Research Report
KTC-05-15/SPR-280-04-1F

KENTUCKY TRANSPORTATION CENTER

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EVALUATION OF METHODS TO LIMIT THE TIME TAKEN TO INVESTIGATE CRASH SITES

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EVALUATION OF METHODS TO LIMIT THE TIME TAKEN TO INVESTIGATE CRASH SITES

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in cooperation with

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16. Abstract

Highway crashes have significant direct and indirect costs associated with them. Substantial sources of indirect costs are the congestion and delays that result from lane blockages or road closures while the crash is being investigated and the site cleared. In many cases, vehicles could be moved and roadways reopened very quickly, but this does not occur because of the need (or perceived need) to conduct a detailed investigation of the crash scene. The objective of this study was to identify opportunities to reduce the time required to investigate and clear crash scenes. This project includes a review of state and national best practices with a specific, detailed examination of the use of photogrammetry for reconstruction. Recommendations are presented to reduce the time taken to investigate crash sites.

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EXECUTIVE SUMMARY

Highway crashes have significant direct and indirect costs associated with them. Substantial sources of indirect costs are the congestion and delays that result from lane blockages or road closures while the crash is being investigated and the site cleared. In many cases, vehicles could be moved and roadways reopened very quickly, but this does not occur because of the perceived need to conduct a detailed investigation of the crash scene. Thus, the process of crash investigation can substantially increase the congestion and delay costs associated with the crash. It is possible, in many cases, that the incremental cost of the investigation greatly exceeds any value that it may produce. The objective of this study was to identify opportunities to reduce the time required to investigate and clear crash scenes.

The primary tasks for this project were to identify and summarize current policies and procedures by Kentucky State Police and selected local law enforcement agencies, analyze data from Kentucky's CRASH database, review state and national practices with regard to reducing the time taken to investigate a crash scene, and investigate the advantages and disadvantages of using the photogrammetry method for reconstruction.

First, a telephone survey was conducted with local law enforcement agencies to determine the amount and type of investigation activities that are typically undertaken at a crash site. Of the 239 agencies that responded, more than 25 percent have at least one reconstructionist on staff. Most agencies responded that they use the coordinate method for reconstruction with traditional equipment (i.e., tape measure). Sixteen local agencies indicated that they were using total station (at times) for reconstruction.

A separate, detailed survey was conducted with those state and local law enforcement agencies responding to the highest number of fatalities, in order to gain more specific information on current policies and procedures. The findings showed that the policies and procedures vary greatly from one agency to another. Some of the common policies or procedures included: 1) a fatality almost always warrants additional investigation; 2) additional investigation may include taking pictures, video, measurements, or using a reconstructionist and creating detailed drawings; and 3) most agencies who investigate a fatality have a reconstructionist on staff.

The national survey and literature review also showed that policies and procedures vary greatly from agency to agency. The information did help to identify several best practices with regard to crash site investigation. Some of those include: use faster and better methods for reconstruction (i.e., total station, photogrammetry, etc.), improve coordination among responding agencies, move tasks off the roadway or delay the investigation until an off-peak time, ensure that responders have the proper training and expertise, and obtain consent of the coroner to remove deceased victims.

Crash records from the 2003 CRASH database were analyzed. The analysis examined the closure duration based on multiple variables. Some of the variables included: if an occupant

was trapped, the roadway type where the crash occurred, the number of units involved in the crash, the posted speed limit on the roadway where the crash occurred, and the injury severity of the crash victims. One of the primary conclusions from the data analysis was that as the severity of injuries or number of fatalities increases, so does the duration of the roadway closure.

Photogrammetry is the technique of measuring objects from photographs or digital images. Its use for crash site investigation is relatively new and some agencies are skeptical about its use for this application. However, many agencies have tried the method or are currently using it. Several agencies were contacted for interviews in order to get their perspective on the use of photogrammetry for accident reconstruction. Of the seven agencies who responded that had used (or were using) photogrammetry, five were no longer using it (or using it very little). Some of the reasons for not using photogrammetry included: the high cost of implementing the change, the labor and time intensity of photograph analysis, and the steep learning curve for analyzing the data.

Several recommendations to reduce the time taken to investigate crash sites were identified as a result of this project. Some of those recommendations include: enhance the training of law enforcement officers to include information on the safety and congestion repercussions associated with closing the roadway, perform a review and side-by-side comparison of various reconstruction technologies, and make use of accident response teams for major incidents.

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Nancy Albright	Kentucky Transportation Cabinet
Major Sonny Cease	Kentucky State Police (retired)
Cash Centers	Kentucky Transportation Cabinet (formerly)
Terry Chism	Federal Highway Administration
Homer Druin	Kentucky Emergency Management
Lieutenant Joe England	Kentucky Vehicle Enforcement
Andy Fluegemann	Northrop Grumman / ARTIMIS
Sergeant Neil Gilreath	Covington Police Department
Captain Todd Kelley	Ashland Police Department
Chuck Knowles	Kentucky Transportation Cabinet
Chief Allen Love	Versailles Police Department
Gary Mitchell	Kentucky Transportation Cabinet
Captain Lisa Rudzinski	Kentucky State Police
Tim Schoch	Northrop Grumman / ARTIMIS
Officer John Smoot	Lexington Police Department
Carl Sumner	Insurance Institute of Kentucky
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1.0 INTRODUCTION

1.1 Background

Highway crashes have significant direct and indirect costs associated with them. Substantial sources of indirect costs are traffic congestion and delays that result from lane blockages or road closures while the crash is being investigated and the site cleared. In many cases, vehicles could be moved and roadways reopened very quickly, but this does not occur because of the need to conduct a detailed investigation of the crash scene. Thus, the process of crash reconstruction can substantially increase the congestion and delay costs associated with the crash. It is possible in many cases that the incremental cost of the reconstruction greatly exceeds any value that it may produce.

There is a responsibility for law enforcement agencies to treat some highway crashes as felony crime scenes. In those instances, the collection of data is important, and investigators are often meticulous. There is often a difference of opinion on where the priority should be, even within law enforcement agencies. Officers controlling the traffic may consider clearing the roadway and restoring traffic their top priority, while investigators may consider preserving the scene and collecting data their main objective.

When a roadway is closed for significant amounts of time, numerous problems may arise. Traveler delay is the problem most commonly associated with roadway closures due to crashes, but another serious problem is the secondary crashes that may occur. It is not unusual for the secondary crash to be more severe than the original crash. Another related issue is the danger posed to response personnel serving the public at the scene of a crash. The longer a crash is in place, the longer the responders are vulnerable and exposed to injury.

These problems result in significant costs. If we are conducting activities at crash scenes in Kentucky that generate substantial costs while producing little value, then it is essential that we reexamine those activities and develop improved guidelines and procedures.

1.2 Objective

The objective of this study was to identify opportunities to reduce the time required to investigate and clear crash scenes.

1.3 Tasks

To achieve the objective of this study, the following tasks were completed:

- Task 1 – A survey was conducted with the Kentucky State Police and selected local law enforcement agencies to determine the current policies and procedures used for crash site investigation.

- Task 2 - Kentucky’s current policies and procedures were summarized and evaluated. The content of the summary was determined by the Study Advisory Committee and included such items as: how agencies are conducting crash scene investigations, what types of equipment are being used, how many people are trained to use the equipment, and what type of training is required.

- Task 3 – Police records from the Collision Report Analysis for Safer Highways (CRASH) database for the year 2003 were examined to determine the closure duration associated with each crash. These closure durations were represented in graphical form for analysis. General conclusions were drawn from these graphs.

- Task 4 - A literature review and national survey was conducted to identify other states and urban areas that have special procedures in place to reduce the time spent for crash site investigation. These findings, or “best practices”, represent the lessons learned and practices implemented by other states or regions.

- Task 5 – A specific review of photogrammetry equipment was conducted that included a literature review and survey. This review helped to identify the specifics of photogrammetry including: how it is used, advantages and disadvantages of using the method, the cost, and the specific agencies that are using it. Follow-up interviews were conducted with some agencies who were known (or thought) to have experience with photogrammetry.

- Task 6 - The findings from this study were summarized and documented in this final report. The report includes recommendations for reducing the amount of time spent on the scene for crash site investigation.

  Sections 2.0 through 5.0 of this report describe these tasks in greater detail.

2.0 CURRENT POLICIES AND PROCEDURES OF CRASH SITE INVESTIGATION IN KENTUCKY

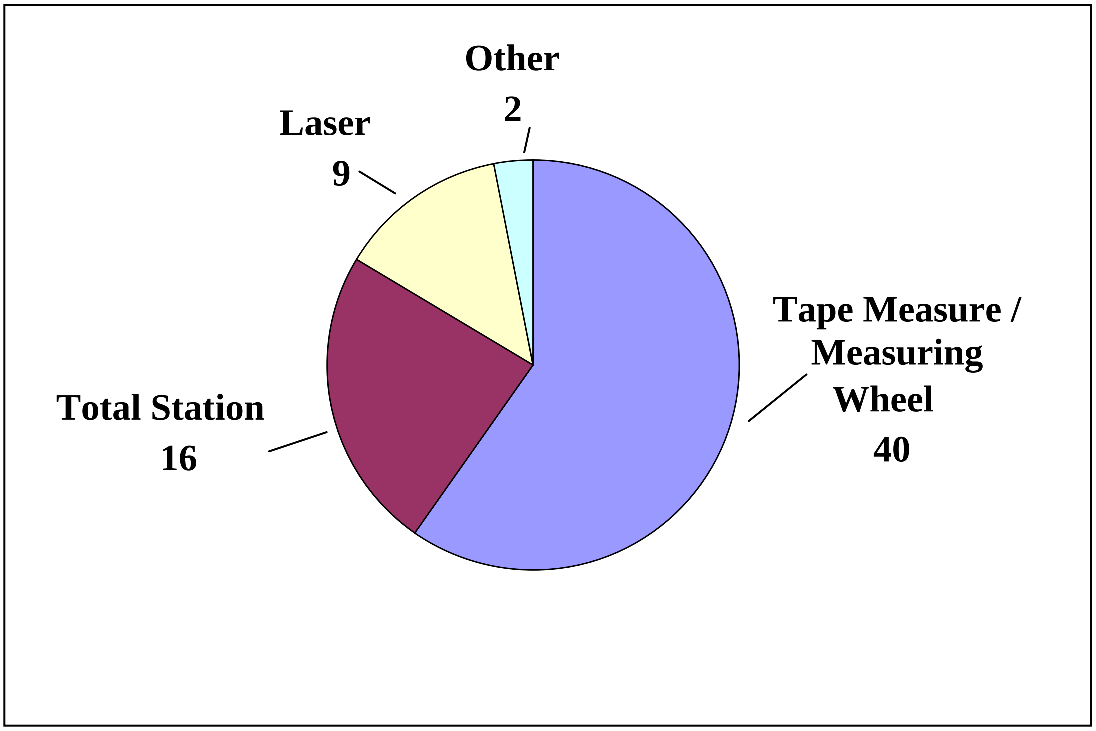
As part of Task 1, a telephone survey was conducted with several law enforcement agencies in Kentucky to determine the amount and type of crash site investigation (or more specifically, reconstruction) activities undertaken at a crash scene by local agencies. Of 395 county and city police agencies and sheriff departments identified, 239 responses were recorded for the survey. A complete list of the agencies that responded to the survey can be found in Appendix A.

One hundred seventy-nine agencies (responding to the survey) had no reconstructionist on staff and used another agency when a reconstructionist was needed. Of these agencies, 147 used the Kentucky State Police (only), 26 used a local agency, and 4 used either Kentucky State Police or a local agency (depending on availability). No information was provided for two of the agencies.

Sixty of the responding agencies stated that they had at least one reconstructionist on staff. Of these, 27 agencies had more than one reconstructionist on staff. Agencies with a reconstructionist were also asked about the method they used to obtain measurements for crash scene investigation. Most agencies responded that they used the coordinate method with a tape measure or measuring wheel. Several of the agencies responded that they used more than one method. Figure 1 shows the breakdown of the type of equipment used for reconstruction. None of the agencies surveyed were using photogrammetry. The following agencies were using total station:

- Boone County Sheriff's Office
- Covington Police Department
- Elizabethtown Police Department
- Erlanger Police Department
- Fort Wright Police Department
- Georgetown Police Department
- Hardin County Sheriff's Office
- Jeffersontown Police Department
- Kenton County Police Department
- LFUCG Division of Police
- Louisville Metro Police Department
- Pulaski County Police Department
- Nicholasville Police Department
- Radcliff Police Department
- Scott County Sheriff's Office
- Versailles Police Department

Figure 1. Type of Equipment Used by Local Agencies for Reconstruction



To gain more specific information on the current policies and procedures being used for crash site investigation, a separate detailed survey was conducted with a select group of law enforcement agencies. Agencies were chosen for the survey by reviewing Kentucky's 2003 CRASH data and identifying the agencies that had worked the highest number of fatal crashes for that year. In addition, Captain Todd Kelley, a member of the Study Advisory Committee, completed and returned a survey for the Ashland Police Department. Twenty-six agencies were contacted and twenty-five responses were documented. The following agencies responded to the survey:

- Ashland Police Department
- Boone County Sheriff's Office
- Boyd County Sheriff's Office
- Clark County Sheriff's Office
- Daviess County Sheriff's Office
- Graves County Sheriff's Office
- Henderson County Sheriff's Office
- Jackson County Sheriff's Office
- Jessamine County Sheriff's Office
- Kentucky State Police
- Laurel County Sheriff's Office
- Lewis County Sheriff's Office
- LFUCG Division of Police
- Logan County Sheriff's Office
- London Police Department
- Louisville Metro Police Department
- Marshall County Sheriff's Office
- McCracken County Sheriff's Office
- Montgomery County Sheriff's Office
- Oldham County Police Department
- Paducah Police Department
- Perry County Sheriff's Office
- Shelby County Sheriff's Office
- Versailles Police Department
- Warren County Sheriff's Office

The survey was conducted over the phone and included eight questions. The goal of the survey was two-fold; 1) to determine when and how crash site investigation was done, and 2) to determine the methods used for crash site investigation. Respondents were specifically asked to focus on work beyond the effort required to document the crash with the CRASH form. Listed below were the questions included in the survey.

1. How does an officer who is working a highway crash determine when more than just basic documentation using the CRASH form is necessary? *(i.e., further investigation is needed)*

2. Is this determination made at the discretion of the officer, or are there written policies and procedures for this?

3. If there are written policies and procedures, can we obtain a copy of those?

4. When it is determined that additional investigation is needed, what exactly does that entail? *(i.e., what is done?)*

5. Is there any kind of special training that is needed to do any of this additional investigation? If so, what training is required, and how many officers have this training?

6. Is there any kind of special equipment that is used to do this additional investigation? If so, what type of equipment?

7. How accessible is this equipment to your officers? *(i.e., how many pieces of equipment does the agency have and how easy/difficult is it to get the equipment on scene?)*

8. After taking care of the injured, either clearing the scene or collection of data can take a considerable amount of time. Are there any guidelines used that, after a certain amount of time, opening of the road is considered to be essential to the point that no more data are collected and any means necessary is used to remove vehicles and cargo from the roadway?

2.1 Summary of Policies and Procedures Survey

The answers varied greatly as to when more than basic documentation was needed. All agencies responded that a fatality was or could be (depending on the specific situation) grounds for further investigation. Most agencies stated that the decision for further investigation depended on the nature and extent of the crash. Several agencies also stated that serious injury crashes and/or those involving possible violations (i.e., drug and/or alcohol use, excessive speeding, etc.) were also potential candidates for further investigation. Five agencies indicated that confusing circumstances (i.e., the officer is not sure what happened or who is at fault) would be grounds for further investigation. Other possible reasons for more than basic documentation of a crash (along with the number of agencies who stated the reason) were: multiple vehicles involved (four); extensive property damage (two); extraordinary circumstances (two); hazardous material spilled (one); and a possible large lawsuit (one).

The decision for further investigation was most often made solely at the discretion of the officer or the supervisor on duty. This was the case for 13 of the 25 agencies surveyed. Another six agencies stated the decision was based on both the officer's discretion and a written policy. Six other agencies said the decision was based solely on a written policy. Of the 12 agencies that stated they had a written policy, nine policies were received. Those policies are summarized in Section 2.2 of this report. The other three policies were requested but not received.

The most commonly identified investigation activities that were used to document the scene beyond what was required on the CRASH form included: taking photographs, video, and measurements of the scene; using a reconstructionist; and creating detailed drawings of the scene. Eight of the agencies surveyed stated that they received no specialized training for this effort. Sixteen agencies stated that reconstruction training was necessary, and that they had at least one reconstructionist on staff. Basic reconstruction training is a six-week course and is typically received through the Institute of Police Technology and Management in Jacksonville, Florida or Richmond, Kentucky. Three agencies mentioned that specialized training was offered by some vendors. For the Kentucky State Police (KSP), a seven-week course is required for reconstructionists. An advanced reconstruction seminar is also offered annually to all reconstructionists. There is no cost for the seminar and many people from Kentucky and out-of-state attend.

The 25 agencies surveyed had a total of 135 trained reconstructionists on staff. KSP had the most with 74 reconstructionists. Lexington-Fayette Urban County Government (LFUCG) Division of Police had 16 and Louisville Metro Police Department had 15. Versailles Police Department and Boone County Sheriff's Office had six reconstructionists each. Ashland Police Department had four, Oldham County Police Department had three, and Daviess County Sheriff's Office and Paducah Police Department each had two. The following agencies had one reconstructionist on staff: Shelby County Sheriff's Office, Laurel County Sheriff's Office, London Police Department, Perry County Sheriff's Office, McCracken County Sheriff's Office, and Graves County Sheriff's Office. The following County Sheriff's Offices stated that currently they had no reconstructionist on staff: Marshall, Jessamine, Montgomery, Clark, Jackson, Lewis, Boyd, Henderson, and Logan.

Of the agencies identifying specific equipment for the investigation, 13 stated they used standard equipment (i.e., drag sled, tape measure, etc.). Five agencies had total station equipment, including: Boone County Sheriff's Office, LFUCG Division of Police, Louisville Metro Police Department, KSP, and the Versailles Police Department. Paducah Police Department and Oldham County Police Department owned laser equipment for reconstruction. Occasionally, McCracken County Sheriff's Office used Paducah's laser equipment for reconstruction. It was also determined at a Study Advisory Committee meeting that LFUCG Division of Police and KSP had access to photogrammetry software, but had not used the method.

With regard to accessibility, total station equipment, laser equipment, and the standard reconstruction equipment (such as a drag sled, tape measure, etc.) were usually available at a central office location or within an officer's patrol car. The location of the crash may have an effect on the time required to get the equipment on site.

With the final question of the survey, agencies were asked if there were any guidelines in place concerning when the roadway would be reopened. Every agency responded that there were no guidelines. Many agencies communicated that how quickly the roadway was opened depended greatly on the specific situation. Several agencies were aware of the problems associated with closing a roadway and made a conscious effort to open at least one lane of traffic as soon as possible. Eight agencies commented that the evidence would be collected regardless of how long the roadway was closed. Three agencies noted that they would occasionally come back later to complete their investigation. Six agencies commented on the problem with calling specific towing companies to the scene. Some towing companies had long response times (depending on distance traveled to the scene) and some did not have the appropriate equipment when they arrived on scene.

2.2 Summary of Policies

The nine policies received as a result of the survey were reviewed and are summarized in the following paragraphs. There were two basic components within the policies that were deemed pertinent to this study: 1) When is more than just a typical investigation performed and what does it entail?; and 2) Are there any specific directions for clearing the roadway in an expeditious manner?

First, it is important to note what a typical crash investigation might entail. Kentucky Revised Statutes 189.580 and 189.635 specify that:

a.) The driver of any vehicle involved in an accident resulting in death, injury, or damage shall immediately stop, notify police, and arrange for medical treatment.
b.) The driver of any vehicle involved in an accident resulting in injury, death, or total property damage of $500 or more shall, within ten (10) days, make a written report of it to the Kentucky Justice Cabinet.
c.) Law Enforcement officers who investigate a vehicle accident for which a report must be made shall, within ten (10) days after completing the investigation, forward a written report of the accident to the Kentucky Justice Cabinet.

Also designated under the provisions of Kentucky Revised Statute 189.635, officers shall record all collision reports on the Kentucky Uniform Police Traffic Collision Report Form (KSP74), supplemental information shall be recorded on the Uniform Police Traffic Collision Supplementary Form, and any supporting documentation on a one-sided sheet of paper.

Table 1 on the following pages summarizes when further investigation is warranted and what is required by each agency. With the exception of the Daviess County Sheriff's Office, each agencies' policy specifically mentioned using a reconstructionist for the detailed investigation. With most of the listed agencies, this was accomplished in house, but some had to contact other local agencies or KSP to respond.

Table 1. Summary of Further Investigation Information Contained Within Local Policies

Agency	What Type of Crash Requires Further Investigation?	What is Required for the Investigation?
Ashland Police Department	• Fatalities • Life threatening injuries • Dismemberment of any body part or sufficient trauma to suggest possible dismemberment • Factors which cannot be readily determined • Serious injuries involving all passenger carriers, or hazardous material carriers, or any traffic accident involving spillage of hazardous material from a carrier • Serious injury involving a train and a motor vehicle or pedestrian • Serious injury involving a vehicle owned by the city of Ashland or other municipal, federal, state or county government • Serious injury where primary cause may be a roadway defect • Vehicles utilized in the commission of a felony	A Traffic Accident Reconstructionist (TAR) will be assigned to reconstruct these crashes. The TAR may also assist with an accident investigation where there is a need for limited participation by the TAR for speed calculations or examination of vehicle parts for manufacturing defects, or whenever specified by the Chief of Police, a Division Commander, or Watch Commander.
Boone County Sheriff's Office	• Fatalities • Serious physical injury that is initially believed to result in death, dismemberment, or serious/permanent impairment • Collisions which may result in felony prosecution	1) When possible, the shift supervisor shall respond, in addition to the primary responding deputy. 2) At the shift supervisor's discretion, a departmental Collision Reconstructionist shall be contacted and requested to respond to the scene.

Table 1. Summary of Further Investigation Information Contained Within Local Policies

Daviess County Sheriff's Office	• Death or injury • Damage to public vehicles or property • Hit and run • Impairment due to alcohol or drugs • Hazardous materials • Disturbances between principals • Major traffic congestion as a result of an accident • Damage to vehicles to the extent towing is required • Occurrences on private property (Only accidents that involved the removing of vehicles before the officer's arrival shall not warrant a full investigation.)	A "full investigation" includes a thorough accident report, photographs if appropriate, as well as any other investigative methods deemed necessary by the deputy such as alcohol testing, etc.
Lexington Police Department	• Fatalities • Life threatening injuries • Accidents that involve any Urban County Government personnel with serious injuries, death, or vehicles with serious property damage	The Accident Reconstruction Unit is called to respond and shall take charge of the investigation.
Louisville Metro Police Department	• All fatal motor vehicle collisions • All other motor vehicle collisions that result in serious injury to one (1) or more persons • Collisions involving death due to natural causes while operating a motor vehicle • Motor vehicle collisions involving Metro Government owned/operated/leased vehicles in which incapacitating injuries occur to Metro Government employees, or where significant property damage is involved • Police-related deaths or serious physical injuries due to pursuits or other collisions • Collisions where felony or criminal mischief charges are appropriate	The Technical Accident Investigation Team will be responsible for conducting a thorough and complete investigation.

Table 1. Summary of Further Investigation Information Contained Within Local Policies

Montgomery County Sheriff's Office	• Fatality • Serious Injury • Accidents involving county-owned police vehicles	In the event of a fatality or serious injury, the Kentucky State Police accident reconstructionist(s) may be notified. Accidents involving county-owned police vehicles shall be investigated by the Kentucky State Police.
Oldham County Police Department	With supervisor approval for: • Fatalities • Serious physical injury • Accidents involving County Police vehicles in which death or serious physical injury occurs to any person	1) An accident reconstruction officer is used to supplement the report.
Paducah Police Department	• Fatal injury or apparent fatal injury • Serious physical injury (coma, loss of limb, etc.) • Accidents that involve the Paducah Police Department or any city-owned vehicle that results in death, serious physical injury, or substantial property damage • At the direction of a police supervisor	1) A Collision Reconstruction Team (CRT) is responsible for investigating and reconstructing the accident.
Versailles Police Department	For particularly serious accidents involving: • Serious injuries • Fatalities • Multiple vehicles	Expert or technical assistance from photographers, surveyors, mechanics, physicians, accident reconstructionists, or other specialist will be called upon. Accidents involving departmental vehicles and personal injury or substantial property damage will be investigated by an outside agency. Supervisors shall first contact the Kentucky State Police.

Table 2 summarizes the information found in each policy that pertained to quick clearance. Some policies did not include this information, but this does not mean that the specific agency does not have a written policy on the subject. This summary is only of what was sent in response to the survey, and is not a review of the agencies' complete policy handbook.

Table 2. Summary of Quick Clearance Information Contained Within Local Policies

Agency	Policy regarding Roadway Clearance and Traffic Movement
Boone County Sheriff's Office	"In the interest of public safety and convenience, the roadway should be cleared as soon as possible. If vehicles can be moved to expedite traffic flow, this should be done as soon as practical after the deputy obtains his/her investigating data."
Daviess County Sheriff's Office	"Deputies should direct the traffic flow to ensure public safety" and "should use all emergency warning equipment to warn oncoming traffic of the accident scene."
Louisville Metro Police Department	"In the interest of safety and convenience, the roadway should be cleared as soon as possible. If vehicles can be moved to expedite traffic flow, this should be done as soon as practical after the officer obtains his investigative data." "An officer may assist a motorist in requesting the towing company of his/her choice. However, if a delay in removal will impede the normal flow of traffic, a wrecker will be called to remove the vehicle."
Montgomery County Sheriff's Office	"If the private towing service cannot respond in a reasonable amount of time and traffic flow will be hindered as a result of this delay, the member may request an authorized wrecker to remove the vehicle."
Oldham County Police Department	"Restore traffic movement to its normal flow as quickly and as safely as possible." Local agencies have developed an "Emergency Traffic Control Plan". This plan includes traffic routing plans for short-term and long-term closures of I-71 within Oldham County.
Paducah Police Department	The first officer at the collision scene has the responsibility for "expediting removal from the roadway of all vehicles, persons, and debris (in property damage-only collisions, where possible, get vehicles off the roadway immediately to get traffic moving)."
Versailles Police Department	The first officer at the collision scene has the responsibility for "expediting removal from the roadway of all vehicles, persons, and debris (in property damage-only collisions, where possible, get vehicles off the roadway immediately to get traffic moving)."

3.0 BEST PRACTICES FOR CRASH SITE INVESTIGATION

As part of this project, a literature search was conducted. This was completed by searching through library journals and magazines, as well as the internet, to find articles or information that pertained to this project. There were 85 documents that were collected and reviewed. Only ten documents had information relevant to crash site investigation. These documents included articles, published research, conference proceedings, and investigation manuals from several different agencies across the United States.

3.1 Summary of Literature Review Results

Crash investigation is an important element in the entire incident management process at a crash scene. Crash investigation is an effort to determine how the crash occurred. Investigators are required to document the cause and description of traffic crashes. Information that is collected during a crash investigation can be used by traffic engineers to support safety improvements in crash prone areas. The information may also be used by insurance companies and provide information for litigation purposes.

After a crash has occurred, law enforcement officers are required to complete a crash report. The purpose of this procedure is to collect information regarding the nature and cause of the crash. Each state within the United States may have their own unique crash report form, but all states collect very similar information. The data collected include general information pertaining to the persons and vehicles involved, the location and site characteristics, the manner of collision, the damage to the vehicles, the injuries sustained, and a description of the crash. If a serious traffic crash occurs, such as those involving fatalities, roadway defects, or suspected criminal activities, additional data are often collected to provide evidence for possible litigation.

All law enforcement officers receive training on how to fill out a crash report. As the seriousness of the crash increases, so does the experience and training needed to investigate a crash. Often crashes are reconstructed during the investigation. Some agencies have multidisciplinary investigation teams for more intensive investigations or reconstructions. These teams can consist of investigators with specialized training in traffic collision reconstruction, traffic engineering, automotive engineering, and vehicle dynamics (1).

When to Investigate

The purposes of a crash investigation are to promote safety, combat criminal activity, and ensure just results in civil litigation. However, specific requirements for when to reconstruct a crash can vary based on individual agency policies. The City of Minneapolis reconstructs crashes that involve a felony, a fatality or serious injury, a Minneapolis Police Department vehicle, an on-duty police officer’s vehicle, and a city or government vehicle (2). California Highway Patrol reconstructs crashes that involve a fatality or personal injury, a school bus, an arrest for a violation, a prosecution that will be sought due to an identifiable violation, a hit-and-run where the vehicle can be identified by license number or physical evidence at the scene, and a state-owned vehicle (3). Florida Highway Patrol reconstructs crashes that involve bodily injury or death, a violation of Florida Statutes, a hazardous material vehicle that poses a significant threat to public safety, a Department of Highway Safety and Motor Vehicle's vehicle, vehicles or property owned by the government, a criminal offense or pursuit, or a commercial vehicle (4). The Florida Highway Patrol policy manual also lists the types of crashes that should not be investigated.

Equipment

Traditionally, investigators collect the data at the crash scene using a procedure known as the coordinate method. This method typically involves using a tape measure or measuring wheel to document the crash scene; however, electronic distance meters or laser instruments can also be used. In this procedure, the investigator first establishes a base line through the incident scene and a reference point on the base line. All the measurements are measured perpendicular from the base line and reference point to the points of interest. This type of field data collection requires a minimum of two trained officers (5).

In recent years, some law enforcement agencies have started using total station surveying equipment to document the crash scene. This system features an electronic theodolite equipped with an internal electronic distance-measuring device and a built-in microprocessor, which make it possible to automatically measure and record distances and angles to a reflector placed at the points of interest at the crash scene. The survey data are recorded in an electronic file, which is processed in the office to generate an accurate, scale diagram of the crash scene. Experience with the total station surveying system indicates that about twice as many measurements can be taken in half the time required with the conventional coordinate method (6). This type of data collection requires a minimum of two trained officers.

Unfortunately, the equipment and training required by the total station surveying system are beyond the means of many local law enforcement agencies. However, advances in digital camera technology have made it possible to develop an affordable traffic crash investigation system that provides the time saving benefits of the total station surveying system with less training and expense (6). This digital camera system is also known as photogrammetry. Refer to Section 5.0 for more information on photogrammetry.

Other modern tools for crash investigation include laser range finder systems and global positioning system (GPS) technology. The laser range finder systems are expensive, fragile, require high maintenance, not usable in all weather conditions, and require line of sight between the measurement points. A drawing program must also be purchased along with the measurement equipment (7). A GPS-based system uses satellites to establish the location of the receiver. The distance to three or more satellites is measured. By knowing the position of the satellites, the location of the receiver can be calculated. Some GPS units are accurate to within one inch or less.   The receiver operates on radio signals so no line of sight is required. The GPS receiver requires only one person to operate. Despite its advantages, the high cost of GPS units has thus far limited their adoption for crash investigation (8).

The use of bar codes and magnetic stripes for identification of driver and vehicle information is becoming common in the US (9). States are beginning to use bar codes on driver's licenses to encode driver identification information and/ or vehicle identification information. Some vehicle manufacturers are beginning to use bar codes to track inventory. A law enforcement officer could then obtain driver and/or vehicle information more quickly and accurately at the scene of a crash. Benefits of this technology include a reduction of errors in the recording of driver and vehicle characteristics, a time savings to the officer completing the report, a reduction in work load and labor hours to the data processing personnel, and a possible reduction of counterfeit or forged driver's licenses and vehicle registration cards.

Crash Investigation Sites

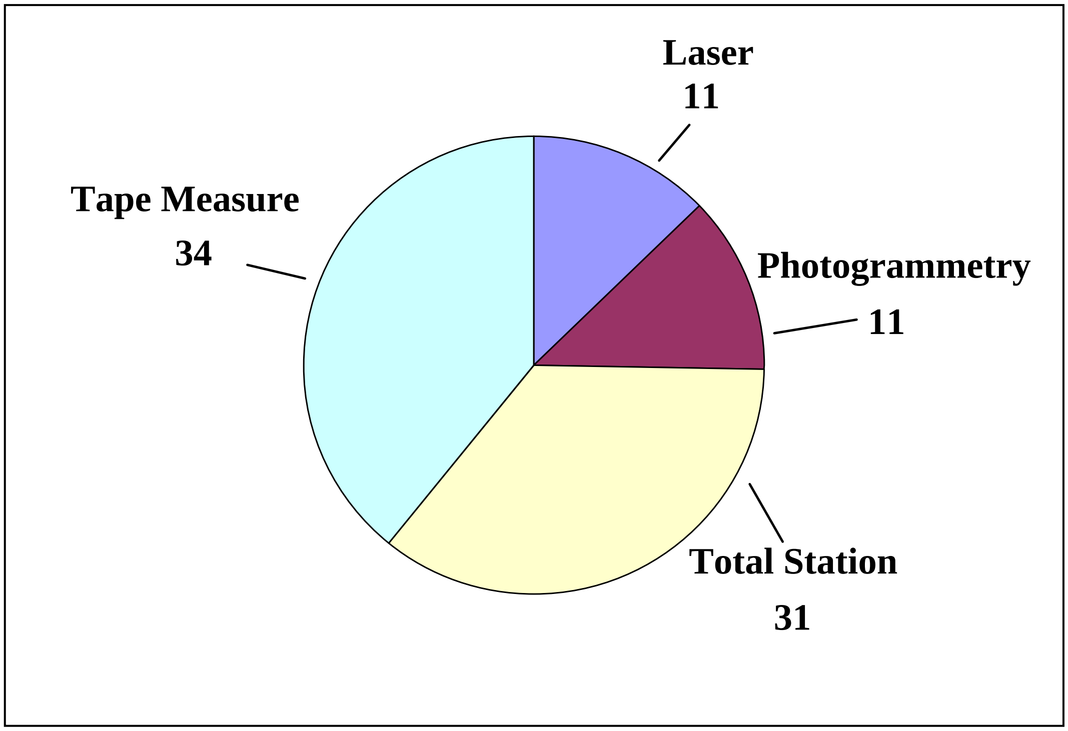
Crash investigation sites are designated areas off the roadway where damaged vehicles can be moved, motorists can exchange information, and law enforcement officers can complete the necessary paperwork (10). These sites are generally located out of view from the roadway to reduce rubbernecking. Typical locations of crash investigation sites include under a freeway overpass, on a side street or parallel frontage road, or in a nearby parking lot. The benefits associated with these sites include reduced motorist delays, reduced secondary crashes, and improved safety for involved motorists and responding personnel (5). The weaknesses of these sites include difficulty in implementing in needed locations, public awareness, and drivers feeling uncomfortable being in an obscure location with a stranger (10).

3.2 Summary of National Survey

A national survey was conducted with state police agencies to identify methods used to reduce the amount of time spent on a crash scene. In addition, methods to improve safety at the scene were identified. KSP provided a point-of-contact for each state police agency, with the exception of Hawaii. Each point-of-contact was sent a brief survey via email to complete and return electronically or by fax. The survey contained four questions dealing with methods of reconstruction and practices used to reduce time and/or improve safety on the scene of a crash. Follow-up was conducted via US mail to all agencies who did not respond to the email. Thirty-seven agencies (77 percent) responded to the survey, and the findings are summarized below. The complete survey, along with a list of agencies that responded, can be found in Appendix B.

The first question dealt with the method used to obtain measurements for crash scene investigation or reconstruction. Most agencies responded that they used more than one method for reconstruction; Alabama, Michigan, and New York were the only state police agencies to respond that they used total station for all reconstruction. The Georgia State Patrol stated that they used the coordinate method 100 percent of the time. Figure 2 shows the methods of reconstruction being used by the responding agencies.

Figure 2. Methods of Reconstruction for Responding State Police Agencies



More than half of the responding state police agencies (24) used the coordinate method for crash investigation or reconstruction 50 percent or more of the time. Several state law enforcement agencies indicated that they used total station 50 percent or more of the time (but not all the time), including: Delaware, Kansas, Louisiana, Maryland, Minnesota, Missouri, Pennsylvania, South Carolina, and Washington. Only one state, Utah, responded that they used photogrammetry the majority of the time (70 percent). None of the agencies responded that they used the triangulation method the majority of the time.

Question number two on the survey dealt with the state police agencies' experiences with photogrammetry. New Hampshire State Police had considered the use of photogrammetry, but had not tried it. The Tennessee Department of Safety stated they were going to begin training for photogrammetry in June 2005. Four states indicated that they had just completed training or were currently testing the method: Florida, Kansas, Wisconsin, and Oregon. Ten agencies stated they had some experience with the method. Table 3 shows the agencies that had experience with photogrammetry, their brief comments regarding their experience with the method, and the percentage of time they currently used photogrammetry for investigation or reconstruction.

Table 3. State Agencies' Experiences with Photogrammetry

State Agency	Comments	Percent Time Using Photogrammetry
Arizona Department of Public Safety	"Yes, Photomodeler was looked at. We have the road closed for 1.5 to 2 hrs in most serious collisions anyway. Our VCU [Vehicular Crimes Unit] can photo and measure in less time, not delaying road openings."	1
Connecticut State Police	"Seldom used, and usually as a last resort. A time-consuming process that produces approximate values (we do not have "high-end" photogrammetry equipment. It has been beneficial when no other means were available.)"	1
Idaho State Police	"Some of our officers have used photogrammetry. Can be very hard to get juries to understand it.)	0
Louisiana State Police	"The Department's reconstructionists have rarely utilized this method of reconstruction. The method is complex and not easily explained to a jury when the case goes to court."	2
Maryland State Police	"Fastest method w/ quick re-opening of the roadway, but difficult to use on longer scenes, such as high speed crashes on highways. Training is difficult to get and very involved."	5
Minnesota State Patrol	"We use both Photomodeler and iWitness. Typically we use photogrammetry for evidence and vehicle positions and the total station for the intersection and road lines. Smaller scenes best."	20
Missouri State Highway Patrol	"Two officers received the training and equipment. Our crash team members found this method too time consuming and work intensive to utilize for quick clearance of crash scenes a BAD system for an interstate highway."	1
New York State Police	"Pilot program only- approximately 5 years ago. This method presented luke-warm results."	0
Utah Department of Public Safety	"Very good. We started photogrammetry for the 2002 Winter Olympics to clear roads. We have decreased "on-scene" time by a third."	70
Washington State Patrol	"The Photomodeler Pro program the WSP uses is a good program. However, it has a substantial learning curve which causes frustration for users."	11

Question three dealt with practices the agency had used or seen others use to reduce the time spent at the crash scene. The most common answer to this question was that the agency had an improved way to investigate the crash scene or reconstruct the incident. The methods mentioned included the use of total station, laser, GPS, and the photogrammetry method. Another common answer was that investigators reduced the time on scene by marking the scene appropriately and then returning later to complete the investigation. This allowed the roadway to be opened more quickly and officers could complete their investigation when conditions were more favorable (i.e., less traffic, better weather, etc.). Also mentioned frequently was the process of distributing the work among various officers and working together to complete the tasks more quickly. A complete list of all the time-saving methods is included below in order of frequency in which they were mentioned.

1) Use faster and better methods for reconstruction (total station, laser, GPS, photogrammetry, etc.).
2) Postpone the investigation to a later time when traffic and/or weather conditions are better or do not do the investigation at all.
3) Divide the job into various tasks and work as a team to get it done more quickly.
4) Quickly clear vehicles and cargo from the roadway when possible.
5) Use in-vehicle computers to verify and record information.
6) Ensure that the officers have the proper training and experience.
7) Use incident response teams to handle major crashes.
8) Use roadway service patrols to help with minor incidents.
9) Make use of an at-scene crash investigation form to get the necessary information and then move off the roadway.

Question four dealt with practices the agency had used or seen others use to improve safety at the crash scene. The most common answer to this question was the improved visibility of officers on the scene. Reflective safety vests and improved lighting on the scene were mentioned as ways to improve visibility. The next most common answer was the use of traffic control devices such as traffic cones, message signs, flares, arrowboards, barricades, and “crash trucks”. These items were used to manage traffic and communicate to drivers. Also commonly mentioned was the use of incident response teams or traffic control teams on the scene and improved technology for reconstruction. A complete list of all the safety-improving methods is included below in order of frequency in which they were mentioned.

1) Improve the visibility of responders on the scene.
2) Use traffic control devices to manage traffic and communicate to drivers.
3) Use traffic control teams (from the DOT or fire department) or incident management teams to help with the control of traffic.
4) Use faster and better methods for reconstruction.
5) Full roadway closures or additional lane closures to keep traffic away from responders.
6) Quickly clear vehicles and cargo from the roadway when possible.
7) Postpone the investigation to a later time when traffic and/or weather conditions are better.

8) Implement a policy for crash scene investigation.
9) Have more units respond to the scene.
10) Improved training for responders.
11) Use the media to inform drivers of incidents.
12) Use officers to follow the queue of traffic as a warning to drivers.
13) Develop a partnership with the DOT.

It should be noted that the 2003 MUTCD has added Chapter 6I that deals with control of traffic through traffic incident management areas. Information is given for traffic control through major (more than 2 hours), intermediate (30 minutes to 2 hours), and minor (under 30 minutes) traffic incidents. A fluorescent pink background with a black legend was established for warning and guide signs used for traffic incident management situations (11).

3.3 Summary of Best Practices

The following methods have been identified as best practices based upon their implementation in other areas and/or their identification as a best practice by multiple agencies. These methods were used to reduce the time spent on the scene of an incident.

Coordination with Responding Agencies

Working together with all responding agencies (and within a single agency) is a good way to reduce the time spent on scene. Incident management is a team effort and when all the agencies come together to do their job the scene is managed and cleared more efficiently and effectively. Training together is an important part of this coordination. Agencies should not meet each other for the first time at the scene of a crash. The ability to communicate is also an important consideration when coordinating with other agencies. Incompatible radio systems and agency lingo are barriers to communication.

Establish Guidelines for Reconstruction

A policy or guidelines should be in place for each law enforcement agency establishing when reconstruction is necessary. Reconstruction is a time-consuming component of the investigation and should only be done when the conditions of the crash warrant. This may eliminate some of the times when reconstruction is performed.

Incident Response Teams

Incident response teams are interagency groups that have specialized training in incident response, management, and clearance. They are often used in the event of a major incident and can significantly reduce the time needed on scene. The implementation of incident response teams would allow responders to get more opportunity to use their skills on serious crashes, thus reducing the time required to complete the task.

Improved Methods for Reconstruction

Reconstruction of an incident is a time-consuming component of crash scene investigation. Improved methods are available to reduce the time on scene for investigators. The following equipment and/or methods have been recognized to save time on scene: laser units, total station equipment, GPS technology, high density scanners, and photogrammetry.

Move Tasks Off the Roadway

When possible, crash investigation tasks should be moved off the roadway. This improves safety for responders and reduces delay for motorists. For instance, it may be possible to mark the evidence and then perform the reconstruction on the side of the roadway. It is also possible to organize the investigation in such a way to do only necessary tasks while in the roadway. Once these tasks are done, the vehicles, cargo, and people are removed from the roadway and the investigation is completed elsewhere. The investigation report should designate which items need to be collected before the roadway is cleared of the incident.

Off-Peak Hour Investigation

Many times the investigation can be postponed until there will be less impact on traffic conditions and better traffic control available. Vehicle locations and critical evidence must be documented prior to removal from the roadway. Investigators can then return to the scene at a later time to finalize the investigation. This reduces traffic delay and improves safety for the investigators.

Proper Training and Expertise

Properly trained and experienced responders working at a crash scene are critical to reduce the time spent on scene. Training should be required within single agencies (for their specialized activities), but also between various agencies (for incident management). Local fire departments, who are often tasked with traffic control, need training in this area to improve safety and reduce delay. They may also need appropriate equipment such as reflective safety vests and traffic cones to perform their job effectively. It is also important that each agency puts experienced people in charge at the scene of a crash.

Quick Clearance Legislation

The passage of quick clearance legislation or a policy is a good way to reduce the time spent on the scene of a crash. These laws (or policies) require that motorists remove their vehicle from the lanes of travel when it is under their ability to do so. These laws may also allow responding agencies to remove vehicles and cargo from the lanes of travel using the most expeditious means possible.

Roadway Service Patrols

Roadway service patrols traverse the roadway and are used to assist stranded motorists, clear the road of debris, and aid in minor incidents. These programs are well received by the public and by public agencies. They can reduce delay for drivers and reduce the responsibility of agencies in some minor incidents.

Modify Crash Reports to Promote Quick Clearance

Collecting evidence for a crash can be a time-consuming task. By customizing the crash report so critical information is easily documented first, officers can save valuable time on-scene. The remaining report items can then be completed off the roadway or in the office.

Electronic Data Collection

Portable computers such as laptops, pen-based computers, or palm computers can aid in collecting data at the crash scene. These computers replace the traditional pen and paper method of reporting a crash. They can be programmed with task-specific applications that request the necessary data for the appropriate crash type. This reduces the amount of missing or inaccurate data by having built-in checks and prompts for the information. The use of computers can also reduce the problems associated with legibility of reports.

Consent of Coroner

In many instances, the removal of a fatal crash victim from the incident location is not permitted until the coroner has arrived on scene. Permitting the EMS unit to certify death or by telemetrically relaying the vital signs of the victim to an off-site coroner for verification can eliminate the need for the coroner to travel to the site; thus reducing the incident duration.

Crash Investigation Sites

Crash investigation sites allow motorists who have been involved in a crash to relocate their vehicles to a designated place off the roadway for exchanging insurance information and completing a crash report. These sites are usually located on a side road or existing parking lot out of view from other drivers on the roadway (to reduce rubbernecking). Occasionally, specific areas are designated for this purpose only and are located near high-crash areas.

Hold Harmless Policy

A hold harmless policy is intended to permit an agency to more rapidly open the roadway to normal conditions without the concern of liability issues. This type of policy allows an agency to remove certain vehicles from the roadway on an urgent basis, recognizing that public safety is of the utmost importance. This policy protects the public agency from liability for additional damage to the vehicles and contents that may occur during removal.

Bar Codes and Magnetic Stripes

Bar codes and magnetic stripes on driver's licenses and vehicles can be used for driver identification information and/ or vehicle identification information. Law enforcement officers can quickly and accurately obtain driver and/or vehicle information at the scene of a crash. This technology can reduce the number of errors in the records data base related to the driver and vehicle characteristics, the time to complete the report, the work load and labor hours of the data processing personnel, and the number of counterfeit or forged driver's licenses and vehicle registration cards.

4.0 ANALYSIS OF 2003 CRASH DATA

4.1 Closure Times for Non-Fatal and Fatal Crashes

The Collision Report Analysis for Safer Highways (CRASH) database records for 2003 were used in the data analysis. The purpose of the data analysis was to calculate the duration of the closure that resulted from a crash. The closure duration was defined to include the time when all or some portion of the roadway was closed, thus causing some impact to the traffic capacity.

When analyzing the crash database records, there were four individual times listed on the crash report: the collision time, time notified, time arrived, and roadway opened time. To calculate the closure duration, the difference between the collision time and the roadway opened time was used. These times represented the start and finish of the closure in this analysis.

A large portion of the database records had either a zero listed or was left blank in the "roadway opened" box. As indicated in the Traffic Collision Report Manual from the Kentucky State Police, the roadway opened time is "the time that the roadway was opened for traffic to return to its normal movement…If the traffic flow was not obstructed at the time of the officer's arrival, leave this area blank." Therefore, if this area was left blank, it was assumed that the roadway was never closed and that the roadway capacity was never affected. These types of records include run-off-the-road crashes. Since traffic capacity was never affected by these types of crashes, they were removed from the analysis.

There were several other types of records that were removed from the analysis. These included records that had a closure duration of zero because the collision time and roadway opened time were listed as the same time. Also removed were records listed as a hit-and-run crash. The majority of these crashes included parked cars where the owner was unaware of the collision time.

There were 129,831 records in the 2003 CRASH database when this analysis was conducted. Because a closure duration could not be calculated for all these records, only 69,857 were considered in the analysis. The initial intent was to calculate the closure duration for all of the 69,857 records. However, that was not done because: (1) the project completion date was approaching so there was not ample time to calculate and verify the closure duration for all the records; and (2) the project funding was depleting and would not support the time needed to calculate and verify the closure duration for all the records. Out of the 69,857 records, there were 26,400 records or 38 percent that were actually used in the analysis. This 38 percent represents the records that had a closure duration that was calculated and verified starting with the lowest 2003 Master File Number in CRASH and working in ascending order until the analysis process was terminated due to budget and time constraints. Although this was not technically a "random" sample, the records do appear to be a fair representation of all the records based upon location and month of the year the crash occurred. The location of each crash record that was included in the analysis is represented by a dot on the map in Figure 3. The month when the crash occurred is shown in Table 4.

Figure 3. Crash Locations for the Representative Sample

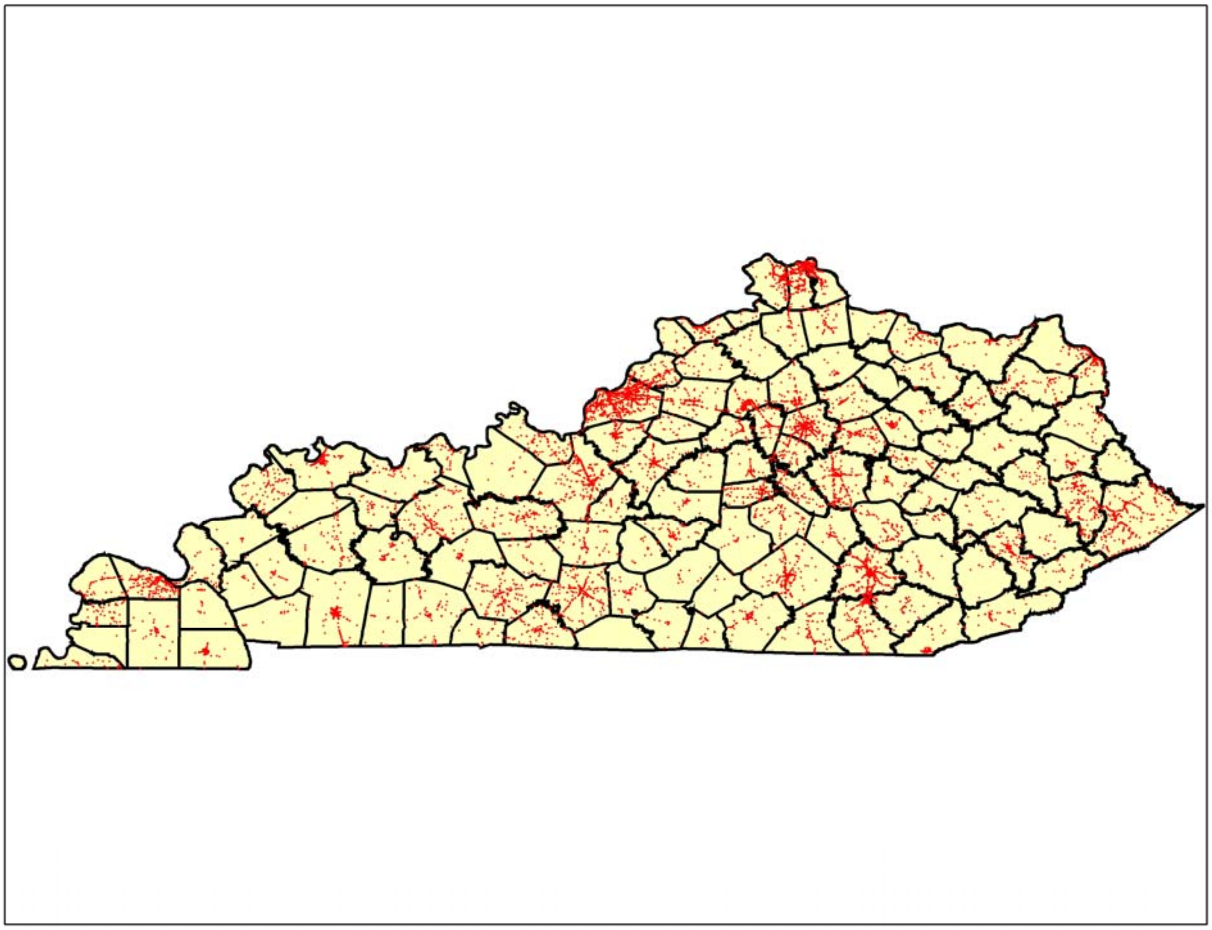


Table 4. Month of the Crash in the Representative Sample

Month	Number of Crashes	Month	Number of Crashes
January	2,117	July	1,616
February	2,214	August	1,953
March	2,116	September	2,072
April	2,397	October	2,372
May	2,602	November	2,515
June	1,614	December	2,812

A separate analysis was performed for fatal crashes. Of the 129,831 records in the 2003 database, 848 records were fatal crashes. Of the 848 fatal crash records, only 681 were considered in the analysis because a closure duration could be calculated. Since that amount of fatal records was considerably smaller and more manageable compared to the entire 2003 CRASH database, all of the 681 fatal crash records were used in the analysis. It should be noted that not all the 681 fatal crash records were included in the representative sample of 26,400 records mentioned above.

4.2 2003 CRASH Records Analysis Results

Throughout this section, the graphs will be labeled to distinguish whether they contain all the 26,400 crash records (labeled as *crashes*) or the 681 fatal crash records (labeled as *fatal crashes*). Each point denoted on the graphs represents a closure duration time.

The longest closure duration for all crashes was 23 hours 50 minutes and for fatal crashes was 14 hours 11 minutes. The average closure duration for all crashes was 32 minutes and for fatal crashes was 2 hours 36 minutes. Cumulative distribution graphs for the crash data records are shown in Figures 4 and 5. In Figure 4, 95 percent of the crashes had a closure duration of 1 hour 30 minutes or less. At 95 percent for fatal crashes, the duration of the closure was 5 hours 35 minutes, or over three times as long (Figure 5). The data shows that fatal crashes generally had longer closure durations. These longer closure times may be due to the more in-depth investigation or reconstruction that was conducted for a fatal crash.

Figure 4. Closure Duration for 2003 Crashes

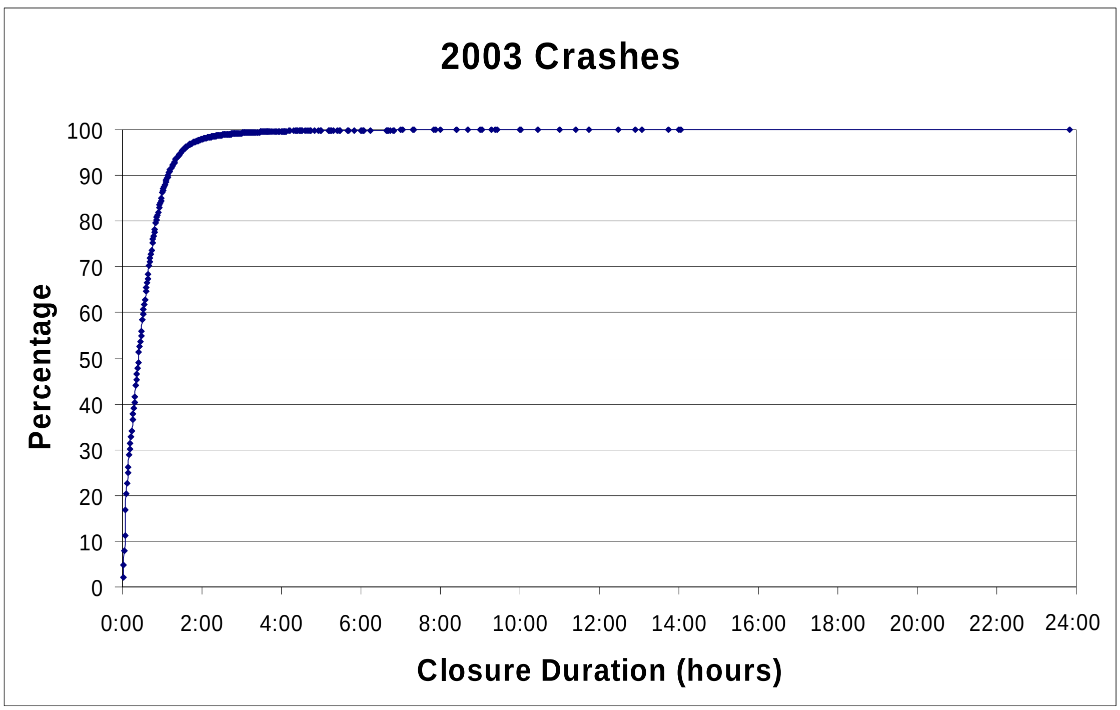
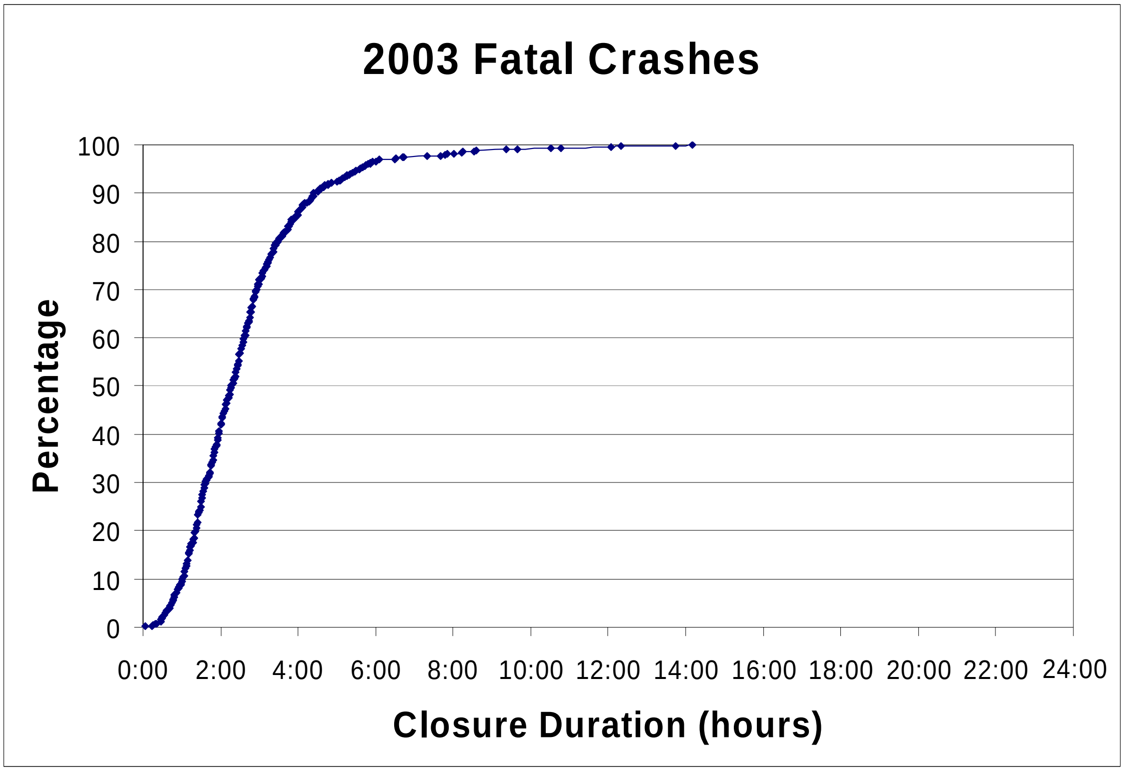


Figure 5. Closure Duration for 2003 Fatal Crashes



The closure durations were evaluated by the type of roadway where the crash occurred. The type or classification for roadways designated as “County”, “Federal”, “Local” and “State” refers to the type of agency that owns or maintains the roadway. The “frontal” roadway classification could be used by itself or in combination with one of the other roadway types. The “frontal” roadway refers to a roadway that generally parallels an expressway, freeway, parkway, or through street that is designed to facilitate accessibility to property that otherwise would be isolated as a result of the controlled-access created by the expressway, freeway, etc. The “unknown” classification includes those listed on the crash report as unknown or that were left blank.

The average closure duration for all crashes ranged from 23 minutes on local roadways to 55 minutes on Parkways (Figure 6). In comparison, the average closure duration for fatal crashes ranged from 1 hour 57 minutes on local roadways to 3 hours 41 minutes on interstates (Figure 7). It is difficult to determine a clear relationship between the average closure duration and the roadway classification.

Figure 6. Closure Duration by Roadway Type for All Crashes

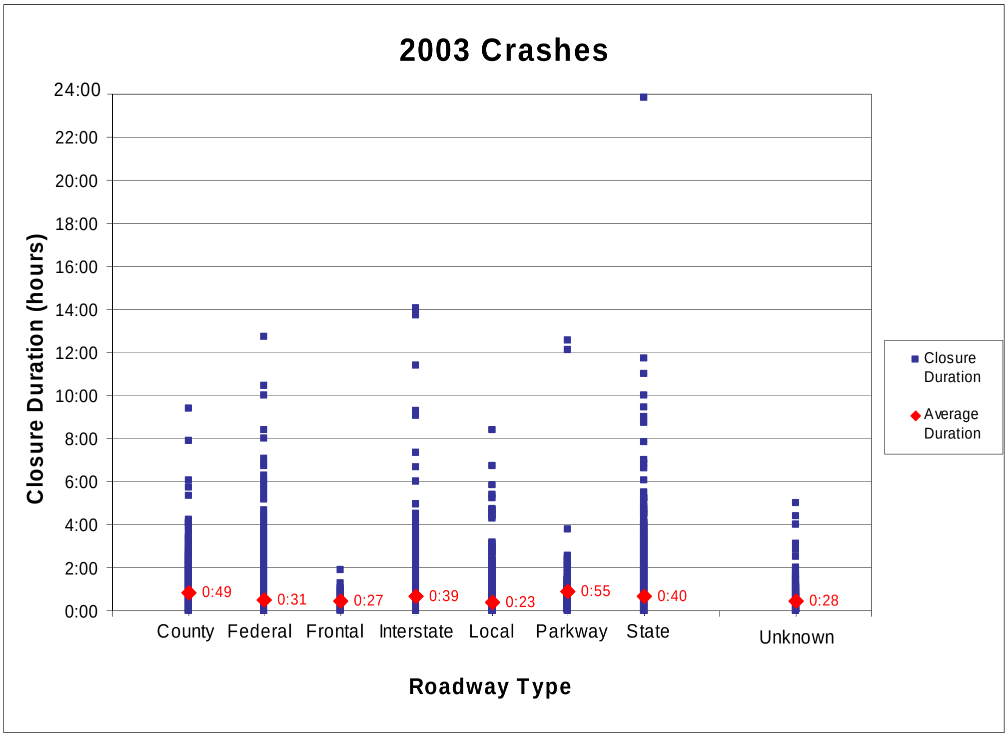
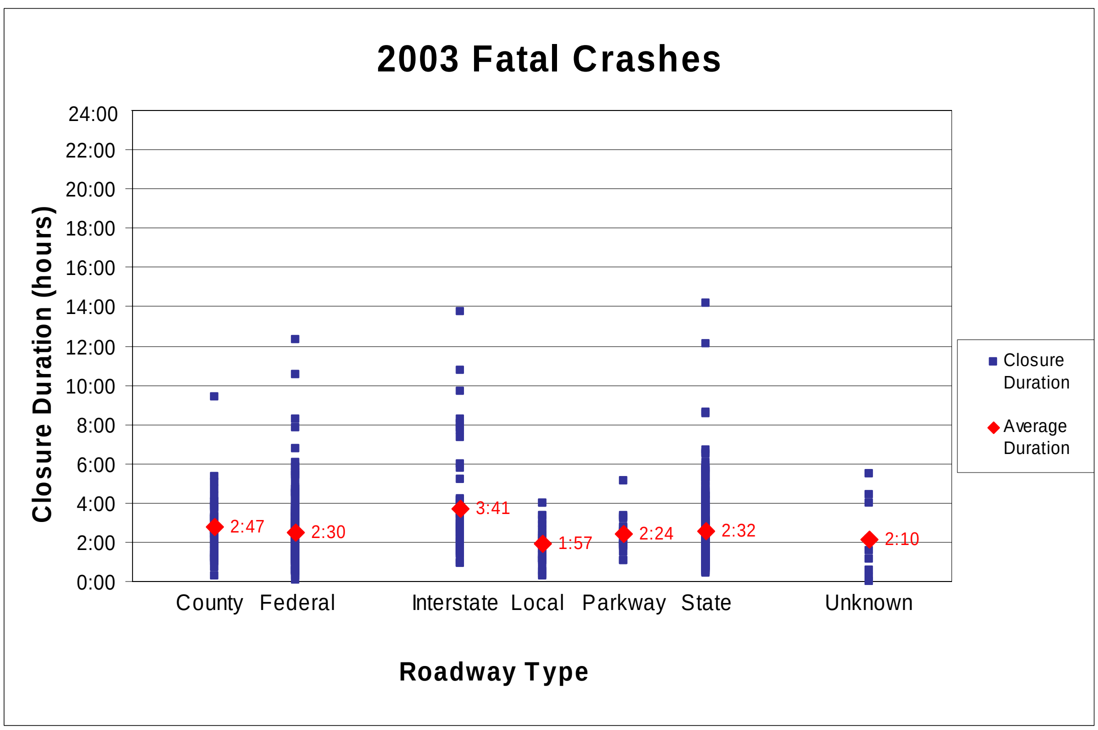


Figure 7. Closure Duration by Roadway Type for Fatal Crashes



Graphs for the number of units involved for all crashes and for fatal crashes are shown in Figures 8 and 9. A "unit" includes a passenger vehicle, a bicycle, a pedestrian, a railroad train, a bus, a truck and trailer, farm equipment, or other modes of transportation on the roadway that could be involved in a crash. Some of the sample sizes for the higher number of units (e.g. 4 units, 5 units, etc.) have a small number of data points and may not yield reliable results. For example, the 8-unit crash in Figure 7 or the 6-unit crash in Figure 8 contain only one crash data point each. Therefore, the average listed is actually the value of that one crash.

The average closure duration for all crashes (Figure 8) ranged from 27 minutes for crashes involving 2 units and 7 units to 2 hours 8 minutes for crashes involving 8 units. The average closure duration for fatal crashes (Figure 9) ranged from 2 hours 29 minutes for a crash involving 1 unit to 6 hours for a crash involving 6 units. The general trend showed that as the number of units increased, so did the closure duration. The single-unit crash category and the categories with small sample sizes did not follow this trend.

Figure 8. Closure Duration by Number of Units Involved for All Crashes

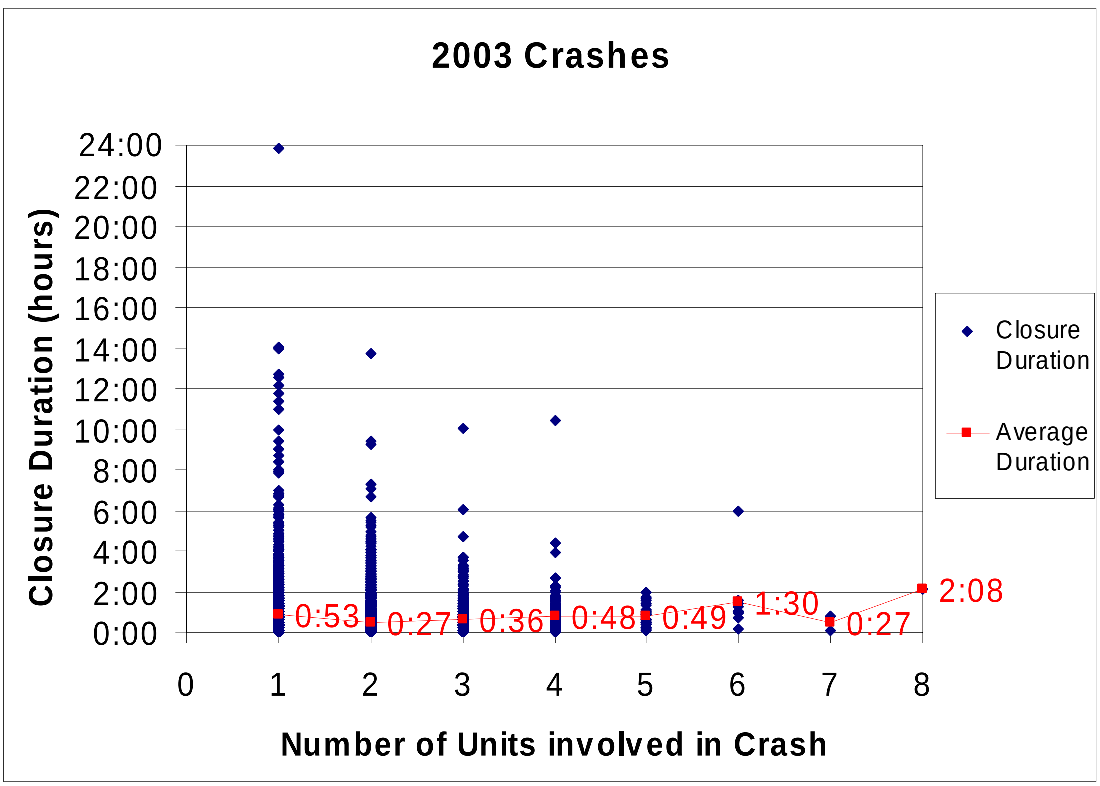
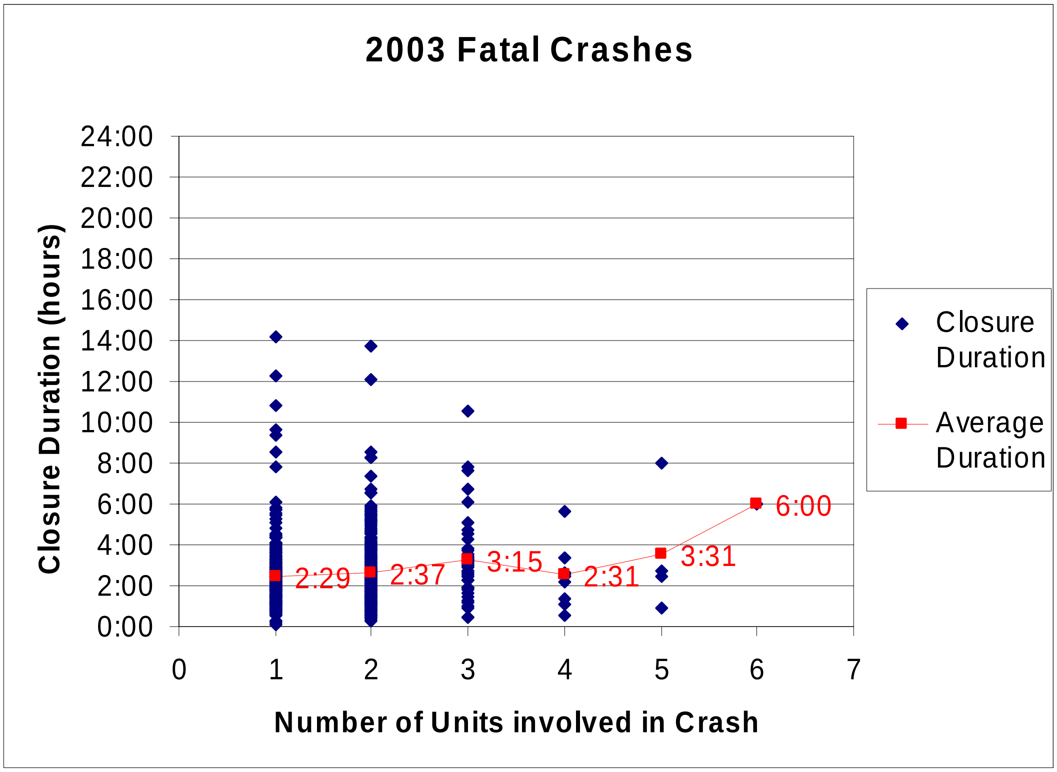


Figure 9. Closure Duration by Number of Units Involved for Fatal Crashes



The duration for crashes involving trapped occupants is shown in Figures 10 and 11. The average closure duration for all crashes was 38 minutes if an occupant was trapped versus 31 minutes if not. The average closure duration for fatal crashes was 2 hours 48 minutes if an occupant was trapped versus 2 hours 23 minutes if not. Therefore, the average closure duration was slightly longer if an occupant in the vehicle was trapped.

Figure 10. Closure Duration Involving Trapped Occupants for All Crashes

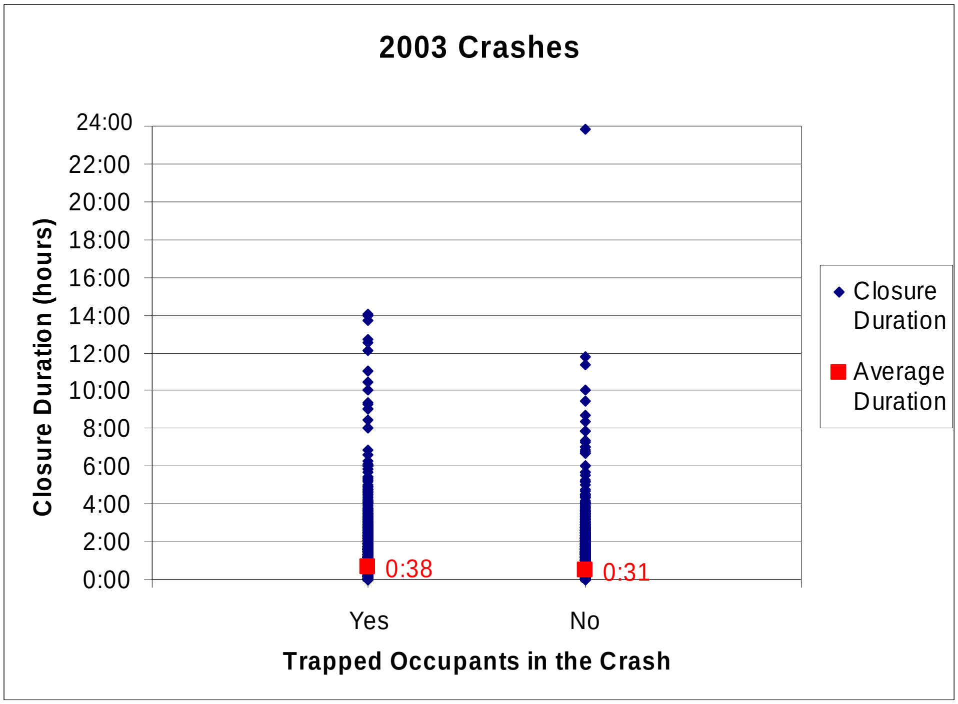
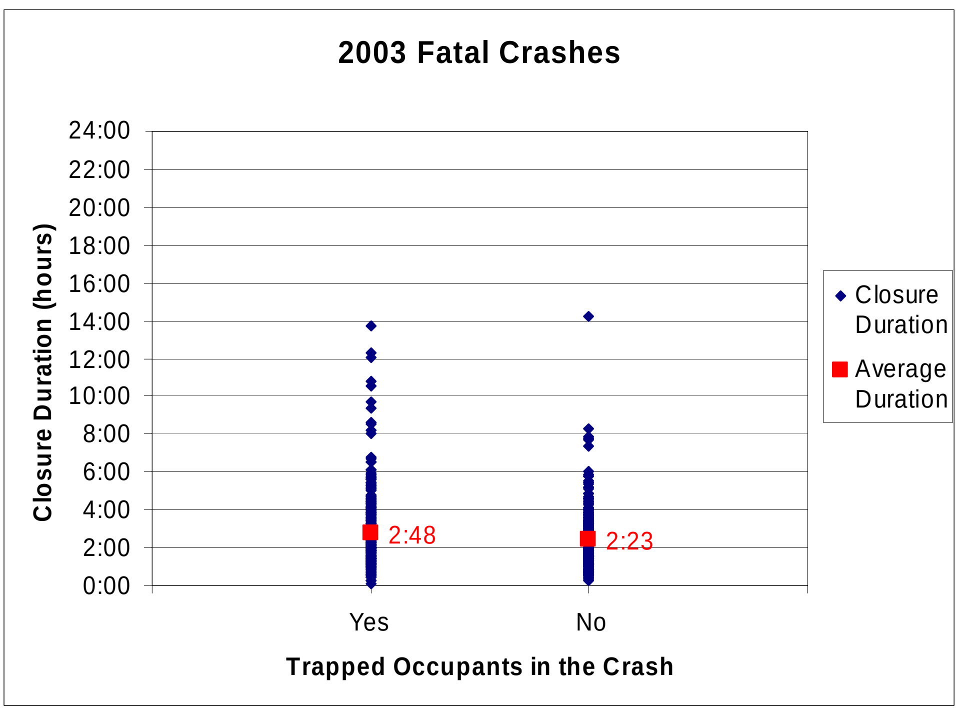


Figure 11. Closure Duration Involving Trapped Occupants for Fatal Crashes



Closure durations for crashes involving hazardous material were analyzed. There were no crashes in the representative sample being analyzed that involved hazardous material. To make certain that our sample was representative of the entire database, further review of the entire 2003 CRASH database was conducted. It was found that there was no crash records in the year 2003 coded as involving hazardous material.

Another variable that was examined in this section was the posted speed limit on the roadway where the crash occurred (Figures 12 and 13). Some of the sample sizes for the lower speed limits have a small number of data points. For example, the speed limits below 25 miles per hour (mph) on the fatal crashes graph (Figure 13) only contain a few crash data points each. Therefore, the average listed may not yield reliable results when compared to the average value of other speed limit categories that contain numerous crash data points.

The average closure duration for all crashes (Figure 12) ranged from 17 minutes for the 30 mph speed limit to 52 minutes for the 65 mph speed limit. The average closure duration for fatal crashes (Figure 13) ranged from 1 hour 9 minutes for the 30 mph speed limit to 4 hours for the 5 mph speed limit. For speeds greater than 40 mph, the general trend showed that as the speed limit increased, so did the closure duration. For speeds less than 40 mph, it was difficult to determine a clear relationship between average closure duration and the posted speed limit.

Figure 12. Closure Duration by Speed Limit for All Crashes

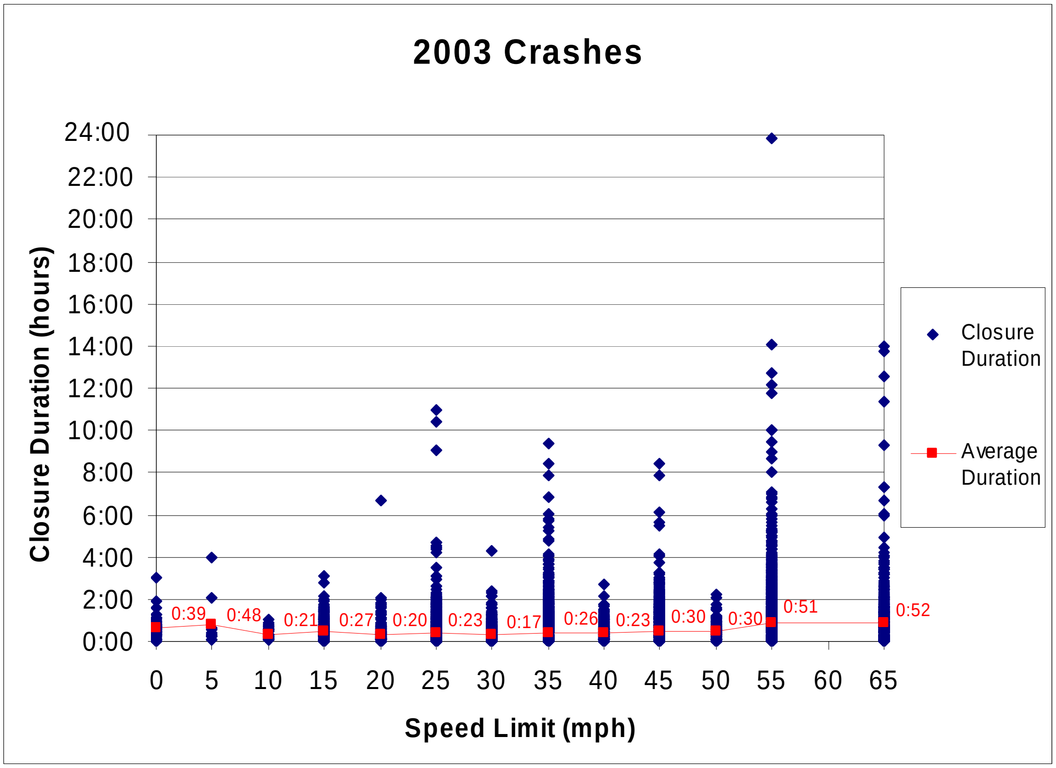
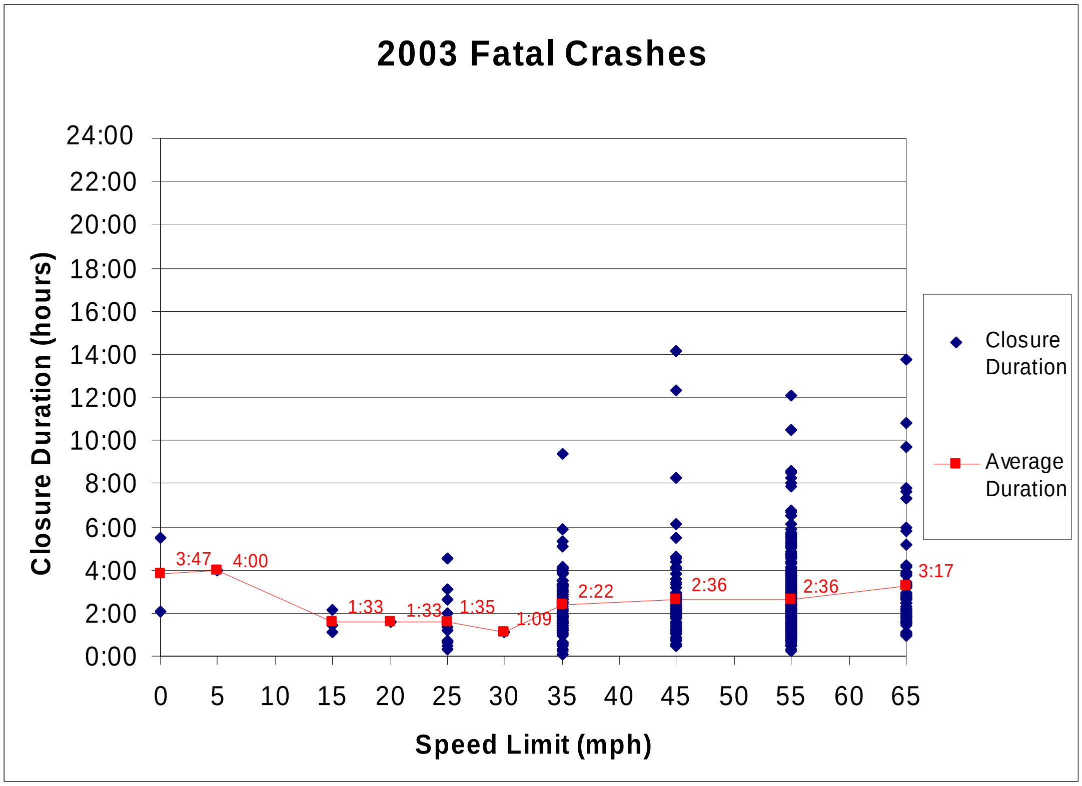


Figure 13. Closure Duration by Speed Limit for Fatal Crashes



The injury severity of the crash victims was analyzed and graphed in Figure 14. The data points were separated into the following three categories: no injuries or fatalities; at least one injury but no fatality; and at least one fatality. The data points categorized as "at least one fatality" were crashes that included at least one fatality and may or may not include injuries. The average closure duration ranged from 28 minutes for no injuries or fatalities to 2 hours 24 minutes for a crash involving a fatality. The graph showed that as the injury severity increased, so did the closure duration.

Figure 14. Closure Duration by Injury Severity for All Crashes

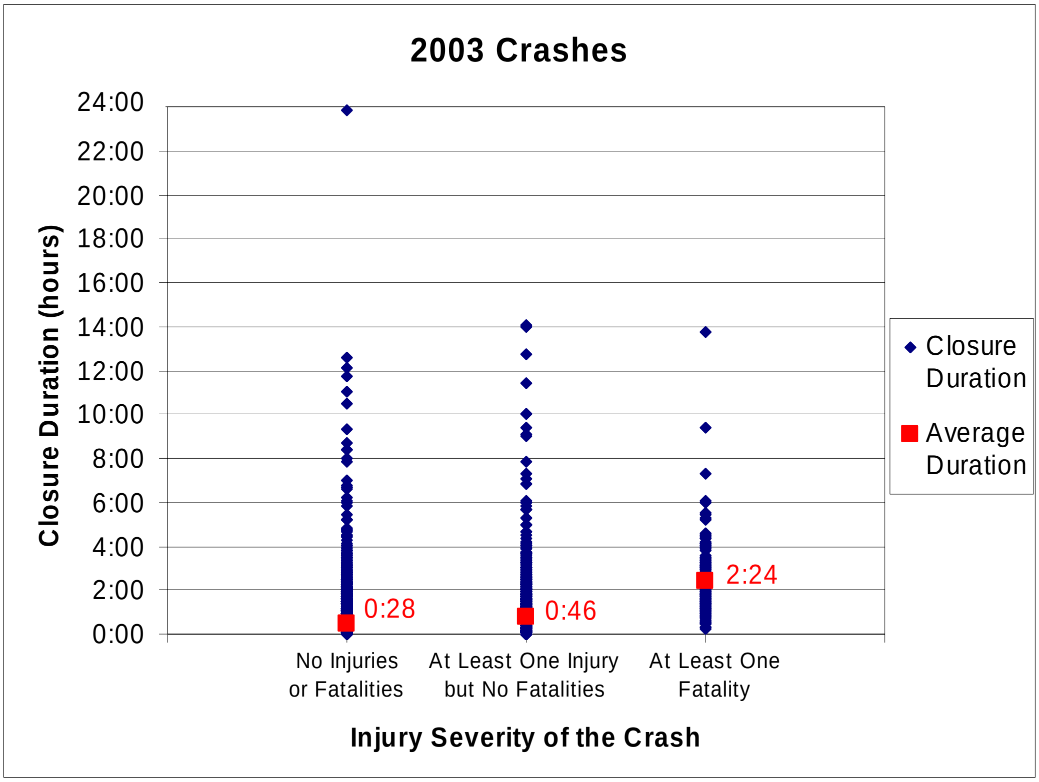
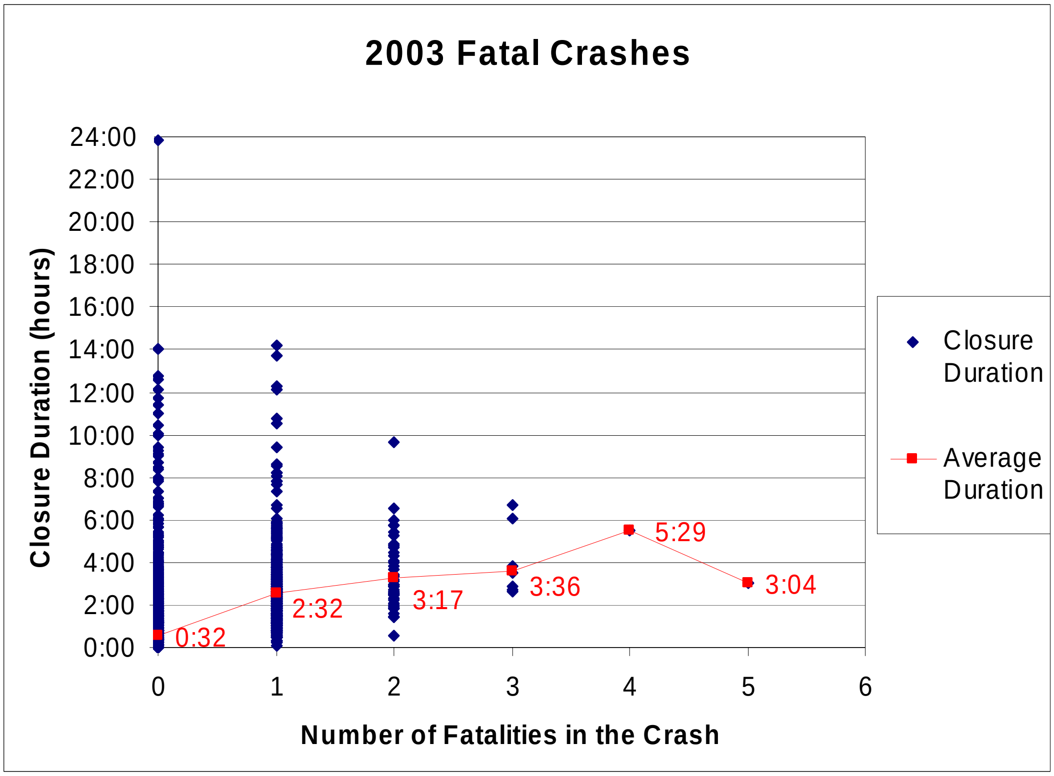


Figure 15 shows how the closure duration varied with the number of fatalities. As the number of fatalities increased, the sample size was reduced. For crashes involving 3 or more fatalities, the number of data points compared to other categories was significantly less. There were 26,212 crashes with no fatalities, 622 crashes involving 1 fatality, 50 crashes involving 2 fatalities, 7 crashes involving 3 fatalities, 1 crash involving 4 fatalities, and 1 crash involving 5 fatalities. Therefore, the smaller sample sizes may not yield reliable results.

The average closure duration for a crash not involving a fatality was 32 minutes. The average closure duration for a fatal crash ranged from 2 hours 32 minutes for a crash involving one fatality to 5 hours 29 minutes for a crash involving four fatalities. As the number of fatalities per crash increased, the crash duration increased.

Figure 15. Closure Duration by Number of Fatalities



4.3 2003 CRASH Records Analysis Summary

The data analysis in Section 4.2 yields the following summary:

- Fatal crashes generally had longer closure durations than non-fatal crashes.
- As the number of fatalities per crash increased, so did the closure duration.
- As the number of units involved in a crash increased, so did the closure duration.
- The average closure duration was slightly longer if an occupant in the vehicle was trapped versus no occupant trapped.
- As the posted speed limit on the roadway increased above 40 mph, so did the average closure duration.
- As the injury severity of the crash increased, so did the closure duration.

5.0 EVALUATION OF PHOTOGRAMMETRY EQUIPMENT FOR CRASH SITE INVESTIGATION

5.1 What is Photogrammetry?

Photogrammetry is the technique of measuring objects from photographs or digital images. As defined by Baker in “Traffic Collision Investigation”, photogrammetry involves taking photographs, measuring the photographs, and processing the measurements to produce an accurate diagram or map. Physical dimensions can be determined by using the map (12). The term “remote sensing” is synonymous with photogrammetry and describes that process where object measurements are taken without physical contact.

Photogrammetry can be divided into two categories: far range (aerial photogrammetry) and close-range (terrestrial photogrammetry). Aerial photogrammetry is mainly used to produce topographical or thematic maps and digital terrain models (13). Close-range photogrammetry has several uses, one of which is for crash scene investigation by police departments.

Investigators using photogrammetry first mark relevant objects at the scene and then take photographs of the markers. On-scene investigators must include every marker in at least three different photographs at large angles to get a three-dimensional representation of the crash. The scanned photographs or digital images are then transformed into a three-dimensional model of the original scene from a vertical view. This bird’s-eye view, or orthogonal view, is then used to make measurements of the scene (14).

Typically, the equipment used for photogrammetry includes: a camera, measurement software, evidence markers, a personal computer, a scanner (if using a conventional camera), computer aided drafting software, and electronic storage media. Photogrammetry can be accomplished using a variety of cameras including video, digital, 35 millimeter, single use cameras and others. If special attention is given to picture quality, viewpoint, and camera aim, the images will be easier to use and the results will be more accurate. Photographs that were not intended for use in photogrammetry can still be used when proper measurements are lacking, but the results will be much less accurate (12).

Several factors affect the accuracy of photogrammetry. In general, the accuracy of photogrammetry ranges from 1 to 5 percent, but is greatly dependent on the quality of the photographs. Other factors that affect accuracy are lens distortions and scanning resolutions (for conventional cameras) (14). According to an accuracy study for Eos Systems’ Photomodeler, the measurement software is accurate to within 1 part in 1700, which is better than 1 inch in 140 feet (15).

An interview with an Accident Reconstruction Specialist with the Utah Highway Patrol (UHP) revealed that their officers can use photogrammetry as “the sole measurement technique” for crash site investigation. One distance is needed to scale the scene, and then any object/distance in the photo can be measured with a level of accuracy that exceeds the requirements for accident reconstruction (16).

5.2 Advantages and Disadvantages of Using Photogrammetry

Although the science of photogrammetry has been in existence for some time, its use for crash site investigation is still relatively new. There is still some skepticism regarding its use for accident reconstruction. Some of the advantages and disadvantages of using photogrammetry have been documented in Table 5.

Table 5. Advantages and Disadvantages of Using Photogrammetry

Using Photogrammetry for Crash Scene Investigation	
Advantages	**Disadvantages**
Less time on scene	More time in the office
Scenes are diagrammed only as needed	Lighting may be required
Cost less than total station	Significant cost of equipment
Acceptable level of accuracy for accident reconstruction	Still in the early stages of deployment (for this application)
Training may be less than for total station	Significant training is required
Photos can be taken by a single officer	Not as effective when used on long scenes

5.3 The Cost of Photogrammetry

Photomodeler Pro 5.0 Software is one of the software programs used for photogrammetry. In an interview with Matt Klymson, Eos Systems, he provided the following price information: $895 for software, $2615 for the camera kit with software, $590 for the evidence markers kit, and approximately $5000 for training (17). Of course for law enforcement use, the cost of the camera and evidence marker kits would be multiplied according to the number of units needed.

The cost of photogrammetry should not be limited to the monetary considerations. There is also a significant amount of time required to learn a new method of reconstruction. Consideration should be given to the fact that training time often deducts from that time an officer would be on patrol. In other situations, the officer may use time off to take the training, likely meaning overtime expenses for the department. To get the maximum benefit from this method of reconstruction, the appropriate amount of time and money must be allocated for adequate training.

5.4 Who is Using Photogrammetry?

Some states and metropolitan areas are beginning to consider photogrammetry as an alternative to total station equipment for crash site investigation. Some of the agencies that have used or are using this technology include:

Arizona Department of Public Safety
California Highway Patrol
Dallas Sheriff's Office (Texas)
Law enforcement in Nashville, Knoxville, Memphis, and Chattanooga (Tennessee)
Maryland State Police
Maui Police Department (Hawaii)
Minnesota State Patrol
National Police Agency of Japan
National Transportation Safety Board
New Jersey State Police
New York State Police
Northwestern University Traffic Institute
Oregon State Patrol
Royal Canadian Mounted Police
Transportation Safety Board, Canada
Utah Highway Patrol
Washington State Police

5.5 Summary of Interviews

Several agencies were contacted for interviews to get their perspective on the use of photogrammetry for crash reconstruction. Many of these agencies were known (or suspected) to have used photogrammetry. Others agencies were recommended by the Study Advisory Committee. These interviews were conducted over email or telephone.

<u>Arizona Department of Public Safety</u>

Contacted, but no response was received.

<u>California Highway Patrol</u>

David Fox, reconstruction supervisor, responded to the request for information on February 3, 2005. He responded that the California Highway Patrol (CHP) does not use photogrammetry for their day-to-day activities. Reconstruction teams typically handle 500 crashes per year and collect data using total station equipment. Other crashes that require investigation are handled by the responding officer using roll meters and tape measures.

CHP did consider using photogrammetry, but the cost of implementing such a change, along with the steep learning curve of the method, kept them from doing so. They tried photogrammetry three or four years ago and found the analysis of photographs to be very labor intensive. Mr. Fox stated that any use of this method would probably be for minor injury collisions only.

Florida Highway Patrol

Contacted, but no response was received.

Georgia State Patrol

Lt. Ken Peterman, the Commander of the Georgia State Patrol Specialized Collision Reconstruction Team (SCRT), responded on January 21, 2005. He states that the SCRT use total station equipment for nearly 100 percent of the crash scenes. They consider this method of reconstruction to produce excellent information for courtroom presentations. The measurements are much easier to record than baseline or coordinate measuring methods. He provided no information regarding their use of photogrammetry.

Idaho State Police

Major Steve Jones responded on February 3, 2005 that they do not use photogrammetry for reconstruction. They use Laser Technology, Inc. (LTI) laser units for reconstruction.

Maryland State Police

Contacted, but no response was received.

Memphis Police Department

Captain William Porter responded to the request for information on January 6, 2005. He stated that they do not use photogrammetry for crash reconstruction.

Missouri Highway Patrol

A representative from the Missouri Highway Patrol responded to the request for information on January 26, 2005. He stated that seven troopers with the Missouri Highway Patrol went to photogrammetry training, and all the officers decided that the software used to analyze the photographs was not practical to use. They currently use total station for reconstruction. According to the respondent, some of the disadvantages to using photogrammetry include: 1) difficulty in mapping large scenes or those that have significant changes in elevation; 2) line-of-sight problems (objects getting in the way); and 3) extensive time required for preparing diagrams with the data. He was not pleased with the method of reconstruction, equipment, or training, and stated that the Missouri Highway Patrol will continue to use total station for reconstruction.

Nevada Highway Patrol

Sergeant John Schilling responded on January 25, 2005 that they do not use photogrammetry. They map their crash scenes utilizing total stations.

New Jersey State Police

Robert Parlow, of the Fatal Accident Investigation Unit, responded on January 24, 2005 that the New Jersey State Police do not use photogrammetry for crash scene investigation. They use LTI Impulse Laser units for all the crashes requiring reconstruction. They have been trained in the use of photogrammetry, but they have only used it to retrieve information from photographs when no reconstruction mapping took place.

New York State Police

Sergeant Dan Bates, head of the Collision Reconstruction Unit, was interviewed on January 19, 2005. He responded that the New York State Police have 25 total station units and are committed to using that method for reconstruction. They investigated photogrammetry because the New York Department of Transportation encouraged them to find a better and faster method of reconstruction in order to open the roadway more quickly. Sergeant Bates compared data collected using the photogrammetry and total stations methods. While some data was very similar, he found some to show several feet of difference. He identified three primary disadvantages to using photogrammetry, including: 1) difficulty to use on a large scene; 2) difficulty qualifying the data for court room purposes; and 3) extensive time required to analyze the data.

Northwestern University – Center for Public Safety

Contacted, but no response was received.

Ohio State Highway Patrol

Sergeant Toby Wagner, supervisor of the Crash Reconstruction Unit, was interviewed on January 19, 2005. He stated that the Ohio State Highway Patrol is using total station equipment for reconstruction and has no plans to use photogrammetry. The previous supervisor of the Unit used photogrammetry, but no one else ever did. Sergeant Wagner's impression was that the learning curve for photogrammetry was such that it would not be practical to try to use it on a large-scale basis.

Oregon State Police

Contacted, but no response was received.

Utah Highway Patrol

On January 19, 2005, Captain Bob Anderson was interviewed. The Utah Highway Patrol uses photogrammetry almost exclusively for crash scene measurements. They first started using the method in 1999 before the 2002 Winter Olympics in Salt Lake City. All their officers are trained on how to take the appropriate photographs. One or two officers in each district are trained to prepare the diagrams from the photographs. They are only required to produce diagrams for fatal crashes.

Captain Anderson noted the following advantages to using photogrammetry for reconstruction: 1) useable at any location; 2) very accurate (equivalent to total station); and 3) reduced time in the field collecting data (from 2 to 4 hours with total station to 15 minutes using photogrammetry). He also noted that there was no problem with introducing evidence at trial based on the photogrammetry method. He would use some object (such as a stop sign) for scale and show the accuracy to measure the sign using photogrammetry. They had some issues with the training in the past and with officers taking inadequate photographs.

Washington State Police

Detective Sergeant Jerry Cooper, Team Leader and Collision Reconstructionist for the Major Accident Investigation Team, responded to the request for information on January 7, 2005. He stated they do use photogrammetry, along with total station and the baseline-coordinate method for crash reconstruction. They first received training in photogrammetry in April 2002, and about 30 detectives are trained in the method. About 20-25 percent of the crashes requiring reconstruction are being measured using the photogrammetry method.

Detective Sergeant Cooper noted the following advantages to using the method: 1) one officer can do the measurements; 2) shortens roadway closures; and 3) accuracy is comparable to total station. He also noted that they do not have any problem with court admissibility of the photogrammetry data. Although he considers photogrammetry an excellent and effective tool, he did note the following limitations: 1) large areas require that the scene be broken into zones and merged; 2) getting people and things out of the way to photograph the scene; 3) lighting in order to get adequate photographs; and 4) time to learn the method.

In total, 16 agencies were contacted. Five agencies did not respond to the request for information, while four agencies responded that they did not use photogrammetry. Seven agencies responded that they (or someone at their agency) had tried photogrammetry as a method for reconstruction. Of the seven agencies that responded that they had tried photogrammetry, five are no longer using the method or using it very little. The reasons listed for not using photogrammetry for reconstruction included:

1) Cost of implementing such a change
2) Labor intensive and time consuming for photograph analysis
3) Steep learning curve for analyzing the data
4) Difficult in mapping large scenes or scenes with significant changes in elevation
5) Difficulty in getting line-of-sight with objects in the way
6) Difficulty in qualifying the data for court room purposes

The primary reasons for using photogrammetry for reconstruction included:

1) Useable in any location
2) Accuracy of data is comparable to total station
3) Reduced time in the field collecting data
4) One officer can do all the measurements

6.0 RECOMMENDATIONS

The following items are recommended to reduce the time taken to investigate crash sites:

1) Establish guidelines for when reconstruction is needed and encourage local and state law enforcement agencies to incorporate these guidelines into their own policies.

2) Establish guidelines for clearing the roadway in an expeditious manner in an effort to get traffic flowing and encourage local and state law enforcement agencies to incorporate these guidelines into their own policies.

3) Enhance the training of law enforcement officers by including information on the safety and congestion repercussions associated with closing the roadway.

4) Perform a review and side-by-side comparison of various reconstruction technologies, including: total station, photogrammetry, GPS, and others (as appropriate).

5) Implement crash investigation sites in high incident locations and/or on high volume corridors.

6) Implement in-vehicle computers in law enforcement vehicles to verify and record information quickly.

7) Encourage major law enforcement agencies to develop and deploy accident response teams for major incidents.

8) Implement roadway service patrols in high incident locations to help clear minor incidents from the roadway.

9) Work to revise the Kentucky Uniform Police Traffic Collision Report form (KSP74) to encourage quick clearance.

10) Encourage responding agencies to take part in the interagency training program, Highway Crash Site Management.

11) Seek passage of quick clearance legislation which includes limits on liability for responders who are acting under the direction of the incident commander to open the roadway in an expeditious manner.

12) Work with state and local coroners to give EMS personnel the ability to certify death at the scene of a crash or to move the body prior to the coroner's arrival.

13) Implement a pilot project to evaluate the use of bar codes and magnetic stripes on drivers' licenses and vehicles to help quickly obtain information for accident reporting.

14) Reference and utilize procedures in Chapter 6I of the 2003 MUTCD for temporary traffic control.

7.0 REFERENCES

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Appendix A

Local Police Agencies and Sheriff Offices Responding to the Survey

SURVEY

Agency Name ______________________________

Phone Number ______________________________

Spoke to: ______________________________

1 Does your agency have an accident reconstructionist?

☐ Yes How many? ____________________

☐ No If no, what agency does your accident reconstruction for you?

____

2 What method do you use to obtain your measurements in your investigation/reconstruction?

(Check all that apply.) (If more than one method is used, estimate % used.)

☐ Coordinate (traditional) Method ☐ %
 ☐ Tape measure ☐ Laser

☐ Triangulation Method ☐ %
 ☐ Tape measure ☐ Laser

☐ Total Station Survey Method ☐ %

☐ Photogrammetry Method ☐ %

☐ Other ____________________ ☐ %

Comments:

____

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Survey Completed by: ______________________________

Date Completed ______________________________

Agency	Point-of-Contact	Agency	Point-of-Contact
Allen Co. Sheriff Office	Sheriff	Dayton P. D.	Dispatcher
Scottsville P. D.	Officer	Bellevue P. D.	Dispatcher
Anderson Co. P. D.	unknown	Highland Heights P. D.	Dispatcher
Lawrenceburg P. D.	Dispatcher	Fort Thomas P. D.	unknown
Anderson Co. Sheriff Office	Dispatcher	Cold Spring P. D.	Dispatcher
Ballard Co. Sheriffs office	Dispatcher	NKU Public Safety	Dispatcher
LaCenter P. D.	Dispatcher	Alexandria P. D.	Dispatcher
Barren Co. Sheriff Office	Dispatcher	Carlisle Co. Sheriff Office	Dispatcher
Glasgow P. D.	Dispatcher	Bardwell P. D.	Dispatcher
Bath Co. Sheriff Office	Dispatcher	Carroll Co. Sheriff Office	Dispatcher
Bell Co. Sheriff Office	Sheriff	Carrollton P. D.	Dispatcher
Pineville P. D.	Officer	Christian Co. Sheriff Office	Sheriff
Boone Co. Sheriffs Office	Pete Schierloh	Christian Co. P. D.	Sheriff
Florence P. D.	Dispatcher	Crofton P. D.	Dispatcher
Cin/NK International Airport P. D.	Tim Carr	Oak Grove P.D.	Dispatcher
Paris P. D.	Dispatcher	Clark Co Sheriffs Office	Cpt. Howard
Millersburg P. D.	Dispatcher	Winchester P. D.	Dispatcher
Bourbon Co. Sheriffs Office	Dispatcher	Clay Co. Sheriff Office	Dispatcher
Boyd Co. Sheriff Office	Sheriff	Manchester P. D.	Dispatcher
Boyd Co. P. D.	unknown	Clinton Co. Sheriff Office	Dispatcher
Ashland P. D.	Cpt. Todd Kelley	Albany P. D.	Dispatcher
Catlettsburg P. D.	Sheriff	Crittenden Co. Sheriff Office	Dispatcher
Junction City P. D.	Dispatcher	Marion P. D.	Dispatcher
Perryville P. D.	Dispatcher	Burkesville P. D.	Dispatcher
Danville P. D.	Dispatcher	Daviess County Sheriffs Office	Lt. J.D. Marksberry
Bracken Co. Sheriff Office	Dispatcher	Edmonson Co. Sheriff Office	Dispatcher
Augusta P. D.	Dispatcher	Elliott Co. Sheriff Office	Dispatcher
Brooksville P. D.	Dispatcher	Estill Co. Sheriff Office	Dispatcher
Breathitt Co. Sheriff Office	unknown	Irvine P. D.	Dispatcher
Jackson P. D.	Dispatcher	Ravenna P. D.	Dispatcher
Breckinridge Co. Sheriff Office	Officer	LFUCG	John Smoot
Cloverport P. D.	Dispatcher	Transylvania University P. D.	Richard Cook
Bullitt Co. Sheriff Office	Deputy	University of KY P. D.	Travis Manley
Pioneer Village P. D	Dispatcher	Fayette Co. PS, P.D.	Dispatcher
Hillview P. D.	unknown	Fleming Co. Sheriff Office	Deputy Roberts
Mt. Washington P. D.	unknown	Flemingsburg P. D.	Randy Sergeant
Morgantown P. D.	Dispatcher	Floyd Co. Sheriff Office	Rick Thornberry
Caldwell Co. Sheriff Office	unknown	Prestonsburg P. D.	Dispatcher
Princeton P. D.	Dispatcher	Martin P. D	Dispatcher
Murray State U. P. D.	Dispatcher	Frankfort P. D.	Officer Schmidt
Calloway Co. Sheriffs Office	Dispatcher	Fulton Co. Sheriffs Office	Robert Hopper
Campbell Co. Sheriff Office	unknown	Hickman P. D.	Dispatcher

Agency	Point-of-Contact	Agency	Point-of-Contact
Fulton P. D.	Donna	University of Louisville P. D.	Dispatcher
Warsaw P. D.	Donnie Gould	Meadow Vale P. D.	Chief Connie Henson
Garrard Co. Sheriffs Office	Ronnie Wardrip	West Buechel P. D.	Dispatcher
Lancaster P. D.	Sgt. Skeens	Lincolnshire P. D.	Chief
Grant Co. Sheriff s Office	Sheriff Randy	Shively P. D.	Dispatcher
Williamstown P. D.	Phyllis	Jefferson Co. Public Schools P. D.	unknown
Graves Co. Sheriffs Office	DeWayne Redmon	Audubon Park P. D.	Kernel Benito
Mayfield P. D.	Dispatcher	Northfield P. D.	Dispatcher
Grayson Co. Sheriff Office	David Simon	Jeffersontown P. D.	Major Steve DeBell
Leitchfield P. D.	Cpt. Margaret Fey	Jenkins P. D.	Sgt. Dingus
Green Co. Sheriff Office	Ryan Jewell	Hollow Creek P. D.	Chief
Greenup Co. Sheriff Office	Deputy McCarty	Louisville P. D.	Sgt. Joe Hornek
Russell P. D.	Det. Tim Wilson	Prospect P. D.	Chief Wilson
South Shore P. D.	unknown	Wilmore P. D.	Dispatcher
Flatwoods P. D.	Sparks	Nicholasville P. D.	Dispatcher
Hancock Co. Sheriff Office	Kari	Jessamine Co. Sheriffs Office	Kevin Corman
Lebanon P. D.	Sgt. Luckett	Paintsville P. D.	Chief
Radcliff P. D.	Det. Kwiatkowski	Villa Hills P. D.	Chief
Elizabethtown P. D.	Richard Dearborn	Independence P. D.	Dispatcher
Hardin Co. Sheriffs Office	Sheriff Williams	Kenton Co. P. D.	Cpt. Tim Hayes
Harlan Co. Sheriff Office	Sherlie	Erlanger P. D.	Chief
Evarts P. D.	Denise	Elsmere P. D.	Dispatcher
Harlan P. D.	Dispatcher	Fort Mitchell P. D.	Dispatcher
Cumberland P. D.	Cope	Crescent Springs P. D.	Sgt. Jeff Mosier
Cynthiana P. D.	Officer Parrot	Edgewood P. D.	Officer Johnson
Harrison Co. Sheriffs Office	Dispatcher	Fort Wright P. D.	Officer Schworer
Hart Co. Sheriff Office	Dispatcher	Ludlow P. D.	Asst. Chief
Munfordville P. D.	Sgt. Johnny Vance	Covington P. D.	Kim
Henderson Co. Sheriff Office	Cpt. Rick Evans	Park Hills P. D.	Chief Rick Smith
Henderson P. D.	Ron Burleson	Knott Co. Sheriff Office	Carolyn
Henry Co. Sheriff Office	Dispatcher	Pippa Passes P. D.	Chief of Police
Pleasureville P. D.	unknown	Hindman P. D.	unknown
Eminence P. D.	unknown	Knox Co. Sheriff Office	Dispatcher
Campbellsburg P. D.	unknown	Barbourville P. D.	James Ray
New Castle P. D.	unknown	Larue Co. Sheriff Office	Patsy Thomas
Hickman Co. Sheriff Office	Sheriff J.W.	London P. D.	Sgt. Joe Smith
Clinton P. D.	Chief Tracy House	Laurel Co. Sheriffs Office	Sgt. On duty
Dawson Springs P. D.	Michael Norris	Beattyville P. D.	Brenda
Hopkins Co. Sheriffs Office	Scotty Alexander	Letcher Co. Sheriff's Department	Deana Hall
Nortonville P. D.	Tim Vaughn	Lewis Co. Sheriffs Office	Disp
Jackson Co. Sheriff Office	Dispatcher	Vanceburg P. D.	Chief Billman
Jefferson Co. Sheriffs Office	Sgt. Berkey	Stanton P. D.	James Watson

Agency	Point-of-Contact	Agency	Point-of-Contact
Livingston Co. Sheriff Office	Sheriff T. Williams	Perry Co. Sheriffs Office	Chief Dep. Poss
Logan Co. Sheriff Office	Cpt. Steve Stratton	Pike Co. Sheriff Office	Dispatcher
Lyon Co. Sheriff Office	Kent Murphy	Powell Co. Sheriff Office	Joyce Rogers
Eddyville P. D.	Chief Allison	Clay City P. D.	Dispatcher
Madison Co. Sheriff Office	Cochran	Somerset P. D.	unknown
Salyersville P. D.	Chief Watson	Pulaski Co. Sheriffs Department	Deputy Berry
Marion Co. Sheriff Office	Debbie	Robertson Co. Sheriff Office	unknown
Marshall Co. Sheriffs Office	David Maddox	Mt. Olivet P. D.	unknown
Calvert City P. D.	Sharon Nelson	Rockcastle Co. Sheriff Office	Derrick Price
Martin Co. Sheriff Office	Dacia Preece	Mt. Vernon P. D.	Dispatcher
Mason Co. Sheriff Office	Dolly	Rowan Co. Sheriff Office	Shelly
Maysville P. D.	Dispatcher	Morehead P. D.	unknown
McCracken Co. Sheriff Office	Terry Long	Scott Co. Sheriff Office	Jeff Hollan
Paducah P. D.	Officer David White	Georgetown P. D.	unknown
McCreary Co. Sheriff Office	Chief Deputy Tom Smith	Shelby Co. Sheriffs Office	Det. Jason Rice
McLean Co. Sheriff Office	Kim Reeve	Shelbyville P. D.	Major Goodwin
Meade Co. Sheriff Office	Deputy Mike Robinson	Franklin P. D.	Lieutenant Whiles
Mercer Co. Sheriff Office	Timi Bell	Spencer Co. Sheriff Office	Sharon
Harrodsburg P. D.	Kernel Rodney Harlow	Keeneland P.D.	Dispatcher
Edmonton P. D.	Chief Harris	Taylor Co. Sheriff Office	Deputy on duty
Fountain Run P. D.	Dispatcher	Campbellsville P. D.	Betty
Montgomery Co. Sheriff Office	Det. Barry	Todd Co. Sheriff Office	Keith Wells
Mt. Sterling P. D.	Dispatcher	Cadiz P. D.	Rebecca Blite
Morgan Co. Sheriff Office	Sheena Cantrell	Uniontown P. D.	Chief Beckett
West Liberty P. D.	Danny Terry	Union Co. Sheriffs Office	Brenda
Muhlenberg Co. Sheriff Office	Kathy McDonald	Warren Co. Sheriffs Office	Sgt. Brent Brown
Central City P. D.	Davida	Washington Co. Sheriff Office	Sheriff Tommy Bartley
Bardstown P. D.	Officer Tony Satterly	Springfield P. D.	Dispatcher
Nelson Co. Sheriffs Office	K.C. Holbert	Monticello P. D.	Officer Tony Morris
Carlisle P. D.	William Earlywine	Providence P. D.	Dispatcher
Ohio Co. Sheriff Office	Sheriff Elvis Doolin	Webster Co. Sheriffs Office	Billy Ashby
LaGrange P. D.	Dispatcher	Whitley Co. Sheriffs Office	Kendra
Oldham Co. P. D.	Officer Latham	Corbin P. D.	Metty
Owen Co. Sheriff Office	Dty. Heather Snell	Wolfe Co. Sheriff Office	unknown
Owsley Co. Sheriff Office	Claude Hudson	Versailles P. D.	Asst. Chf. Tyler Prudy
Hazard P. D.	Jamie Turner		

Appendix B

National Survey and Responding Agencies

Survey

Agency: ______________________ Name: ______________________

1. What method does your agency use to obtain measurements for crash investigation/reconstruction?
(check all that apply) (If more than one method is used, estimate % used.)

- ☐ **Coordinate (traditional) Method** ☐ %
  - ☐ **Tape Measure** ☐ **Laser**
- ☐ **Triangulation Method** ☐ %
  - ☐ **Tape Measure** ☐ **Laser**
- ☐ **Total Station Survey Method** ☐ %
- ☐ **Photogrammetry Method** ☐ %
- ☐ **Other** ______________________ ☐ %

2. If your agency has ever used photogrammetry as a method of reconstruction, please describe your experience:

____

____

3. What practices have you used or seen others use to reduce the time spent at the accident scene (for accident reconstruction or any other part of the response, management, and clearance of a crash)?

____

____

____

4. Has your agency implemented any practices that have improved the safety of those on the crash scene? If Yes, please describe:

☐ **Yes** ☐ **No**

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____

Additional Comments:

____

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Agency	Individual Responding to Survey
Alabama Dept. of Public Safety	1) Trooper Marc Boyd 2) Sgt. James D. Patterson
Arizona Dept. of Public Safety	Sgt. Jeff King
Arkansas State Police	Lt. J.C. Johnston
Colorado State Patrol	Trooper Ryan Holmes
Connecticut State Police	Sgt. Frank Sawicki
Delaware State Police	Sgt. Matthew Cox
Florida Highway Patrol	Sgt. Robert Ashburn
Georgia State Patrol Headquarters	Planning
Idaho State Police	Fred Rice
Illinois State Police, Information and Technology Command	Aaron Schroeder
Indiana State Police	Sgt. William Myers
Iowa Dept. of Public Safety	Sgt. Randy Bulver
Kansas Highway Patrol	Capt. Dan Meyer
Louisiana State Police	Sgt. Jason Jacob
Maine State Police	Sgt. Rick McAlister
Maryland State Police	Sgt. Charles Travers
Michigan State Police	Lt. Gary Megge
Minnesota State Patrol Headquarters	Sgt. Don Schmalzbauer
Missouri State Highway Patrol	Lt. Greg Smith
Montana Highway Patrol	Trooper Scott Tenney
Nevada Highway Patrol	Sgt. Schilling
New Hampshire State Police	Sgt. Scott Sweet
New York State Police	Sgt. Daniel S. Bates
North Carolina State Highway Patrol	M.S. Hartsell
North Dakota Highway Patrol	Captain Gordon LaFrance
Ohio State Highway Patrol	Lt. J. A. Gebhart
Oregon State Police	Sgt. Michael W. Stupfel
Pennsylvania State Police	Tpr. Martin C. Long
South Carolina Highway Patrol	Lt. J.D. Moore
South Dakota Highway Patrol	Sgt. Dana Svendson
Tennessee Department of Safety	Sgt. John Albertson
Utah Dept. of Public Safety	Capt. Robert Anderson
Virginia Dept. of State Police	Ms. Cynthia A. Vernacchia
Washington State Patrol Headquarters	Det. Sgt. Ken Noland
West Virginia State Police	Sgt. Jay Powers
Wisconsin State Patrol	Maj. D. Lonsdorf
Wyoming Highway Patrol	Capt. Len DeClercq