safety audit is the formal and systematic procedure for an independent and qualified examiner to analyze safety problems of an existing or proposed transportation project that affects the roadway network or interacts with roadway users. Thus, a safety audit is a formal method of investigating the accident potential of an existing or proposed design, making safety an integral and separate component of the design process. With modification, it could easily be incorporated into an existing safety review process.

PURPOSE AND OBJECTIVES

The purpose of a safety audit is to analyze existing or new transportation projects to identify safety deficiencies or problems that are not compatible with the function of the roadway. It is not specifically designed to provide solutions or suggest recommendations for remedies. The various objectives of a safety audit are to:

- Minimize the potential and severity of crashes on transportation facilities affected by the project;
- Minimize the need for changes or improvements after construction;
- Reduce overall costs of the project for the length of its operational life; and
- Improve general awareness of safe design, construction, operational, and maintenance practices.

By implementing a safety audit process, a transportation agency can work to ensure that existing and new facilities are designed to function as safely as possible.

TYPES OF PROJECTS

Safety audits are applicable to all types of road projects and roads, existing or proposed. Nearly every project, with the possible exception of routine maintenance projects where pavement markings are not affected, can benefit from a safety audit, regardless of its size. The diverse list of such projects includes:

- New freeways;
- Major divided roads;

- Reconstruction and realignment projects;
- Intersections;
- Pedestrian and bicycle routes;
- Local road detours near major projects;
- Local area traffic management schemes;
- Signal projects;
- Subdivision proposals; and
- Accident reduction schemes.

Safety audits can also be conducted on projects that are considered "off-road" but still affect adjacent roadway facilities. Such projects might include commercial, residential, or industrial developments. These projects might affect such transportation issues as:

- Vehicle/pedestrian conflicts;
- Increased pedestrian volumes;
- Spillover parking onto adjacent roadways;
- Restricted visibility or delays at access/egress points; and
- Significant changes in circulation, access, egress, and unloading patterns by users, especially including heavy vehicles.

By conducting safety audits on these and similar projects, a transportation agency can reduce the likelihood of accidents and ensure that all projects operate as safely as possible.

STAGES OF AUDIT

The road safety audit should not be a one-time occurrence. Instead, it should be incorporated into the entire design process, requiring safety analyses at each critical design stage so that no issue is overlooked. Each audit stage involves the analysis of current documents and plans to ensure that safety deficiencies are identified early and remedied prior to construction. The following sections describe those features to be addressed in the audit at each design stage.

Stage 1: Feasibility

A safety audit at the initial feasibility stage of a project can positively influence the entire scope and course of the project and address various fundamental issues that help ensure a safe design. Assessing the safety at the feasibility stage can help reduce the possibility of major safety problems that require remedies once the design process begins.

Stage 2: Preliminary Design

At the preliminary design stage, a safety audit can consider the overall design of the project and help eliminate safety hazards or concerns so that necessary changes are made prior to land acquisition. A safety audit at this stage is crucial in that it is the last opportunity to make significant changes in the alignment and overall design of the roadway prior to the right-of-way purchase and commencement of detailed design efforts.

Stage 3: Detailed Design

At this stage, prior to the preparation of contract documents, a safety audit can carefully analyze the entire design for safety deficiencies. At this stage, the safety audit team can also ensure that the needs of special user groups are addressed. Problems identified and remedied at the detailed design stage can help reduce the costs associated with last-minute changes prior to or during construction.

Stage 4: Pre-Opening

A safety audit at the pre-opening stage involves driving, riding, and walking the entire area of the project, both during the day and at night, to ensure that the safety needs of all special users are adequately provided. The key to this audit is to ensure that safety deficiencies and issues identified in earlier audits were adequately addressed during final design and construction.

Stage 5: In-Service or Existing Roads

At this stage, a safety audit can be used to monitor a new design for the adequacy of the road, roadside, intersections, and street furniture from a safety standpoint. A safety audit can also be conducted on existing roads to identify any safety deficiencies. The features analyzed in an audit of an existing roadway are similar to those investigated for a new design. As with earlier stages, any safety deficiencies should be identified and remedied as needed to increase the safety of the facility.

SAFETY AUDIT PROCESS

Each transportation agency can adopt a unique safety audit process that is tailored to its existing organization. In this way, each agency can ensure that its design process addresses safety at key stages to optimize the efforts of the auditor or audit team and reduce costs and wasted efforts on the part of the design team as well as associated consultants and contractors. Furthermore, any road agency developing a safety audit process should include several fundamental requirements to ensure an effective and comprehensive program. These requirements include management commitment, a formalized safety audit procedure, an organizational structure, and a series of checklists for use by the auditor or audit team in the process.

MANAGEMENT COMMITMENT

Perhaps the most critical component of a safety audit process is the commitment of the transportation organization and its staff. Such commitment ensures that the audit is a permanent component in the organization's overall safety program. Without it, the integrity of the process is undermined, and the potential benefits decrease in importance. Hence, each individual and group involved in the safety audit process should have as their goal the participation in the process to promote roadway safety and crash prevention.

PROCEDURE

A safety audit program needs a clearly defined and comprehensive procedure that considers the overall safety of a project. Having a set procedure helps reduce the entire cost of the project and facilitates decision making by the auditor or audit team as well as all other parties involved in the project. The following components are critical to such a procedure and may or may not be needed at each safety audit stage.

Selection of Auditor/Audit Team

The transportation agency or design team should select an auditor or audit team made up of individuals who have the skills and independence to conduct the audit. The team should satisfy the criteria set forth in the section later in the report entitled "Organization."

Provide Background Information

The design team should gather all plans and site information related to the project that the auditor or audit team will need to conduct the audit. This information should include a statement of the project's objectives.

Hold Commencement Meeting

The design team and the auditor or audit team should meet to discuss the audit and to complete transfer of background information. At this time, the auditor or audit team should have sufficient information to begin the safety audit.

Site Visit

A site visit is necessary for the assessment of local conditions and the integration of a new design with existing facilities. It is clearly important for a Stage 1 audit (Feasibility), so the auditor or audit team has a clear idea of the proposed project and its place in the overall transportation network. Another site visit is important during the Stage 3 audit (Detailed Design) to ensure that the final design is compatible with the existing facility or site. Finally, a third site visit is even more critical at a Stage 4 audit (Pre-Opening) to assess the finished project and identify any deficiencies prior to operation. The auditor or audit team can conduct site visits at other audit stages as deemed necessary.

Examination of Plans

A careful and detailed analysis of all aspects of the design plans and project documentation is critical to determining safety deficiencies. At Stage 1 (Feasibility) and Stage 2 (Preliminary) audits, a detailed and ordered examination of all of the project drawings and project documentation is necessary. Furthermore, at Stage 2 and Stage 3 (Detailed) the auditor or audit team should carefully investigate the interaction of design details by layering all of the different plans. This layering task reduces the likelihood of safety deficiencies generated by conflicting plans that are overlooked until construction is complete and a final site visit is conducted. A plan analysis is also needed at Stage 3 (Detailed) and Stage 4 (Pre-Opening) audits, although a site visit at the Stage 4 audit is even more critical to identify deficiencies after construction.

Use of Checklists

Checklists can aid the safety auditor or audit team in their task. The purpose of checklists is to illustrate the types of safety issues, problems, and deficiencies that have the potential to develop at each particular design stage. They are helpful in guiding the auditor or audit team in the review tasks and provide a framework for careful analysis. However, these checklists are not comprehensive. It is virtually impossible to anticipate every problem that may occur with every type of project. Care must be taken to ensure that these checklists are not the only tool used and that they do not serve as a substitute for audit team members with safety engineering experience.

Use of Safety Guidelines and Control Data

Any safety guidelines associated with relevant design, published safety research, or any other control data should be used by the auditor or audit team in the process. Such information can help the safety auditor or audit team predict the types of accidents that might occur as a result of certain design features. Moreover, past experience and knowledge of successes and failures in safety engineering are invaluable to the safety audit process. This knowledge enables the safety auditor or audit team to specify proven remedies early in the design process to avoid costly changes later. Hence, guidelines, data, and knowledge are powerful tools to the safety audit process.

Reporting

The safety auditor or audit team is responsible for identifying and reporting any safety deficiencies at each audit stage. These individuals should also make recommendations regarding issues that involve unnecessary or unreasonable hazards. It is important to note that these recommendations are general in nature and not specific solutions to the noted deficiencies. The report should include the following sections, which should be written in clear and concise terms:

- *Project Information:* project title, its extent along with a brief description of the proposal including the stage at which the audit is being conducted;
- *Background Information:* a list of supportive material (i.e., reports and plans) used, the names of the audit team members, and information about the audit team site visit;
- *Findings and Recommendations:* a statement regarding what safety concerns and possible enhancements were found, cross-referenced to plans and supported by photographs, and any general recommendations for corrective action; and
- *Formal Statement:* a statement signed and dated by the auditors confirming the completion of the audit.

Completion Meeting

The design team and the safety audit team should meet to transfer the audit report and to discuss the findings and general recommendations.

Monitoring

After the completion of the safety audit process, the transportation agency responsible for the facility should consider each deficiency and document reasons for eliminating or accepting each one. This record of decisions should be forwarded to the audit team. The agency should also continue to monitor the accident record of the new or improved design and incorporate the results back to the audit process both at the design and audit team levels. This exercise helps enhance the audit process and maintains the commitment to overall safety within the agency.

DESCRIPTION OF THE PILOT PROGRAM

Based on the results of the work studying the feasibility of implementing the safety audit process within the Commonwealth, which was cited previously (Kuhn, Pietrucha, and Garvey, 1996), the Bureau of Highway Safety and Traffic Engineering (BHSTE) sought a sample of PennDOT's Engineering Districts to pilot test the implementation of safety audit reviews. Representatives from Engineering Districts 6-0 and 10-0 volunteered their units to be part of the pilot study.

On April 15, 1997, representatives from the BHSTE, Engineering Districts 6-0 and 10-0, the Federal Highway Administration (FHWA), and the Pennsylvania Transportation Institute met to discuss the details for the execution of the pilot program. Topics discussed at the meeting included:

- An overview of the safety audit process,
- FHWA's perspective on safety audits,
- PennDOT concerns and issues related to safety audits,
- Methods for evaluating the benefits of safety audits, and
- Development of a set of tasks and a schedule for implementing the process.

In the course of the meeting, it was determined that several projects would be audited in each of the volunteer districts. Further, it was decided that records or project diaries would be kept by key district personnel, who were to be involved with the project, to assist the evaluation team (i.e., PTI) in developing its final assessment and report.

A description of the safety audit activities conducted in Engineering Districts 6-0 and 10-0 follows.

DISTRICT 6-0

Located in eastern Pennsylvania, engineering district 6-0 is composed of Bucks, Chester, Delaware, Montgomery, and Philadelphia (i.e., the City of Philadelphia) counties. It covers an area of 2,176 square miles, and its population is just over 3,729,000. There are 3,684 miles of road under the district's jurisdiction.

The district's pilot program was carried out by two road safety audit facilitators. These two facilitators were the district traffic engineer and the assistant district traffic engineer.

Selection of Teams

District 6-0 used audit review teams composed of four members. For each project, there was a different review team. As this was a pilot project, the facilitators felt that having different district personnel serve on each of the review teams would provide an opportunity to have different perspectives and approaches brought to the effort. The review team was composed of personnel from the following units:

- Plans,
- Construction,
- Maintenance, and
- Traffic.

As related by the district facilitators, members of the District's Safety Review Committee (SRC) were purposely left out so that the independent nature of the review was preserved. It was thought that the audit would be another tool that could be employed by the SRC, rather than be used as a replacement for SRC efforts.

Selection of Projects

Three projects were reviewed as part of the district's pilot program. The implementation team chose projects that would have them utilize different stages of the audit process. The projects selected were:

- Pennsylvania Route 41 corridor study,
- U.S. Route 1 safety and mobility improvement project (sections HO5 and HO6), and
- U.S. Route 1 safety and mobility improvement project (section HO3).

The Pennsylvania Route 41 corridor study was selected to provide an example of an audit during the feasibility stage of a project. This study was in the process of developing alternatives for a proposed bypass of the Avondale and Chalfont areas in southern Chester County. The needs study phase of the project's environmental assessment was completed, and the design team was in the process of evaluating alternative alignments.

The safety and mobility improvement (SAMI) project covering sections HO5 and HO6 of U.S. Route 1 was selected to provide an example of an audit during the preliminary design stage of a project. The project involves work on the Baltimore Pike (S.R. 0001) from Brandywine Creek in Chadds Ford Township to north of Pennell Road (S.R. 452) in Middletown Township. The project tasks include the addition of a concrete median barrier, rehabilitation of the minor roadways, left turn lanes, and jughandles at intersections where such improvements are deemed appropriate.

The SAMI project covering section HO3 of U.S. Route 1 was selected to provide an example of an audit during the construction/pre-opening stage of a project. The project involves work on a four-mile section of the Baltimore Pike (S.R. 0001) starting from Pennsbury Township to East Marlborough Township. The project tasks include the installation of a concrete median barrier, left turn channelization, signalization, and a jughandle.

General Audit Procedure

Team members were identified by the road safety audit facilitators. As mentioned previously, the team was composed of one member each from the Plans, Construction, Maintenance, and Traffic units in the district. Once these members were identified, they were notified of their participation in the project and given background information on the safety audit process as well as the project to be audited. Subsequent to their notification regarding their participation, a one day work effort/meeting was scheduled to complete the audit process. The meeting began with a presentation from the design team regarding the project in question, which was followed by a site visit by the audit team. Once the site visit was completed, the team reconvened to review the project plans. The review took place with the aid of the checklists provided in the initial PennDOT safety audit report (Kuhn, Pietrucha, and Garvey, 1996). It was conducted as a "brainstorming" session wherein the checklists were used to provide a focus and maintain some order in terms of what general areas were covered and what specific topics were discussed. From these activities, the audit team began to formulate findings and general recommendations, which, in turn, were summarized into a final report that was submitted to the district administrator.

Conduct of Field Views

The field views were conducted by having the audit team members travel to the project site in a van. Once they arrived at the site, the team would drive and walk the project route with a member of the project design team so that questions could be answered and options considered immediately. The audit team would reconvene later the same day in the office to discuss concerns and formulate general recommendations based on the field view and the other activities described previously.

Development and Communication of Findings and General Recommendations

As discussed previously, the audit team developed findings and recommendations based on their initial briefing, site visit, examination of plans, and brainstorming session. The findings and recommendations were compiled by one of the facilitators into a final report. This report was then circulated to each of the team members for a final review and sign-off of their concurrence with the report's findings and recommendations. Once this stage was reached, the report was forwarded to the district administrator for action.

General Observations

Based on discussions with the facilitators, the following general observations were noted:

The composition of the audit team was such that the reviewers were all PennDOT employees from district 6-0. There was a general concern associated with allowing experts from outside PennDOT be part of the process. This concern was based on an apprehension that people from outside PennDOT do not have a vested interest in seeing individual projects completed. Since PennDOT employees understand the internal processes related to project programming, scheduling, and budgeting, it was simpler to build a consensus among people familiar with the process.

The checklists acted as a catalyst for the discussion ensuring that all of the members of the audit team contributed to it. The checklists were also helpful in giving initial structure to the team report. The findings and recommendations were approved by all team members, but this did not mean that there were no minor conflicts and disagreements internal to the team. It was thought that conflict resolution was best handled by keeping the review teams as small as possible.

Potential liability problems associated with not accepting the findings and recommendations of the audit team or from individual members of the team (i.e., minority opinion) were an issue of concern. There was no strong sense of how to alleviate this potential problem. It is believed that the process works best for 3R, 4R, and capital type projects.

The facilitators expressed the opinion that audits seem to be most appropriate at the feasibility, preliminary design, and in-service stages. Further, within each of these stages, the audit should be conducted early as possible. Lastly, it was felt that team members should be individuals who are used to working in a team environment and able to work toward a consensus on difficult technical issues.

DISTRICT 10-0

Located in western Pennsylvania, engineering district 10-0 is composed of Armstrong, Butler, Clarion, Indiana, and Jefferson counties. The district covers an area of 3,569 square miles, and its population is just over 400,000. There are 3,201 miles of road under the district's jurisdiction. The district's pilot program was carried out by a road safety audit coordinator who was the district traffic engineer.

Selection of Teams

District 10-0 used an audit review team composed of five members. The same team was used to review all of the projects evaluated as part of the pilot program. The team consisted of the following members:

- Traffic engineer (safety audit coordinator),
- Construction services engineer,
- Design project manager,
- Maintenance program engineer,
- Risk management engineer, and
- Comprehensive safety coordinator.

All of the team members were district 10-0 employees except for the comprehensive safety coordinator, who worked with PennDOT through a cooperative arrangement with a local university, the actual employer of this individual.

The traffic engineer was selected to provide expertise in the areas of signs, signals, markings, and safety. The construction services engineer had expertise in construction and traffic engineering. This representative was also a member of the district's Administrative Staff and Program Management Committee. The project manger provided expertise in highway design standards, accident reconstruction, and traffic engineering. The maintenance program engineer had experience in maintenance and traffic engineering. The risk management engineer provided expertise in tort liability, traffic engineering, and environmental impact requirements. The comprehensive safety coordinator was chosen to provide expertise in the areas of human factors and highway safety education.

Selection of Projects

The projects that were part of the pilot study were selected by the audit team and the assistant district engineer for design. The primary consideration in the selection of the projects was to have a variety of project types. The selection ensured that the effect of the audit process could be evaluated for several different types of projects. Eleven projects were chosen. This group of projects ensured that at least one project would match up with each of the different audit stages. The eleven projects selected were:

- U.S. Route 422, Armstrong County (Kittanning Bypass)—This was the preliminary engineering phase of a capital project covering five miles of new construction of a four lane concrete roadway.
- U.S. Route 119, Indiana County—This was the preliminary engineering phase of a capital project covering 10 miles of a two-lane roadway being reconstructed into four/five lanes with a median barrier, left turn lanes, and jughandles.

- U.S. Route 119, Jenks Intersection, Jefferson County—This was the preliminary engineering phase of a SAMI project covering the reconstruction of an intersection to provide a left turn lane and improved intersection geometry.
- Pennsylvania Route 66, Armstrong County (Forks Church 3R)—This was the final design of a betterment project covering the redesign of six miles of rural two-lane roadway with narrow shoulders and poor alignment.
- U.S. Route 119, Jefferson County (Punxy South Climbing Lane)—This was the feasibility stage of a capital project covering three miles of two-lane reconstruction to provide a southbound truck climbing lane.
- Pennsylvania Route 56, South Bend Bridge, Armstrong County—This was the preliminary design of a 200-ft-long bridge replacement project that included the reconstruction and improvement of the roadway's horizontal and vertical alignment.
- U.S. Route 119, Indiana County (Marchand 3R)—This was the final design of a betterment project covering three miles of rural two lane with poor horizontal and vertical alignment.
- State Route 4023, Armstrong County (Tarrtown Road)—This was the preliminary design of a capital project covering three miles of rural road with poor alignment and cross section. The road is heavily traveled by large trucks.
- U.S. Route 119, Indiana County (Little Mahoning 3R)—This was the pre-opening phase of a betterment project covering three miles of rural road. The project tasks included the realignment of several curves.
- Butler County Surface Improvement Program—This project covered the resurfacing of various roadways throughout Butler County.
- U.S. Route 22, Indiana/Cambria Counties (Gas Center)—This was the preliminary engineering of a capital project covering eight miles of new four-lane construction including several jughandles.

General Audit Procedure

As stated previously, the composition of the review team was the same for each audit review. The team was made up of the traffic engineer, construction services engineer, design project manager, maintenance program engineer, risk management engineer, and comprehensive safety coordinator. All members were given background information and brief training on the safety audit process by the safety audit coordinator. Subsequent to their notification regarding their participation, a preliminary meeting was scheduled to familiarize key personnel (i.e., the design team and the audit team) with the process. After this initial meeting, a full day work session was scheduled to complete each project audit. This full day meeting would begin with the project manager giving a briefing on the proposed work. If a consultant was used for the design, this briefing was given both with and without someone from the consultant's design team present. After the briefing, the safety audit team would review the project plans. Once this review was complete, the team would proceed to field view the site. After the field view was completed, the team would return to the office to discuss the issues that were identified by their reviews.

The outcome of these discussions was the development of a preliminary set of findings and recommendations from the team. After the meeting, the safety audit coordinator would check the findings and recommendations to see if they were actually feasible given the project's current status. Using this check, the safety audit coordinator would develop a final set of findings and recommendations regarding the project. He would later meet with the project manager to discuss the findings of the team. Subsequent to this meeting, the coordinator would produce a memorandum to the assistant district engineer for design. Copies of this memorandum would be provided to the members of the audit team; however, there was no formal approval by the team members.

Conduct of Field Views

The audit team members traveled to the project site in a van to conduct the field views. Once they arrived at the site, the team would drive the project route in both directions following along and extending beyond the project boundaries. Each run was videotaped to provide a visual record and to record spoken comments from members of the team. No effort was made to reach a consensus on any problematic issues noted during the field view. Rather, as issues were raised, they were noted with the intention that they would be discussed once the team returned to the office. The videotape recording proved to be highly useful as a reference when the team began its deliberation session back at the office.

Development and Communication of Findings and General Recommendations

As noted previously, the audit team developed a preliminary set of findings and recommendations based on its plan and field reviews. Once these preliminary findings and recommendations were developed, the safety audit coordinator evaluated the feasibility of the findings and recommendations relative to the project's status. After this step, the coordinator developed a final set of findings and recommendations regarding the project. These final findings and recommendations were first discussed with the project manager and were then sent in the form of a memorandum to the assistant district engineer for design. Again, as noted previously, copies of this memorandum were provided to the members of the audit team, but there was no formal approval of the memorandum by the audit team members.

General Observations

Based on discussions and written communications with the district safety audit coordinator, the following general observations were noted.

Auditors found that strict adherence to standards or a combination of standards may be inappropriate or unnecessary and can create potential safety concerns or eliminate an even more suitable roadway improvement. Standards frequently provide only a minimum of the treatment that may be required. The audits helped determine if the required treatment was sufficient when considering safety and compatibility for other road users.

Changes to design features made during value engineering reviews and/or construction may create safety concerns.

It seemed that project managers experienced greater confidence in their designs knowing that their project was constructively scrutinized by others. Further, they seemed satisfied knowing that their project would serve all road users, not only drivers.

The audit process forced communication among and awareness of the disciplines involved. Brainstorming concerns and achieving consensus among the team of experts increased the members' individual knowledge of the project, other disciplines, and current standards/policies, which can be applied to other audits and other duties. The team continually learned from its successes, and more so, from its shortcomings.

Intersection improvements showed the most dramatic changes. These included basic improvements, such as removal of earth banks to increase available corner sight distance or the addition of left turn lanes to provide safe storage for turning vehicles. More complicated intersection improvements included an interchange redesign that replaced left-turn movements with safer right-turn movements and a realignment of approaches to reduce conflicts. Access management improvements, such as relocating, removing, and/or eliminating driveways, were also incorporated.

The presence of potentially hazardous fixed objects is best found in field reviews. As part of the review, the focus was on removing, relocating, and/or combining above ground utilities that pose potential hazards, particularly where there may be an increase in speeds.

Costs incurred by an audit, considering salaries and equipment only, ranged from $2,000 to $5,000. Delays and changes were inevitable and generated costs in the form of lost time available for other duties and forcing project milestones off track. One redesign feature created a loss of credibility with property owners when it also necessitated an undesirable change in the acquisition of right-of-way.

Challenges were encountered throughout the pilot. The team was successful in incorporating needed improvements in approximately 50 percent of the attempts to improve particular situations. This success rate was somewhat surprising considering that the types and phases of projects were purposefully varied for evaluation purposes.

The crowded and dynamic schedules of the high-level team members sometimes created a pattern of organizing and subsequently postponing field reviews. These multiple schedule changes were somewhat frustrating for many of the audit team members. When team members changed positions, requiring that they leave the team, a loss of expertise was experienced, and a new team member had to be brought up to speed on the details of the project and the audit.

Since no formal plans exist during the initial development of a project, which is a time of frequent changes, performing detailed reviews posed a challenge because many design decisions had not yet been made. This situation required the coordinator to keep track of the numerous options, possibilities, and directions.

It is imperative that the audit utilize the short window of opportunity when change is easy. Decisions to incorporate improvements can be controversial and require many meetings, discussions, and changes requiring time and money. On a major construction project requiring environmental approvals, changes that forced the design outside of the environmental footprint were challenged because the time needed to reevaluate the impacts might have delayed or jeopardized the project.

Metric plans caused difficulty and frustration when comparing design standards to field conditions. As the use of the metric system is still relatively new to PennDOT, audit team members are proceeding along a learning curve, which may have caused the team to unknowingly miss some issues.

Every project has unique road users and stakeholders, which makes it difficult to gain input from all parties concerned. Having representation present from local municipal officials, emergency services, transit agencies, businesses, and interest groups is desirable, but it would seem to be unmanageable given scheduling and liability concerns.

The team make-up is an extremely important consideration in ensuring a successful audit. A coordinator keeps the process moving and allows it to be effective for a number of projects. This requires a person with knowledge, experience, and enthusiasm. The pilot team consisted of five members with strong backgrounds in safety, traffic engineering, risk management, accident reconstruction, design, construction, maintenance, and programming disciplines of highway engineering. Human factors expertise was not available within the district, and the coordinator did not seek an expert. However, the team included an individual from Indiana University of Pennsylvania who closely collaborates with local schools and aging agencies. Most of the recommended expertise is available within the staff, including accident reconstruction. Police officers could have been utilized if accident reconstruction expertise had not been available. Practical safety knowledge is imperative to the audit.

The audit process should be independent of the projects' routine safety reviews and incorporation of countermeasures for existing crash clusters; therefore, the team did not include the safety engineer. An understanding of the AASHTO Roadside Design Guide, positive guidance techniques, access management, and the reasons why crashes occur are valuable in identifying potential problems. Awareness of technology and intelligent transportation system capabilities can assist in incorporating needs of many road users in ways that may not be readily apparent. The knowledge of current standards was an asset when determining the finished roadway features. Geometric design specialization was valuable in relating the level of safety associated with design features. Training may be necessary if the recommended expertise does not exist. Training relative to the needs of pedestrian and bicyclists was provided to several members of the audit team.

The team must thoroughly understand the audit process and accept that not all individual team members' concerns will be accepted by the rest of the team. This ensures that the audits remain productive and the concerns raised remain reasonable and prudent. Using higher level managers helps maintain credibility by adding well-rounded knowledge to determine the suggested improvements' feasibility. It should be noted that the team's expertise grew with every audit.

Employee time was monitored to determine the feasibility of conducting audits internally. It seems that the value added by an audit is directly proportional to the time and effort spent on reviewing the plans and site. The team met only when audits were scheduled (approximately one day per month). The project managers need time to prepare briefings, attend field views, search for solutions to concerns, redesign features, contact property owners, resubmit plans for required approvals, communicate with the coordinator, and seek necessary funding increases (approximately three days per month). The coordinator needs time for arranging meetings and field reviews, analyzing field notes, processing reports, maintaining communication with project managers, researching possible solutions, and resolving conflicts (approximately five days per month). Separate audit teams would reduce the time commitment of the team members; however, a single team would build experience, improve consistency, reduce the possibility of duplicating mistakes, and reduce the possibility of missing the same opportunity to enhance safety twice.

Project costs generally increased. Costs associated with safety concerns were not an issue in rejecting improvements except occasionally when the cost of addressing a finding or implementing a recommendation would have scuttled the project completely. Costs resulting from early reviews were more easily absorbed, and costs resulting from later reviews usually resulted in the elimination of another project feature. Occasionally, value engineering and constructability were discussed, and cost savings suggestions resulted.

Delay in project development is the most sensitive issue of the audit process. It is even more critical than cost as money can be moved or items can be eliminated to cover costs. However, a loss of time can jeopardize commitments, which adversely affects PennDOT's credibility. Although delays did occur, projects were not unreasonably delayed. Commitment to the letting schedule overrode any decision to incorporate an improvement that could greatly delay the project. Concerns cited later in the project development phases were more susceptible to delay and usually resulted in incorporating an improvement that would cause the least delay.

Documentation can range from too little to too much. PennDOT needs to determine the optimum level that captures all concerns, conveys needed improvements, and communicates results, but does not increase tort exposure.

The methods of reporting results to the project manager varied. The absence of a formal report may reduce tort liability concerns, but it caused some confusion. Recommendations that were too specific were found to be undesirable because they left the project owner with no flexibility in formulating a response and may create unnecessary liability exposure if the recommendations were not accepted, even for very valid reasons. The most suitable method appeared to be a formal report drafted by the audit team, that only cited concerns and refrained from making recommendations. Submission of this report was followed by a meeting between the coordinator and project manager to resolve concerns, discuss details not included in the report, and select remedial treatments. The report must be prepared in a timely manner so that short windows of opportunity are not missed and information is not forgotten.

The project managers frequently had difficulties formulating responses to the lists of concerns provided by the audit team. This was due to the fact that resolving multiple issues is a dynamic process and solutions to individual issues were created simultaneously. This complex situation left the project manager with no convenient way to respond to the audit team members to assure them that their concerns were being addressed.

Not all project types were well suited for an audit. Capital improvement (new construction) projects were excellent candidates. They resulted in the greatest number of successful improvements because generally there were fewer overall constraints, and more time available for redesign. These projects also had the greatest level of funding available to absorb cost increases.

Betterment projects (rehabilitations) were also prime candidates for audits. They generally featured a broader scope of work, which allowed for the incorporation of improvements with only minor changes. They also had a higher level of funding that could absorb cost increases.

Audits of safety projects did not raise many concerns. They generally involved a much smaller section of roadway and already had an existing emphasis on safety. Some opportunities existed for recognizing the needs of non-driving highway users.

Bridge projects benefitted from audits. Projects involving a complete rehabilitation successfully incorporated improvements because of efforts to improve alignment and approaches. Projects involving only deck replacement had a more narrow scope and did not feature design elements that would benefit from an audit.

Surface improvement projects were intended to improve ride quality and generally had little money available for additional improvements. Ironically, these types of projects raised the most concerns among audit team members because the surface improvements usually generate an increase in driving speeds; however, other speed-sensitive design features are usually not upgraded.

Permit projects (curb cuts for private developments) usually lacked sufficient lead-time and involved non-agency funding, thus making them poor candidates for audit. Since little or no public money is involved, the opportunities and benefits are great; however, there is resistance by the private sector parties involved as they have to cope with redesigns and subsequent reviews.

It would seem wise, at least initially, to select projects that are conducive to audits due to their inherent capability and flexibility to change the plans so that the team is not stonewalled in its efforts. If the team has early successes, it will probably put forth more effort, and the rest of the organization will respond in kind.

Suitable phases of project development for audits were also determined by auditing projects in various phases and by comparing the results. Most concerns cited in preliminary engineering were addressed. Audits performed in later phases resulted in fewer improvements; the defining line appears to be the completion of the environmental approval. After this point, the amount of effort required and the possibility of delaying the project for major design changes is greatly increased. Concerns cited beyond the mid-point to final design were scrutinized more closely, required demonstrated cost-benefit improvements to be accepted, and used the most inexpensive method to alleviate the concern. These steps are minimized if audits are started early in project development to give the agency time to react.

Concerns raised during the construction of a project are often costly as they may generate additional work; however, this work will still be less expensive than any work needed to correct problems after the construction is completed. Audits performed at this stage were beneficial in identifying utility and roadside barrier concerns. They were most beneficial in determining field changes to the design that may adversely affect safety, such as drainage and pavement markings.

Control of projects must be maintained by the agency or else cash flow, approvals, scopes of work, and commitments will become unmanageable. Some decisions based on existing circumstances are prudent from the agency's perspective, but can be counterproductive and create a loss of control if improperly exposed outside of the agency. Non-agency representatives on the audit team were not initially needed because the expertise was available internally; therefore, further evaluation is needed to determine if the use of non-agency members is beneficial.

PennDOT should not allow audits to control all decisions and possibly jeopardize completion of projects. Controversial concerns were not incorporated when this was a possibility. Some improvements were desirable, but not worth a great delay or the loss of a needed project. This problem can be minimized if the audits are started early in the development of the project to give PennDOT time to react.

Conflict resolution regarding citing concerns, reporting concerns, and accepting remedial improvements can be the difference in the success of the road safety audit (RSA) process. Conflicts arising during these periods were monitored to determine how to best resolve them. It was decided that the team must reach a consensus and the coordinator must communicate the concerns of the team and not his own. Further, the coordinator and project manager must strive to mutually resolve any areas of conflict. However, if this is not possible the district's Program Management Committee would make any final determinations relative to cost and delay; the team must then accept these final decisions. Using this procedure, only minor conflicts arose, and consensus was easily reached throughout the pilot program.

Liability is reduced by a process that purely addresses safety concerns for all road users. However, identifying concerns that may not be adequately addressed, even for good reasons, may be damaging in future torts. Even concerns cited—that will be adequately addressed in the upcoming project—could be used as ammunition in torts arising from recent crashes by providing proof that the agency itself recognized the existence of a problem. Tort exposure is greatly minimized through responsible documentation as discussed previously in this report.

ASSESSMENT OF THE EFFECTIVENESS OF THE AUDIT PROCESS

As mentioned in the introduction of this report, this pilot effort was to be used to determine if the safety audit procèss is a valuable tool for PennDOT. As part of that determination the following three key issues were to be considered.

- Does the safety audit process "add value?"
- Does the safety audit process slow down the design process?
- Can the safety audit process be implemented with existing resources?

Each of these issues will be considered in detail in the following.

DOES THE SAFETY AUDIT PROCESS "ADD VALUE?"

Given the observations of PennDOT staff members, who were involved in this pilot effort along with those of the evaluation team, it would seem that the safety audit process does add value to PennDOT's other design-, operation-, and maintenance-based activities. In both districts, the audit teams found potential problems associated with several types of projects in various stages of development. In both districts, an effort was made to keep the audit from being influenced by the activities of the safety review committees in their performance of safety reviews. In as much as the work of the SRCs is primarily related to addressing adherence to standards, it would appear that the audit teams performed a different function, one that identified issues that would not have been discovered as part of the safety review. The real value of the safety audit process and its interaction with the safety review process was best illustrated in an observation from one of the pilot program participant's:

> Auditors found that strict adherence to standards or a combination of standards may be inappropriate or unnecessary and can create potential safety concerns or

eliminate an even better roadway improvement. Often, standards only provide a minimum of the treatment that may be required. The audits helped determine if this was sufficient when considering safety and compatibility for other road users.

This observation does not diminish the value of the safety review process since an organization should not formulate standards if it does not intend to follow them. However, a design approach that only relies on compliance with standards may fail to see the true problem at the heart of the matter. The safety audit process allows for a check of the work by a team of individuals who offer a fresh view of the project. Problems that can be identified before the project is completed will ultimately save PennDOT money in the long run in terms of reduced rehabilitation costs and reduced exposure to tort claims.

With this added value, however, there is some additional risk involved as well. Does using the audit process take the control of the project out of the hands of the project manager and put it into the hands of the audit team? In many districts, the problems associated with scheduling "another set of meetings" are daunting. What are the implications if certain concerns raised by the audit team are not addressed? Could this unnecessarily expose PennDOT to tort actions? These are certainly areas of concern that must be addressed once operating rules are established for the execution of an audit.

DOES THE SAFETY AUDIT PROCESS SLOW DOWN THE DESIGN PROCESS?

The safety audit process does delay the overall design process. The extent of the delay generated is highly dependent on the type of project and the stage of the audit. For simple designs that are audited early in the development of the design, the delays are minimal. For complicated projects audited in later stages (e.g., construction or pre-opening), the delays could be extremely long.

Most delays are associated with the production of an altered design, one that accounts for the problems identified by the audit team. Longer delays could be caused by design "fixes" that require the use of areas that exceed the project's "environmental footprint." Other long delays can be caused by constructability problems.

Some delays can be caused by the management of the audit team. For example, delays can be produced when plan or field reviews have to be rescheduled due to scheduling conflicts, or when audit team members take on new positions within PennDOT, which necessitates that they leave the audit team. However, delays such as these are encountered in many of the tasks that PennDOT employees frequently encounter.

If balanced against the benefits derived from conducting the audits, the delays that are added to the design process may be acceptable; however, one can but acknowledge that incorporating safety audits into the design procedures does delay the overall process.

CAN THE SAFETY AUDIT PROCESS BE IMPLEMENTED WITH EXISTING RESOURCES?

Costs for conducting each of the pilot programs were estimated by the implementation teams from both districts. Detailed information on these cost estimates is given Appendix A. It was estimated that the implementation of the three road safety audits conducted in district 6-0 cost PennDOT $4,000, based on an estimate of 154 professional staff hours and the cost of using vehicles for the field reviews. This means the average cost per audit was $1,333.33. The total cost associated with conducting safety audits for 11 projects in district 10-0 was estimated at $31,600, based on 392 professional staff hours and 300 support staff hours. This translates into an average cost of $2,875.00 per project.

In these analyses, the cost of professional time in district 6-0 was estimated at $25 per hour. District 10-0 estimated these same costs at $50 per hour. If these costs are equalized at

$50 per hour, then the total cost for running the three audits conducted in district 6-0 becomes $7,850 with an average cost per audit of $2,615.

It was noted that not all projects necessitated the same level of effort to conduct the audit. Given the rough estimates that were made and based on this simple analysis, it would appear that conducting an audit runs somewhere between $2,500 and $3,000 per review per project. These costs would seem to be in line with estimates produced in the United Kingdom ($3,000 to $4,500 for small jobs) and Australia ($3,000 for large jobs) (Schuckel and Hughes, 1997). For all projects reviewed in both districts, general overhead funds were charged for all of the expenses that were incurred.

It is difficult to determine whether safety audits can be implemented with existing resources. While there are additional direct charges related to safety audits—as demonstrated by the costs apportioned to the different district overhead budgets, these costs may be offset by savings accrued due to reduced future maintenance costs or reduced exposure to tort claims. Also, if the average cost per audit charges is correct, the additional costs are negligible when considered as a percentage of the overall project cost including program planning, engineering design services, and construction costs.

RECOMMENDATIONS

Based on the observations of the implementation teams and the research team, it is recommended that PennDOT expand the road safety audit process within its organization. Given that PennDOT has other types of project reviews (e.g., value engineering, constructability, Step 9, etc.), every effort should be made to coordinate safety audit reviews with these other activities. However, it should be noted that in coordinating safety audits with these other reviews, the recommendations made in the following should not be compromised. The following general procedure to integrate safety audits into PennDOT's design process is recommended.

SELECTION OF TEAMS

For the audit process to proceed smoothly, one person should be responsible for the introduction and continued implementation of road safety audits. Different approaches were used in each of the districts; however, it appears that the responsibility for each effort was vested in a single individual. Based on the apparent success of this approach, it is recommended that a safety audit coordinator be appointed in each district where road safety audits will be conducted. The coordinator will be responsible for the selection and training of audit teams along with the administration of all activities related to conducting audits. In conjunction with the district plans development engineer and district design liaison engineer, the coordinator will select the projects that will undergo a safety audit.

To allow for broad coverage of all subject areas related to design, operations, and maintenance, the audit teams should be composed of professional staff from each of the following units:

- Plans,
- Construction,

- Maintenance, and
- Traffic.

It is also suggested that multiple audit teams be formed in each district. This step will distribute the audit review work load so that no one group of individuals is overburdened by performing this function. Consequently, the audit team members will be able to continue to focus on their primary job responsibilities wherein they gain the experience that makes them valuable members of the audit team. Multiple teams will also reduce some the problems associated with the member turnover due to a change in job title. Thus, a member of another audit team, with the same expertise as the missing member, will be able to fill the vacant position until a replacement team member is identified, selected, and trained.

All safety audit coordinators should receive specific training relative to how to administer this type of program. All of the other individuals listed previously should receive training on how to conduct safety audits.

As recommended in the earlier PennDOT report on safety audits (Kuhn, Pietrucha, and Garvey, 1996), the research team still believes that every effort should be made to assemble an independent audit team. This will allow the audit team members to maintain their objectivity as they review different plans. PennDOT should consider having the team members come from district offices other than the project setting. This step could lessen the pressure on specific individuals to silence criticism within their home district office out of fear of offending co-workers.

As with the earlier report, it is still believed that the audit team should call on the expertise of the statewide pedestrian and bicycling coordinator or motor carrier safety assistance program (MCSAP) specialists for specific projects. Also, as stated in the earlier report, as far as the study team knows, there is no human factors expertise resident within PennDOT. While there is no instant remedy for this problem, PennDOT should seriously consider developing this type of expertise in the central office and each district office.

SELECTION OF PROJECTS

It is recommended that a safety audit take place for specific project types during certain phases of design. Safety audits should be performed for capital, 3R, 4R, and bridge projects. The bridge projects should only be audited if there is going to be a complete rehabilitation of the bridge and a redesign of its approaches. Bridge projects that will only include a reconstruction of the bridge deck should not be subject to a road safety audit.

For the projects mentioned previously, each of which requires an Environmental Impact Statement or Environmental Assessment, audits should be conducted:

- During the Internal Administrative Activities described in PennDOT's *Environmental Impact Statement Handbook* (Publication 278);
- During the Detailed Alternatives Development and Review described in PennDOT's *Environmental Impact Statement Handbook* (Publication 278);
- After the project has advanced to the final design stage as described in PennDOT's *Design Manual, Part 1, Highway Procedures* (Publication 10); and
- During construction of the project.

GENERAL AUDIT PROCEDURE

Individual audit team members should be selected by the road safety audit coordinator. As mentioned previously, the team should be composed of one member each from the Plans, Construction, Maintenance, and Traffic units in the district along with other individuals who have expertise related to the projects that will be reviewed by a particular team. One member of the audit team should be designated as the team leader or chair. The team leader will be responsible for the scheduling of meetings and procurement of plans for the team to review. There should be a one-day work meeting scheduled to begin the audit process for a single project. This one-day meeting should provide an opportunity for the team to become familiar with the project, field view the project, and draft preliminary findings and general recommendations based on its reviews. The team meetings should begin with the project manager's briefing on the proposed work. If a consultant is used for the design, this briefing should be given by someone from the consultant's design team if possible. After the briefing, the audit team should review the project plans.

The review of the project plans should be conducted with the aid of the checklists provided in the initial PennDOT safety audit report (Kuhn, Pietrucha, and Garvey, 1996). The checklists should be used to provide a focus and maintain some order in terms of which general areas should be covered and which topics should be addressed. Once this review is complete, the team would proceed to project field site and conduct the field view. After the field view is completed, the team should return to the office to discuss the issues that were identified from their reviews. The outcome of these discussions should be the development of a preliminary set of findings and general recommendations from the team. After the meeting, the safety leader should check the team's findings and recommendations to see if are feasible given the project's current status. After this step, the team leader should develop a final set of findings and general recommendations regarding the project. He or she would later meet with the project manager to discuss the findings of the team. Subsequent to this meeting, the coordinator would produce a memorandum to the assistant district engineer for design. In case there are any issues that cannot be resolved through this process, the district engineer, or his designated representative, should be responsible for making the final decision regarding action on the noted safety issues.

CONDUCT OF FIELD VIEWS

To conduct the field views, the audit team members should travel to the project site in a van. If possible, a member of the project design team should accompany the audit team so that questions can be answered and options discussed at the site. Once they arrive at the site, the team would travel the project route in both directions following along and extending beyond the project boundaries. Each run should be videotaped to provide a visual record and to record spoken comments from members of the team. Also, the team should walk the project route to be able to more fully consider whether items such as drainage structures, utility poles, or other features could constitute matters of concern. No effort should be made to reach a consensus on any issues noted during the field view. Rather, as issues are raised, they should be noted and discussed when the team returns to the office.

DEVELOPMENT AND COMMUNICATION OF FINDINGS AND GENERAL RECOMMENDATIONS

For each audit of each project, the audit team should develop a preliminary and final set of findings regarding the project. Once these findings are formulated, they should be assembled into a memorandum form. The memorandum should be circulated to each of the team members for a final review and approval of their concurrence with the memorandum's findings. The memorandum should be forwarded to the assistant district engineer for design for final action.

To ensure the proper handling of any reports related to safety audit procedures or results, audit documents should be kept in a separate file within the project files. This includes all PennDOT, Federal Highway Administration, and consultant project files. The safety audit documents file and all items within the file should be labeled with the following wording:

> **"Confidential–In-Depth Accident Investigation/Safety Study."** In accordance with PA Consolidated Statutes Title 75 - Vehicles (Vehicle Code) Section 3754 and 23 U.S.C. Section 409, this safety study is confidential, and the publication, reproduction, release, or discussion of these materials is prohibited without the specific written consent of the Pennsylvania Department of Transportation's Office of Chief Counsel. This safety study is only provided to official agencies with official duties/responsibilities in the project development.

CLOSURE

Implementation of a comprehensive safety audit process within PennDOT would be a major undertaking. The recommendations made herein represent a goal that PennDOT should strive to achieve. However, it is recognized that given PennDOT's size, complexity, and organizational structure, the type of safety audit review program that can be implemented must reflect practical considerations; the study team may not have had the opportunity to fully consider these items given the scope of this initial effort. An expansion of the pilot program or a staged implementation of the process might be warranted before a fully executed program can be realized.

REFERENCES

Kuhn, B.T., M.T. Pietrucha, and P.M. Garvey (1996). *Development of a Safety Audit Process for Pennsylvania,* Pennsylvania Department of Transportation: Harrisburg, PA, August 1996.

Schuckel, C. and W. Hughes (1997). "Evaluating the Pilot Studies," Presented at the Federal Highway Administration Road Safety Audit Workshop. St. Louis, MO, May 19, 1998.

APPENDIX A – COST ESTIMATES FOR IMPLEMENTING THE ROAD SAFETY AUDIT PILOT PROGRAM

APPENDIX A – COST ESTIMATES FOR IMPLEMENTING THE ROAD SAFETY AUDIT PILOT PROGRAM

DISTRICT 6-0

<u>Using $25/hour as the average hourly salary of persons involved</u>

6 people/audit x 8 hours/person x 3 audits = 144 hours

10 hours expended on typing and administration

154 total hours x $25/hour = $3,850

Expenses for van use = $150

Total expense = $4,000

<u>Using $50.00/hour as the average hourly salary of persons involved</u>

6 people/audit x 8 hours/person x 3 audits = 144 hours

10 hours expended on typing and administration

154 total hours x $50/hour = $7,700

Expenses for van use = $150

Total expense = $7,850

DISTRICT 10-0

<u>Review Team Effort</u>

10 review days x 7 hours/person/review day x 5 people x $50/hour = $17,000

<u>Coordinator's Effort</u>

4 hours arranging field views

30 hours managing field notes

8 hours attending meetings

42 total hours x $50/hour = $2,100

Estimated Redesign Effort

300 hours x $40/hour (combined hourly rate of professional, CADD, and clerical staff) = $12,000

Total Cost

$31,000