FINAL SUMMARY REPORT

Southeastern United States Fatal Crash Study

Prepared By:
Karen Dixon, Ph.D., P.E.

The Georgia Institute of Technology

October 2005

Prepared for the Georgia Department of Transportation

TECHNICAL REPORT STANDARD TITLE PAGE

1.Report No.: FHWA-GA-05-9815

2. Government Accession No.:

3. Recipient's Catalog No.:

4. Title and Subtitle: Southeastern United States Fatal Crash Study

5. Report Date: October 2005

6. Performing Organization Code:

7. Author(s): Karen Dixon, Ph.D., P.E. Georgia Institute of Technology

8. Performing Organ. Report No.: 9815

9. Performing Organization Name and Address:
Georgia Institute of Technology
School of Civil and Environmental Engineering
Atlanta, GA 30332-0355

10. Work Unit No.:

11. Contract or Grant No.:

12. Sponsoring Agency Name and Address:
Georgia Department of Transportation
Office of Materials and Research
15 Kennedy Drive
Forest Park, GA 30297-2534

13. Type of Report and Period Covered: Final; 1999-2003

14. Sponsoring Agency Code:

15. Supplementary Notes:
Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. Abstract:

A significant safety issue in the United States is the substantial number of vehicle related crashes. The number of fatal crashes in the southeastern portion of the U.S. (States of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee) is disproportionately higher than those for the entire country. In general, the eight states collectively report approximately 26-percent of the total annual number of fatal automobile-related crashes in the U.S. On average, the southeastern states experience an additional 30 fatalities per million vehicle miles traveled than the U.S. average. The Federal Highway Administration and the eight southeastern states initiated a joint research effort for the region to study this observed over-representation of fatal crashes.

Findings of the study suggest that improved features such as widening shoulders, enhancing delineation, and protecting the clear zone would substantially reduce these fatal crashes. Some of the researchers recommended that additional procedures and policies may be an appropriate countermeasure for wide-scale improvements. Countermeasures (physical as well as political) were explicitly recommended to address two-lane rural roads, safety restraint use and fixed-object crashes.

A supplemental finding was the presence of extensive pavement edge drop-offs for fatal crash sites in at least two of the participating states. As this observation occurred as a result of field inspection and was not initially identified as a target problem, it was not studied in great detail for this research effort but merits special comment since it is potentially a significant finding of the study.

17. Key Words:

18. Distribution Statement:

19. Security Class. (report): Unclassified

20. Security Class. (page): Unclassified

21. Number of Pages: 53

22. Price:

Form DOT 1700.7 (8-69)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive Summary

This study evaluated the high number of fatal crashes in the southeastern United States in an effort to determine what may be unique to the region resulting in this disproportionate statistic. This eight state region selected a research agency to help with their respective state evaluation. Each participating state research team identified unique issues appropriate for their jurisdiction. Due to the variety of analysis procedures and identified objectives from their respective state representatives, the individual conclusions dramatically varied for each state. In general, seven of the eight states determined that the rural, two-lane road condition is the source of the elevated fatal crashes in the region. Improved features such as widening shoulders, enhancing delineation, and protecting the clear zone were identified consistently during the countermeasure analyses. Some of the researchers recommended to their state representatives that additional procedures and policies may be an appropriate countermeasure for wide-scale improvements. Of the six perceived topical areas identified at a kickoff meeting involving all eight states, countermeasures (physical as well as political) were explicitly recommended to address two-lane rural roads, safety restraint use and fixed-object crashes.

A supplemental finding for this study was the presence of extensive pavement edge drop-offs for fatal crash sites in at least two of the participating states. As this observation occurred as a result of field inspection and was not initially identified as a target problem, it was not studied in great detail for this research effort but merits special comment since it is potentially a significant finding of the study.

Introduction

A significant safety issue in the United States is the substantial number of vehicle related crashes. In particular, death due to injuries sustained in an automobile crash is the leading cause of death for persons between the ages of 2 and 33 years old (*1*).

The number of fatal crashes in the southeastern portion of the United States is disproportionately higher than those for the entire country. Table 1 depicts an eight year summary of the number of fatal crashes for the eight southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. In general, the eight states collectively report approximately 26-percent of the total annual number of fatal automobile-related crashes in the United States. Table 2 includes the individual state fatality rates from 1996 to 2003. On average, the southeastern states experience an additional 30 fatalities per million vehicle miles traveled than the United States average. The Federal Highway Administration (FHWA) and the eight southeastern states initiated a joint research effort for the region to study this observed over-representation of fatal crashes.

This study is complete and this summary report provides an overview of the study participants, their role in the project, and the varying results available.

Table 1. Southeast and United States Fatal Crash Summary (1996 – 2003)

State	1996	1997	1998	1999	2000	2001	2002	2003	8 Year Total
AL	1,024	1,050	958	992	910	900	931	899	7,664
FL	2,496	2,528	2,548	2,629	2,733	2,714	2,810	2,874	21,332
GA	1,402	1,405	1,414	1,314	1,380	1,471	1,362	1,463	11,211
KY	734	774	766	724	721	762	810	845	6,136
MS	695	741	842	832	846	704	769	786	6,215
NC	1,329	1,290	1,433	1,350	1,408	1,360	1,427	1,375	10,972
SC	821	798	912	944	948	962	949	904	7,238
TN	1,120	1,104	1,110	1,169	1,177	1,126	1,058	1,091	8,955
SE Sub-Total	9,621	9,690	9,983	9,954	10,123	9,999	10,116	10,237	79,723
Total U.S.*	37,494	37,324	37,107	37,140	37,526	37,862	38,491	38,252	301,196
Percent of U.S.* Total	25.7%	26.0%	26.9%	26.8%	27.0%	26.4%	26.3%	26.8%	26.5%

* U.S. values include the 50 states and the District of Columbia

Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System

Table 2. Southeast and United States Fatality Rates (1996 – 2003)

Fatalities are Shown per 100 Million Vehicle Miles Traveled

State	1996	1997	1998	1999	2000	2001	2002	2003	8 Year State Average
AL	2.2	2.2	1.9	2.0	1.8	1.8	1.8	1.7	1.9
FL	2.1	2.1	2.1	2.1	2.0	1.9	1.8	1.7	2.0
GA	1.8	1.7	1.6	1.5	1.5	1.5	1.4	1.5	1.6
KY	2.0	1.9	1.8	1.7	1.8	1.8	2.0	2.0	1.9
MS	2.7	2.7	2.8	2.7	2.7	2.2	2.4	2.3	2.6
NC	1.9	1.8	1.9	1.7	1.6	1.7	1.7	1.6	1.7
SC	2.3	2.2	2.3	2.4	2.3	2.3	2.2	2.0	2.3
TN	2.1	2.0	1.9	2.0	2.0	1.9	1.7	1.7	1.9
SE Weighted Average**	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.9
U.S.* Average	1.7	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.6

* U.S. values include the 50 states and the District of Columbia

** Weighted Average is the Entire Number of Fatalities (all eight states) divided by the Entire Number of 100 Million Vehicle Miles Traveled (all eight states)

Source: National Center for Statistics & Analysis, Traffic Safety Facts – State Traffic Data (1996 through 2003)

Project Objectives

This research project had one overall goal: To quantify the influence of various statistically significant factors contributing to fatal crash occurrence through coordinated in-depth studies in the eight southeast states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

On November 17-18, 1998 participants and representatives from each state convened at a kick-off meeting in Georgia to review proposed research objectives, discuss the potential framework of the studies, and define specific topical areas. This meeting included extensive discussion about the targeted study focus for individual states. Each state has unique problems and the research performed by each research group needed to address the issues identified by the state for which that group was to perform the research effort.

Two overall research objectives were identified to help guide the individual development of the research scope for each state. These two general objectives were:

- To identify and quantify the impact of the "top 6 safety concerns" (or a subset thereof) within the states, and
- To identify countermeasures for reducing fatal crashes and/or quantify the effect of various countermeasures (for the top 6) when and where possible.

The meeting participants also discussed a general framework for the research effort. Though each state transportation department directed the required research effort for that state and incorporated unique goals and content for their research, in general the kick-off meeting participants identified four potential research tasks suitable for a broad safety-oriented research framework. These four research tasks included:

1. ***Regional Fatal Crash Description***. This effort was aimed at quantifying road safety differences between the southeastern (SE) and non-southeastern United States. The purpose of this task was to identify and quantify over-representation of crashes in the SE (by certain characteristics), and to identify the largest raw numbers of crash types. This research effort helped identify and quantify high safety concern topical areas for reference and comparison purposes.
2. ***Fatal Crash Causal Analysis of Two-Lane Rural Roads.*** This effort involved the cooperation of all participating states for data collection, and involved one or more of the research teams for analysis efforts. The state representatives discussed evaluating a statistically random sample of 150 fatal crashes for this task.
3. ***Countermeasure Identification.*** The purpose of this effort was to identify and carefully review past literature of countermeasure effectiveness relevant to SE safety concerns. The focus was to synthesize the results into succinct and substantive practical results.
4. ***Targeted Before-After Studies***. The purpose of this effort was to conduct retroactive or new before-after studies to evaluate specific countermeasure effectiveness.

In general, the top 6 topical areas discussed by the participants included:

- Two-lane rural roads,
- Safety restraint use,

- Driver education and licensing,
- Commercial vehicle operations,
- Fixed-object crashes, and
- Speeding.

Not all state representatives felt all 6 topical areas were relevant to their specific jurisdiction. Following the kick-off meeting, each state and respective research team met to discuss their specific research questions, level of participation in the effort, and proposed final product. The appendix includes summary slides from the kick-off meeting, an example of slides for one of the state briefings (Georgia), and two sets of slides summarizing the proposed research evaluation methodologies. These evaluation methods included regional fatal crash summary statistics, fatal crash causal analysis for a collection of randomly selected fatal crashes, countermeasure identification, and a targeted before-after study using expert evaluation combined with statistical analysis.

Research Administration and Participants

The FHWA Atlanta Resource Center provided project oversight and guidance under the direction of Mr. Frank Julian. The FHWA coordinated with representatives of the eight southeastern states individually to help organize and coordinate the pooled-fund research efforts. Each state department of transportation then contracted with a local university to perform the associated research activity. The participating states and university contacts are summarized in Table 3.

Table 3. Participating States and Researchers

State	University	Individuals Responsible for Research
Alabama	Auburn University (with sub-contract to University of Alabama)	Dr. Brian L. Bowman (Auburn), Dr. David Brown (University of Alabama)
Florida	University of South Florida Center for Urban Transportation Research	Ms. Patricia Turner
Georgia	Georgia Institute of Technology	Dr. Simon Washington (now with Arizona State University) and Dr. Karen Dixon (now with Oregon State University)
Kentucky	University of Kentucky Transportation Center	Mr. Kenneth R. Agent Mr. Jerry G. Pigman Dr. Nikiforos Stamatiadis
Mississippi	Mississippi State Transportation Research Center	Dr. James W. Epps (retired)
North Carolina	University of North Carolina Highway Safety Research Center	Mr. James K. Lacy (now with North Carolina Department of Transportation)
South Carolina	Clemson University	Dr. David B. Clarke (now with University of Tennessee)
Tennessee	University of Tennessee	Mr. Matthew Cate

Study Focus

To further narrow the scope of the study, researchers at the Georgia Institute of Technology evaluated the distribution of the fatal crashes to determine if a specific road type, crash type, or location may be appropriate for a targeted study. Georgia Tech team members also specifically evaluated, where feasible, the six perceived topical areas discussed at the project kick-off meeting.

Two-lane Rural Roads

Table 4 demonstrates that approximately 64-percent of the southeastern crashes occurred at rural locations (average for years 1996 to 2003). It is important to note that the eight participating states have varying definitions of "rural" and "urban" unique to each state, so this variable is restricted to the state-by-state rural designation. In addition, the state of Florida experienced a substantially smaller number of rural crashes (approximately 45-percent) than the remaining seven southeastern states. As shown in Table 4, if Florida is removed from the rural analysis, the total average percent of rural crashes for the other southeastern states is approximately 71-percent compared to the United States value of approximately 59-percent.

Table 4. Percent Rural Crash Locations (1996 – 2003)

State	1996 [%]	1997 [%]	1998 [%]	1999 [%]	2000 [%]	2001 [%]	2002 [%]	2003 [%]	8 Year Average [%]
AL	67.9	62.4	63.6	69.9	69.6	70.0	73.8	66.6	68.0
FL	43.3	44.2	44.8	45.5	46.8	46.3	44.0	48.5	45.4
GA	58.3	57.2	59.3	58.3	55.5	56.3	59.9	55.6	57.6
KY	75.3	79.8	77.7	80.0	75.6	75.3	75.7	77.3	77.1
MS	83.3	98.8	98.3	99.0	99.6	99.7	99.0	75.3	94.1
NC	69.8	68.3	63.9	60.4	63.2	67.6	72.0	73.2	67.3
SC	91.2	89.3	84.4	85.4	87.1	89.1	89.1	89.6	88.2
TN	60.8	57.6	62.7	63.6	65.3	63.9	62.5	58.6	61.9
Percent Rural for All SE Crashes	63.2	63.5	64.0	64.5	64.7	64.9	65.7	63.6	64.3
Percent Rural for SE Crashes (excluding FL)	70.2	70.3	70.6	71.4	71.3	71.8	74.1	69.5	71.2
Percent Rural for All U.S.* Crashes	57.1	58.4	59.4	60.0	58.1	58.6	59.1	58.5	58.7

* U.S. values include the 50 states and the District of Columbia

Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System

Table 5 depicts crashes for the year 2000 and further emphasizes the disparity between the Florida crash locations and those for the remaining seven states. Whereas only 38.2-percent of the Florida crashes occurred at two-lane rural roads in the year 2000, the percentage occurring for similar roads in the other southeastern states ranged from 51.2-percent (Georgia) up to 77.7-percent (Mississippi). Due to the high representation of crashes on two-lane rural roads in seven of the states, the FHWA and state representatives chose to narrow the evaluation to fatal crashes on rural two-lane roads. As may be expected, the State of Florida elected to withdraw from the rural two-lane study and perform an independent study relevant to their specific safety concerns.

Table 5. Rural Two-Lane Crash Percentage for 2000

State	Number Rural Two-Lane Road Crashes	Total Number of Crashes	Percent Rural Two-Lane Crashes
AL	607	910	66.7%
FL	1,044	2,733	38.2%
GA	707	1,380	51.2%
KY	537	721	74.5%
MS	657	846	77.7%
NC	778	1,408	55.3%
SC	705	948	74.4%
TN	733	1,177	62.3%

Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System

Safety Restraint Use

The proper use of restraint systems reduces the likelihood of fatal injury to front-seat car occupants by 45 percent (*3*). In general, states with primary seat belt laws experience higher seat belt usage rates than those with secondary laws. In the southeast, the states of Alabama (enacted 1999), Georgia (enacted 1996), and North Carolina (enacted 1985) have a primary seat belt law. On July 1, 2004 the State of Tennessee enacted a primary seat belt law.

Table 6 shows the percent of drivers involved in fatal crashes who did not utilize safety restraint systems. The National Highway Safety Administration estimated overall shoulder seat belt use rates of 79 percent for 2003, 71 percent in 2000, and 67 percent in 1999 (*3*). On average, approximately 35.7 percent of the U.S. drivers involved in fatal crashes for an eight year period did not use their safety restraints. The states with a primary seat belt law demonstrated higher use by drivers of safety restraints than did the states without a similarly enforceable law. The eight southeastern states collectively exhibited almost seven percent more fatal crashes than the national average for drivers who did not wear the required safety restraints.

Table 6. Percent Fatal Crash Drivers Not Utilizing Safety Restraints (1996 – 2003)

State	1996 [%]	1997 [%]	1998 [%]	1999 [%]	2000 [%]	2001 [%]	2002 [%]	2003 [%]	8 Year Average [%]
AL	53.9	49.1	49.2	49.2	44.6	35.9	41.5	37.7	45.1
FL	37.1	35.7	36.7	36.8	40.0	36.9	36.3	35.3	36.9
GA	42.1	39.5	31.9	34.7	33.2	28.9	29.6	29.4	33.7
KY	52.7	49.7	49.7	52.2	48.2	49.0	48.4	46.8	49.6
MS	67.3	61.0	58.5	60.8	58.1	52.7	53.8	55.9	58.5
NC	26.1	26.8	23.5	25.4	28.5	26.8	29.3	23.7	26.3
SC	42.3	40.4	41.6	43.7	42.5	43.9	43.5	42.6	42.6
TN	52.7	51.0	51.8	51.8	52.1	46.9	45.1	43.5	49.4
Percent for All SE Crashes	46.8	44.2	42.9	44.3	43.4	40.1	40.9	39.4	42.8
Percent for All U.S.* Crashes	38.5	37.8	36.6	37.1	35.4	34.3	34.2	32.0	35.7

*U.S. values include the 50 states and the District of Columbia

Note: Shaded regions represent primary seat belt laws in effect for the entire year.

Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System

Driver Education and Licensing

Many crashes are attributed to the age or experience of the driver. Approximately 6.4 percent of the licensed drivers in the United States are between the ages of 15 and 20 years old, yet 14 percent of drivers involved in fatal crashes in the United States were in this age group in 2003. In fact, approximately 18 percent of all police-reported crashes involve young drivers (*4*). Table 7 demonstrates a typical distribution of young drivers in the southeastern states for the year 2000. In general, these states have fewer young drivers involved in fatal crashes than the entire United States; however, the number of young drivers is still disproportionate to the number of licensed drivers in this same age group. Strategies for reducing this over-representation may include expanded driver education or modified driver license procedures where the drivers gradually receive increased levels of responsibility before receiving an unrestricted driver's license.

Table 7. Young Drivers (≤ 20 Years Old) and Crash Percentage for 2000

State	Number Young Drivers involved in Fatal Crashes	Total Number of Drivers in Fatal Crashes	Percent Young Drivers in Fatal Crashes
AL	215	1,363	15.8%
FL	559	4,266	13.1%
GA	286	2,149	13.3%
KY	174	1,082	16.1%
MS	188	1,236	15.2%
NC	275	2,162	12.7%
SC	160	1,411	11.3%
TN	259	1,741	14.9%

Note: Shaded regions indicate states with Intermediate Stages in licensing procedures.
Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System and 2002 Insurance Institute for Highway Safety, Highway Loss Data Institute

Commercial Vehicle Operations

In the United States one out of every nine traffic fatalities results from a collision with a large truck. The extreme differences in vehicle size result in the vehicle other than the truck sustaining considerable damage in a collision. In addition, approximately 75 percent of the fatalities involving large trucks are occupants of the vehicle other than the truck (*6*). Table 8 depicts the number of large trucks involved in fatal crashes for the southeastern states during the eight year period from 1996 to 2003. As shown in the table, large truck crashes in the southeast occur, on average, at a rate similar to that of the entire United States.

Table 8. Percent Large Trucks in Fatal Crashes (1996 – 2003)

State	**1996 [%]**	**1997 [%]**	**1998 [%]**	**1999 [%]**	**2000 [%]**	**2001 [%]**	**2002 [%]**	**2003 [%]**	**8Year Average [%]**
AL	9.0	10.2	10.2	9.4	11.2	10.5	9.0	10.7	10.0
FL	7.1	7.2	7.7	7.8	7.1	7.7	7.9	7.7	7.5
GA	9.9	10.0	8.9	10.5	9.6	9.8	9.2	9.1	9.6
KY	8.2	9.3	8.1	8.8	8.9	8.2	9.3	9.1	8.7
MS	8.5	8.9	8.3	9.1	9.5	8.4	6.5	5.9	8.1
NC	8.0	9.7	10.3	8.9	8.3	8.9	7.7	7.4	8.7
SC	8.0	7.5	8.7	8.7	6.1	7.6	6.6	7.1	7.5
TN	9.7	7.7	7.9	9.4	9.0	7.5	8.3	7.0	8.3
Percent for All SE Crashes	8.4	8.6	8.7	8.9	8.4	8.5	8.1	8.0	8.5
Percent for All U.S.* Crashes	8.3	8.5	8.7	8.6	8.6	8.3	7.8	8.0	8.4

* U.S. values include the 50 states and the District of Columbia

Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System

Fixed-object Crashes

The high percent of crashes on rural two-lane highways in the southeast are represented by numerous run-off-the-road crashes. In general, the rolling terrain in the southeast coupled with narrow right-of-way, adjacent wooded areas, and extreme horizontal road curvature combine to result in a large number of fixed-object crashes. Fixed objects can include trees, utility poles, walls, and other rigid items including roadside barrier. The designation in a police crash report for impact with a fixed object is either a "first harmful" event or a "most harmful" event and is based on the reporting police officer's interpretation of the crash condition. As a result, the data reported in fatal crash databases is, at best, subjective. For this reason, database summaries for fixed-object crashes can provide strong indications of fixed object problems but should not be used as a definitive indicator of this type of problem. The best (and certainly more costly) method to evaluate fixed object crashes is by physical site examination combined with a critical review of the individual crash report.

Speeding

Driving too fast for appropriate road conditions is a common cause for crashes. Speeding can create a serious problem for the single-car crash because it is difficult to correct the direction of errant vehicles at high speeds. In multi-car crashes, the larger speed differential contributes to the crash severity. NHTSA estimates that speeding is a contributing factor in approximately 31 percent of all fatal crashes (*7*). Unfortunately, many state crash reports do not have an appropriate method for determining pre-crash speed. In Georgia, for example, there is no requirement to report estimated vehicle speed but instead the reporting officer must indicate posted speed limit (which is unlikely to represent the travel speed of the vehicles involved in the crash). The reporting officer may elect to report that one of the factors contributing to the crash was "driving too fast for road conditions." This variable, however, is highly subjective. Table 9 depicts speed-related fatal crash statistics for an eight year period (1996 to 2003). Based on the values shown in Table 9, the southeastern states have speeds below the national average. This finding may simply be a factor of police report techniques rather than factually based on actual crash conditions. Most of the state representatives involved in this research project were convinced that speed is a significant factor in many fatal crashes.

Table 9. Percent Speeding-Related Fatalities (1996 – 2003)

State	1996 [%]	1997 [%]	1998 [%]	1999 [%]	2000 [%]	2001 [%]	2002 [%]	2003 [%]	8 Year Average [%]
AL	37.8	35.1	36.1	35.8	37.1	35.3	39.8	46.9	38.0
FL	26.2	27.6	21.7	18.0	17.5	17.6	17.8	17.0	20.4
GA	23.3	22.6	21.2	21.1	22.2	21.1	20.6	20.5	21.6
KY	30.1	28.8	23.8	26.4	20.6	18.5	19.6	13.1	22.6
MS	17.3	27.2	23.1	22.2	23.3	19.0	26.2	19.5	22.2
NC	35.6	34.7	34.7	37.7	35.3	37.5	38.2	37.0	36.3
SC	46.7	49.4	47.3	47.1	29.3	46.3	47.0	42.4	44.4
TN	26.8	26.4	25.2	28.2	24.5	23.0	24.9	22.8	25.2
Percent for All SE Crashes	29.8	30.4	27.9	27.8	24.9	26.0	27.3	25.5	27.5
Percent for All U.S.* Crashes	31.0	31.1	30.1	30.3	29.5	30.5	32.0	31.4	30.7

* U.S. values include the 50 states and the District of Columbia

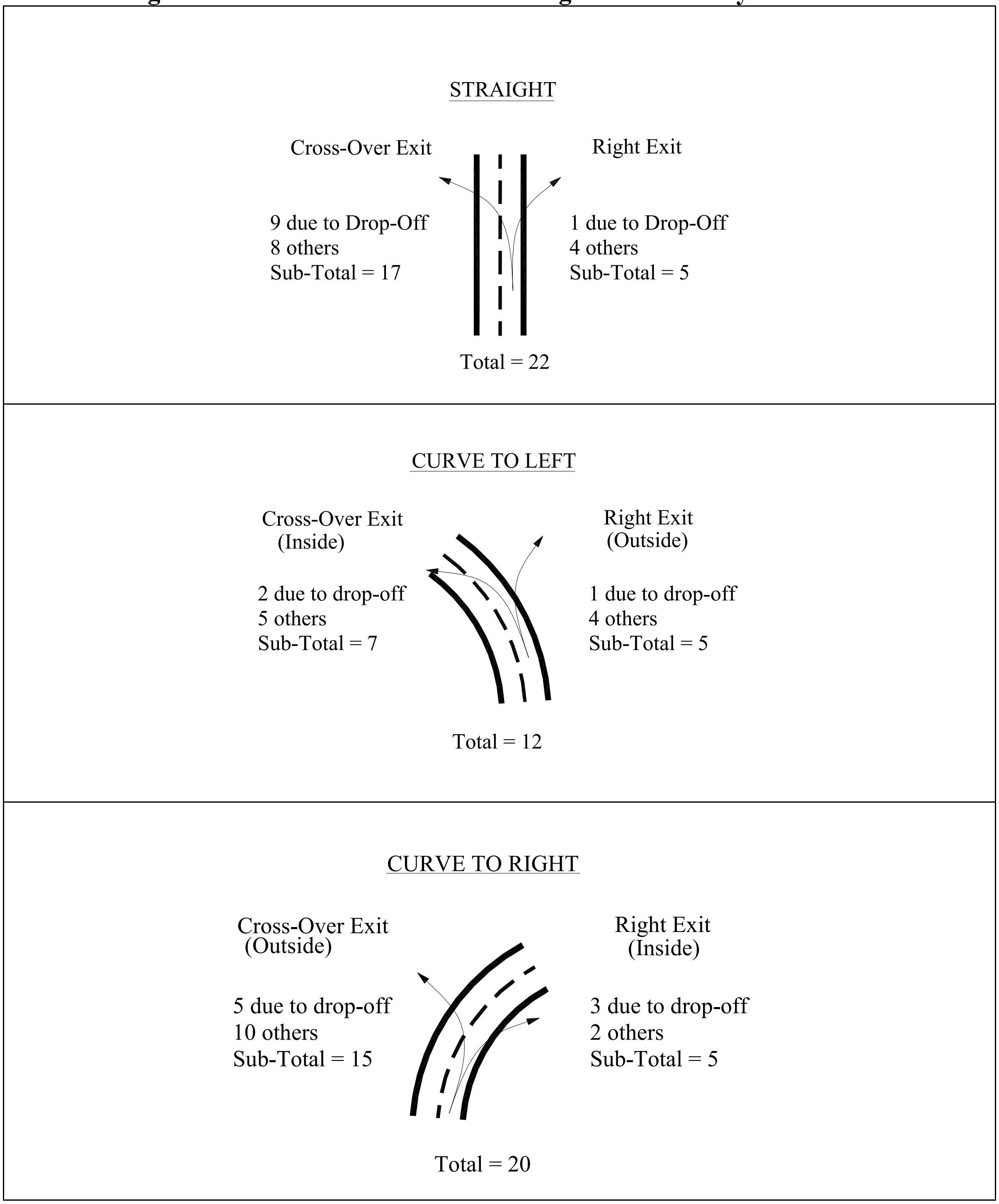
Source: National Center for Statistics and Analysis, Fatality Analysis Reporting System

Supplemental Finding – Pavement Edge Drop-offs

During the site evaluation process, representatives from the Federal Highway Administration and the State of Georgia observed a common theme for non-state-owned roads that were the sites of fatal crashes. At many of these locations, the edge of the pavement was not flush with the adjacent ground. In many cases, the pavement was characterized by a height differential of several inches. This drop-off appeared to be due to erosion as well as pavement maintenance overlays. In addition, rutting was often located adjacent to the road, particularly in the vicinity of roadside mailboxes. Since the specific evaluation of edge drop-offs was not one of the initial project objectives and much of the field work was completed at the time of this observation, only the states of North Carolina and Georgia had an opportunity to evaluate the extent of the drop-off problem.

In Georgia, the researchers only inspected non-state-owned and maintained sites since the state-owned roads had been previously inspected using a video library owned by GDOT. As a result, team members reviewed photographs and site inspection reports for the 69 sites not located on the Georgia state-system. At 55 percent of these sites, drop-offs or edge rutting was present. Upon review of the crash causal analysis, 21 of these 38 crashes included the edge drop-off as one of the direct causal factors to the fatal crash. North Carolina researchers also reviewed their site photographs and reports and determined that drop-offs and edge rutting occurred at 47 percent of their 150 crash locations.

Figure 1. Crash Direction for 54 Georgia Non-State-System Sites



Review of the Georgia drop-off crashes in further detail indicated that day versus night and wet versus dry conditions were distributed evenly. Figure 1 demonstrates the road configuration and vehicle pattern at the Georgia pavement edge drop-off crash locations. Often the right wheels of a vehicle would run off the pavement and the driver would over-correct in an effort to re-direct the vehicle. This driver reaction often resulted in a cross-over exit.

The Georgia researchers reviewed the police crash reports to determine if a crash due to pavement edge drop-offs can be identified from crash data or reports. There were not any consistent variables to point to the drop-off problem. Common police report comments at these locations included:

- "For reasons unknown."
- "… traveled with passenger side tires on the shoulder."
- "… came back on to the roadway and overcorrected and went into a broadside skid…"
- "The driver …steered back onto the roadway and lost control of the vehicle."

The pavement edge drop-off problem appears to be an extensive issue for rural two-lane highways and merits additional focused research based on the preliminary findings of this study.

Project Status

Seven of the eight states completed their evaluations. Each state research team evaluated issues pertinent to their region. Table 10 shows a summary of individual state status. This table also shows the internet address of the final report, if available, via the internet.

Table 10. Project Status Summary Table

State	Current Status	Final Report Web Address (if available)
AL	Complete	---
FL	Complete	http://www11.myflorida.com/research-center/Completed_Proj/ Summary_SF/FDOT_BD158_rpt.pdf
GA	Complete	http://www.dot.state.ga.us/dot/construction/materials-research/ b-admin/research/onlinereports/r-RP9905.pdf
KY	Complete	http://www.ktc.uky.edu/Reports/KTC_01_11_SPR211_00_2F.pdf
MS	Complete	---
NC	Complete	http://www.hsrc.unc.edu/pdf/2002/sefatal_fr.pdf
SC	Complete	---
TN	Incomplete	---

Alabama

The State of Alabama elected to perform a regional fatal crash description evaluation using the comprehensive Critical Analysis Reporting Environment (CARE) traffic analysis database at the University of Alabama. In addition, researchers at Auburn (the lead university for this effort) collected crash information for 150 randomly selected rural, two-lane roads and provided this information to Georgia Tech for future research and analysis. These efforts represented research tasks #1 and #2 as identified at the project kickoff meeting. Alabama researchers have completed their research study and submitted a final report to the Alabama Department of Transportation.

Florida

Florida researchers used a multi-step process to identify safety issues important to the State of Florida. They divided problem areas into the categories of behavior, environment, vehicle, and engineering. Their efforts were based on data from the National Highway Traffic Safety Administration's Fatality Analysis Reporting System (FARS). The top three problems for drivers were determined to be shoulders, vehicles turning left just prior to crash, and crashes involving a drunk driver. Florida proposed research for future efforts will evaluate policies and programs as well as design standards and practices and determine how they differ from other states and the influence of these differences on the crash condition.

Georgia

Georgia researchers participated in the regional fatal crash description, fatal crash causal analysis of two-lane rural roads, and countermeasure identification tasks (Tasks #1, 2, & 3 as identified at the project kickoff meeting). Representatives from the Georgia Department of Transportation asked the research team to focus on possible engineering countermeasures that could be implemented. The analysis performed by the Georgia team included a statistical analysis whereby microscopic crash causal analysis and countermeasure assessments were combined with historic data to determine the most effective countermeasures feasible for two-lane rural roads. The microscopic analysis was based on 150 randomly selected rural two-lane road fatal crashes from 1997. Five specific countermeasures were recommended for future implementation strategies to combat these crashes. These countermeasures included:

1. Addition of advisory speed signs or other speed controls,

2. Geometric alignment improvements,
3. Widening of lanes/pavement widths,
4. Adding and/or widening graded/stabilized shoulders, and
5. Widening/improvement of clear zones.

Future research efforts by Georgia Tech will include the development of predictive models based on the 150 fatal crash databases provided by several of the participating states. Georgia Tech submitted a final Georgia report to the Georgia Department of Transportation in 2002.

Following completion of the Georgia final report, the research team performed an additional evaluation of pavement edge drop-offs. A summary of these findings was previously included in this report.

Kentucky

Researchers from Kentucky evaluated 150 fatal crashes from two-lane rural roads (Task #2 of the kickoff meeting) and recommended countermeasures to reduce the number and severity of crashes for this road type. Crashes were from the years 1996 through 1998. The researchers determined that the effect of the enactment of a mandatory safety belt law had the greatest potential to reduce fatalities on two-lane rural roads. For roadway related countermeasures (excluding work zone devices), the addition of shoulder or centerline rumble strips and the installation of chevron signs at horizontal curves were determined to be the most likely to reduce the fatal crash frequency or severity. Kentucky submitted a final research report to the Kentucky Transportation Cabinet in May of 2001.

Mississippi

Researchers for Mississippi performed a summary analysis to determine the common characteristics of fatal crashes in the State of Mississippi. They prepared a final report summarizing general fatal crash characteristics and submitted the report to the Mississippi Department of Transportation. In addition, Mississippi researchers collected crash data for 150 fatal crashes on rural, two-lane roads. They submitted this database to Georgia Tech for future analysis.

North Carolina

North Carolina researchers performed a causal chain analysis on 150 North Carolina fatal crashes at two-lane, rural roads. In addition to this analysis they developed a ranked list of candidate safety countermeasures that could reduce the frequency or severity of these crashes. The research team identified twelve ranked countermeasures suitable for future consideration due to their proposed influence on the crash condition. These ranked countermeasures include:

1. Clear Zone Improvements – Traversable Drainage Structure,
2. Install or Upgrade Guardrail,
3. Geometric Realignment,
4. Enforce Speed Limits,
5. Improve Sight Distance without Geometric Realignment,
6. Clear Zone Improvements – Remove Fixed Object,
7. Clear Zone Improvements – Widen Clear Zone,
8. Warning Sign,
9. Clear Zone Improvements – Flatten Side Slope,

10. Improve Shoulder – Add or Widen Graded or Stabilized Shoulder,
11. Widen Travel Lanes / Pavement Width, and
12. Improve Longitudinal Shoulder – Pave Existing Graded Shoulder of Suitable Width.

The North Carolina researchers have provided the fatal crash database with 150 two-lane, rural roads to Georgia Tech for future analysis and submitted a final report to the North Carolina Department of Transportation in January 2002.

Following completion of the North Carolina final report, the research team performed an additional overview evaluation of pavement edge drop-offs. A summary of these findings was previously included in this report.

South Carolina

The State of South Carolina (SC) research team, in conjunction with their SCDOT and FHWA sponsors, chose to perform a fatal crash causal analysis and evaluate the potential safety improvements based on a list of 30 safety countermeasures. They performed this analysis using the framework proposed by the Georgia Tech team. The SC team assigned a societal cost of $3 million for each fatal injury and calculated potential benefits based on this value. The results of this research are included in their Final Report titled "Fatal Crashes on Rural Secondary Highways."

Estimated societal benefits for prospective countermeasures ranged from $0 to $846.5 million. The SC research team identified eleven countermeasures that would potentially result in cost savings over $200 million. These ranked items and their associated 1998 estimated societal cost benefits included:

1. Enforce Speed Limits -- $846,489,893
2. Remove Fixed Object -- $603,443,270
3. Rumble Strips -- $565,734,375
4. Pave Existing Graded Shoulder of Suitable Width -- $464,325,490
5. Widen and Pave Existing Shoulder -- $441,165,024
6. Add or Widen Graded or Stabilized Shoulder -- $416,745,068
7. Geometric Realignment (Horizontal, Vertical, Intersection) -- $330,430,540
8. Install or Upgrade Guardrail -- $247,837,236
9. Flatten Side Slope – $228,232,109
10. Relocate Fixed Object -- $222,316,082
11. Warning Sign -- $207,366,237

Three countermeasures the SC research team determined would have had little or no influence on the studied fatal crashes were improved access management, wider clear zones, and traversable drainage structures.

Tennessee

Tennessee researchers did not complete this research effort. They successfully identified and visited 150 two-lane rural fatal crash sites, but did not progress further on this project.

Summary of Findings and Conclusions

Each participating state research team identified unique issues appropriate for their jurisdiction. Due to the variety of analysis procedures and identified objectives from their respective state representatives, the individual conclusions dramatically varied for each state. In general, seven of the eight states determined that the rural, two-lane road condition is the source of the elevated fatal crashes in the region. Improved features such as widening shoulders, enhancing delineation, and protecting the clear zone were identified consistently during the countermeasure analyses. Some of the researchers recommended to their state representatives that additional procedures and policies may be an appropriate countermeasure for wide-scale improvements. Of the six perceived topical areas identified at the kickoff meeting, countermeasures (physical as well as political) were explicitly recommended to address two-lane rural roads, safety restraint use and fixed-object crashes.

A supplemental finding for this study was the presence of extensive pavement edge drop-offs for fatal crash sites in at least two of the participating states. As this observation occurred as a result of field inspection and was not initially identified as a target problem, it was not studied in great detail for this research effort but merits special comment since it is potentially a significant finding of the study.

Future Research

Several of the research teams identified future research needed to further understand the crash condition in their state. In addition, the Georgia Department of

Transportation will direct a study using the available state crash databases (150 fatal two-lane rural roads per state) to further determine the feasibility of predicting crash conditions and to understand the differences in the road conditions or the individual states and how these differences influence safety.

The pavement edge drop-off supplemental finding indicates that future research regarding these drop-offs and methods for addressing this common problem is warranted.

References

1. National Highway Traffic Safety Administration, *Traffic Safety Facts 2003 – Overview*, Report DOT HS 809 767, Washington, DC.
2. National Center for Statistics and Analysis, Traffic Safety Facts -- State Traffic Data (1996 – 2003), National Highway Traffic Safety Administration, Washington, DC.
3. National Highway Traffic Safety Administration, *Traffic Safety Facts 2003 – Occupant Protection*, Report DOT HS 809 765, Washington, DC.
4. National Highway Traffic Safety Administration, *Traffic Safety Facts 2003 – Young Drivers*, Report DOT HS 809 774, Washington, DC.
5. Insurance Institute for Highway Safety, *U.S. Licensing Systems for Young Drivers, Laws as of October 2002*, Arlington, VA.
6. National Highway Traffic Safety Administration, *Traffic Safety Facts 2003 – Large Trucks*, Report DOT HS 809 763, Washington, DC.
7. National Highway Traffic Safety Administration, *Traffic Safety Facts 2003 – Speeding*, Report DOT HS 809 771, Washington, DC.

Appendix

Summary Slides from

Kick-off Meeting

Proposed Cooperative Research Program for Southeast Fatal Crash Study

November 1998

Overall Description

- Universities engage in a subset of research activities that best serves their state's needs
- Subsets of research teams satisfy regional research objectives
- four separate, coordinated, and cooperative research activities undertaken:
  - 1. Regional Fatal Crash Description
  - 2. Fatal Crash Causal Analysis
  - 3. Counter-Measure Identification (lit review)
  - 4. Targeted Before-After Studies

1. Regional Fatal Crash Description

Purpose: To quantify differences b/w SE and NSE regions w/ respect to fatal crashes.

Activities: Conduct aggregate data analysis of fatal and serious injury crashes in SE and NSE. Identify and quantify where differences exist both inter and intra-regional.

Products: Detailed report for states quantifying where crash differences exist

2. Fatal Crash Causal Analysis

Purpose: To identify why fatal crashes in SE are occurring and estimate benefits of various countermeasures

Activities: Conduct detailed literature review of past causal-chain study methodologies, Tri-Level, etc. Collect sample of crash data from SE states, construct causal chains, perform extensive analysis thereof.

Products: Detailed report for states quantifying benefits of countermeasures and ID of 'causes'.

3. Counter Measure Identification

Purpose: To identify and review past literature of counter-measure effectiveness relevant to SE 'problems'.

Activities: Conduct thorough literature review of 'top 6' safety concerns.

Products: Succinct report for SE state DOTs for identifying potential effective countermeasures.

4. Targeted Before-After Studies

Purpose: Engage in new or retroactive Before-Active B-A studies to evaluate their effectiveness.

Activities: Identify specific research questions. Conduct new or identify past B-A study comparisons and conduct analysis with reference groups.

Products: Report quantifying effectiveness of various countermeasures in SE region.

Sample Slides for

State (Georgia) Briefing

Presentation Overview

- Causal Study Overview
- Crash Database Sources
- Causal Inference I: Crash reconstruction
- Causal Inference II: Multi-variable modeling
- Next Steps

Causal Study Overview

Major Components:

- Data collection and database development
- Crash reconstruction
- Causal Inference I: Engineering analysis of crash chain of events (fatals only)
- Causal Inference II: Statistical analysis of crashes in Georgia (fatals and serious injury)

Causal Study Overview

Products:

- Ranked 'approved' list of countermeasures likely to be effective for reducing fatalities in Georgia
- Models relating roadway design features, driver characteristics, environmental factors, and operational aspects to likelihood of fatal crash occurrence.

Causal Study Overview

Input from GDOT & FHWA:

- Identification of 'acceptable' countermeasures
- Exploratory analysis feedback and direction
- screening of crashes in the database

Causal Study Overview

Differences between this study and previous Tri-Level studies:

- Significantly reduced field work and less data collection required
- Lower cost
- More focused

Overview of Causal Chain Studies of early 70's

Multi-level Accident Investigation Studies

Accident Causation Study

Bloomington, IN

General Investigation (13,568)

- General Police Reporting
- Additional Information from
  - Drivers License Records
  - Vehicle Registration Information

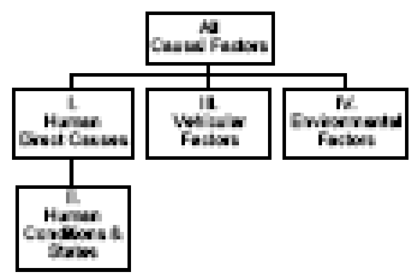
On-Site Investigation (2,258)

- Technician-level investigators collected data on-site
- Data Elements Collected
  - Driver
  - Vehicle
  - Accident Scene
  - Age, Sex
  - Driving Experience
  - Vehicle Familiarity
  - Road Area Familiarity

In-Depth Investigation (420)

- Professional-level investigators followed up with data collection post-crash
- Data Elements Collected
  - Interviewed Drivers
  - Inspected Vehicles
  - Inspected Accident Scene
  - Determination of Human, Vehicle, Envir. Factors
  - Trip Origin, Trip Destination
  - Presence of Fatigue
  - Number of Passengers
  - Causal or Severity Increasing Analysis

Top Level Breakdown of Causal Factors



Crash Database Sources

Data Sources for GA Causal Study

- Accident Reports
- "Safety Enhancement Review Report"
  *state routes only
- EMS Run Reports
- GDOT Roadway Characteristics File
- Driver History Files ???
  *accidents are cited only if driver at fault
  *speeding citation included only if 15 mph above speed limit
- Vehicle Registration

Accident Reports

- Date, Time
- Number & Type of Vehicles
- Driver Info
- VIN, License Info
- Driver Condition
- Vehicle Condition
- Alcohol/Drug Test
- Vehicle Maneuver
- Most Harmful Event
- Traffic Control
- Citations
- Weather
- Lighting
- Roadway Conditions

Safety Enhancement Review Report

- Date, Time of Report
- Roadway Identification
- Speed Limit
- Divider Type
- Auxiliary Lanes
- Pavement Markings
- Traffic Controls
- Access Control
- Adjacent Land Development
- Roadway Geometrics
- Shoulder Material/Width
- Accident Experience
- ADT
- Construction

EMS Run Report

- Date, Time
- Census Tract
- Age, Race, Sex
- Treatment
- Incident Location
- Environmental Causes
  - Alcohol
  - Drugs
- Protective Air Bag
- Protective Car Seat
- Protective Lap/Shoulder Belt
- Severity
- Blood Pressure, Pulse
- Respiration, Pupils
- Extrication

GDOT Roadway Characteristics Files

- Posted Speed
- Number of Lanes
- Direction of Travel
  - Infer Bearing
  - Infer Curve
- Distance
- Grade

Vehicle Registration File

- Vehicle ID
- Salvage/Junk Title Info
- Mileage
- Vehicle Use
- Infer Vehicle Familiarity

Causal Inference I: Crash Reconstruction

Critical elements of the approach:

- Identify comprehensive list of countermeasures deemed suitable to Georgia DOT (for 2-lane rural roads)
- Develop (subjective) rating system for anticipated effectiveness of countermeasures in crash scenario (0-ineffective, 5-very effective)
- Develop (objective) rating system based on past experience and/or research on listed countermeasures (20% reduction)
- Combine rating systems (Bayesian Method) to countermeasure effectiveness likelihood

Crash Reconstruction

Step 1. Identify Environment Conditions

Step 2. Identify Person & Vehicle Characteristics

Step 3. Summarize Crash Sequence of Events

Step 4. "Diagnose" Crash Condition/Circumstance

Step 5. Hypothesize Countermeasure Intervention

"Ideal" Environment Condition

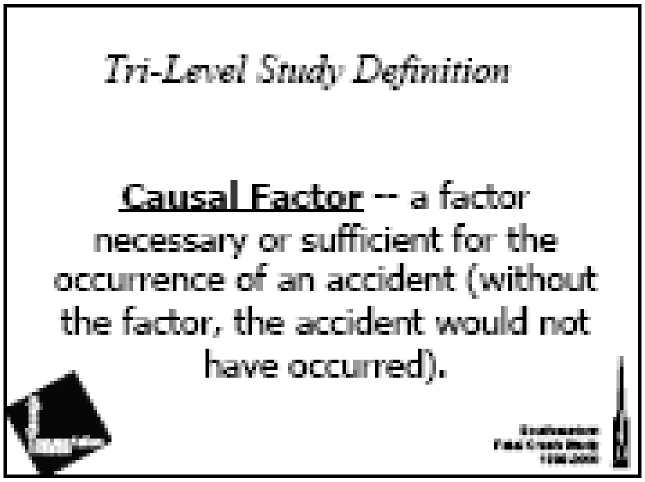
- Daylight, Dry
- Straight Road, Level Grade, No Intersection
- 12' Lanes or Greater
- Paved Shoulders with Adequate Clear Zone
- Reflective Center and Edge Lines

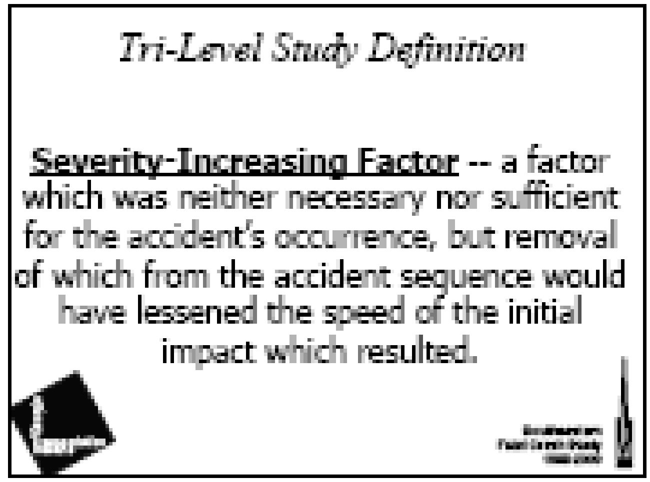
"Ideal" Driver Characteristics

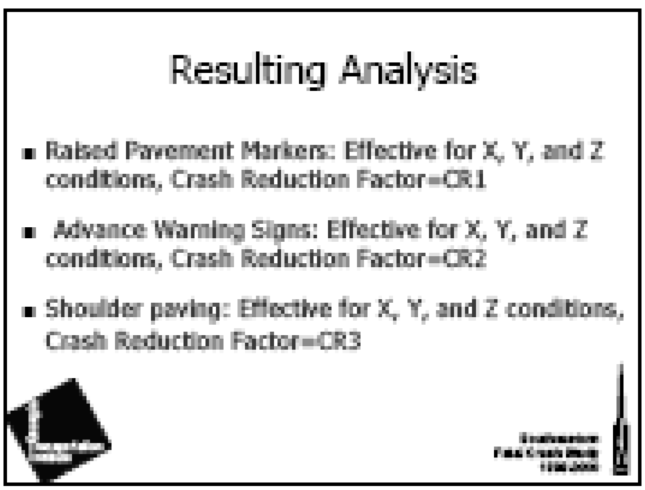
- Between 25 & 65 Years of Age
- No Alcohol or Drug Influence
- Good Driving History
- Experienced Driver (over 5 years)
- Utilizes Appropriate Occupant Restraint
- Drives within 5 mph of the Posted Speed Limit

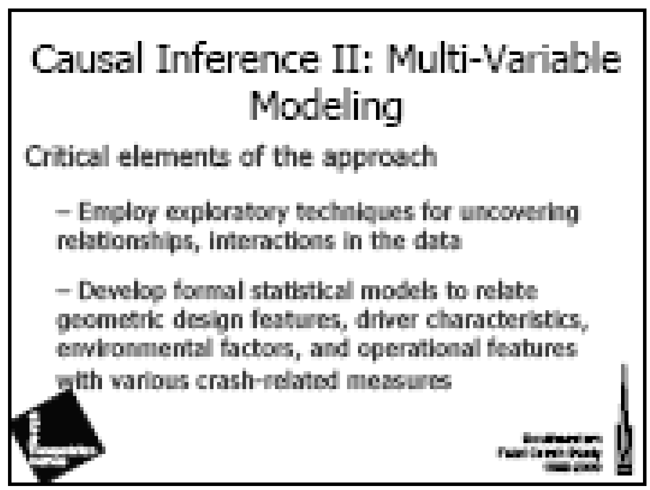
"Ideal" Vehicle Characteristics

- Vehicle in Good Initial Condition
- Currently Registered and Insured
- Passenger Car – Mid-sized


Tri-Level Study Definition
Causal Factor -- a factor necessary or sufficient for the occurrence of an accident (without the factor, the accident would not have occurred).


Tri-Level Study Definition
Severity-Increasing Factor -- a factor which was neither necessary nor sufficient for the accident's occurrence, but removal of which from the accident sequence would have lessened the speed of the initial impact which resulted.


Resulting Analysis
Raised Pavement Markers: Effective for X, Y, and Z conditions, Crash Reduction Factor=CR1
Advance Warning Signs: Effective for X, Y, and Z conditions, Crash Reduction Factor=CR2
Shoulder paving: Effective for X, Y, and Z conditions, Crash Reduction Factor=CR3


Causal Inference II: Multi-Variable Modeling
Critical elements of the approach
– Employ exploratory techniques for uncovering relationships, interactions in the data
– Develop formal statistical models to relate geometric design features, driver characteristics, environmental factors, and operational features with various crash-related measures

Classification Methods: Legend

[illegible]

Resulting Statistical Models

- MOC $_{probability}$ = f(design, environment, operational, driver)
- Crash Severity $_{probability}$ = f(design, environment, operational, driver)
- FHE $_{probability}$ = f(design, environment, operational, driver)

MOC = manner of collision, FHE = first harmful event

Next Steps

- Develop 'approved list' of countermeasures
- Refine database for use in the analysis
- Develop detailed research proposal

Slides for Proposed Research

Evaluation Method – I

Crash Reconstruction

Step 1. Identify Environment Conditions

Step 2. Identify Person & Vehicle Characteristics

Step 3. Summarize Crash Sequence of Events

Step 4. "Diagnose" Crash Condition/Circumstance

Step 5. Hypothesize Countermeasure Intervention

"Ideal" Environment Condition

- Daylight, Dry
- Straight Road, Level Grade, No Intersection
- 12' Lanes or Greater
- Paved Shoulders with Adequate Clear Zone
- Reflective Center and Edge Lines

"Ideal" Driver Characteristics

- Between 25 & 65 Years of Age
- No Alcohol or Drug Influence
- Good Driving History
- Experienced Driver (over 5 years)
- Utilizes Appropriate Occupant Restraint
- Drives within 5 mph of the Posted Speed Limit

"Ideal" Vehicle Characteristics

- Vehicle in Good Initial Condition
- Currently Registered and Insured
- Passenger Car – Mid-sized

Tri-Level Study Definition

<u>Causal Factor</u> -- a factor necessary or sufficient for the occurrence of an accident (without the factor, the accident would not have occurred).

Tri-Level Study Definition

<u>Severity-Increasing Factor</u> -- a factor which was neither necessary nor sufficient for the accident's occurrence, but removal of which from the accident sequence would have lessened the speed of the initial impact which resulted.

Slides for Proposed Research

Evaluation Method – II

A Bayesian Safety Assessment Framework (B-SAF) for Identifying Effective Countermeasures in Regional Safety Management Programs

By: Simon Washington, Karen Dixon, Jennifer Ogle, and Evelyn Wu

School of Civil & Environmental Engineering

Regional Safety Management Goals:

- Safety program managers need to select among a host of countermeasures for improving safety in their region
- Desire quantification of costs and benefits
- Desire highest safety benefit for minimal (or fixed) cost

Limitations of current approaches:

- Cross-sectional studies are used to make inferences over time, which in many cases are inappropriate (i.e. confounding variables).
- Cross-sectional study results may not be transferable due to differences across location/regions/etc.
- Site selection bias results in over-estimating the effect of countermeasures (in B-A studies).
- B-A studies are costly, take a long time to conduct, and require one study per countermeasure to assess.

BSAF Methodology: Key Features

- (1) To incorporate (formally) relevant cross-sectional and before-after study results
- (2) To conduct engineering evaluations (crash-sequence analysis) of all countermeasures (to be evaluated)
- To combine results (1) and (2) to derive estimates of countermeasure effectiveness

BSAF: Analytical Features

- Employ Bayesian statistical methods to combine "prior" and "current" estimates of accident modification factors (AMF's).
- Employ Meta-Analytical methods to combine past research results into AMF estimates.

θ_i is the accident modification factor (AMF) for countermeasure i

S_B is the safety of a site before application of the countermeasure,

S_A is the safety of a site after application of the countermeasure.

$$\theta_i = \frac{S_A}{S_B}$$

BSAF: Philosophical Underpinnings

- Baye's methods give superior statistical estimates of the entity of interest (posterior credible intervals versus confidence intervals).
- Engineering evaluation of accidents can provide useful and objective information in an analysis.
- Past research is useful and should be formalized in the analytical process.

BSAF: Inputs & Outputs

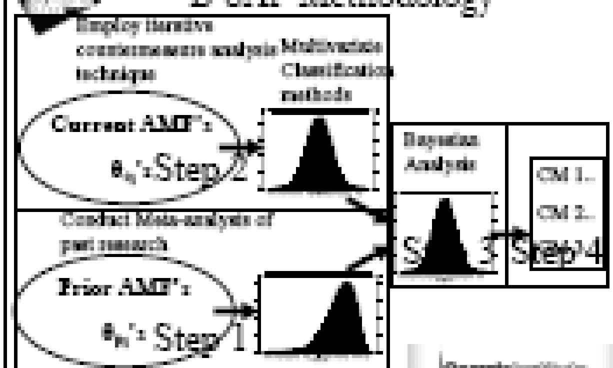
INPUTS:

- Crash information (police reports)
- Site information
- Emergency medical response information
- Exposure data

OUTPUTS:

- Ranked list of countermeasures and expected benefit for each in region of interest

B-SAF Methodology



STEP 1: Prior AMF's

1. Develop list of candidate countermeasures.
2. Identify region of interest (e.g. city, county, state, etc.)
3. Identify safety entities of interest (e.g. all crashes, fatals, injuries, head-on collisions, etc.)
4. Search literature on past studies conducted to assess countermeasures in (1).

STEP 1(cntd): Prior AMF's

From literature synthesis, collect:

- Study results: sample size, site characteristics, AMF's, regression parameters and/or effect sizes, correlations
- Study Artifacts: sampling error, measurement error, confounding variables, selection bias, etc.

STEP 1(cntd): Prior AMF's

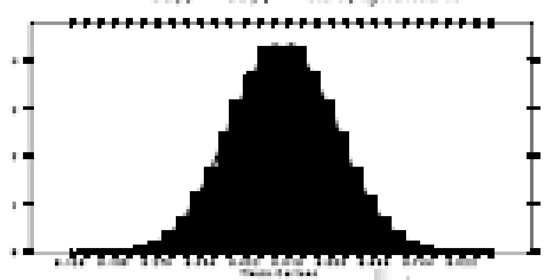
Conduct Meta-Analysis:

1. Average desired descriptive statistics (AMF) across studies.
2. Calculate the variance of AMF across studies.
3. Correct variance for sampling error.
4. Correct mean and variance for study artifacts.
5. Use mean and variance to derive prior estimate of AMF

STEP 1(cntd): Prior AMF's

"Subjective" Prior Beta Distribution of Theta Based on Meta Analysis

$\alpha = 15$, $\beta = 15$, $\mu = 0.50$; *symmetric*



STEP 1(cntd): Prior AMF's

Meta-Analysis Issues/Complexities

1. Search should be based on exhaustive search for relevant studies.
2. Accounting for internal and external threats to validity.
3. Sampling error and capitalization on chance.
4. Loss of information due to low statistical power.

STEP 2: Current AMF's

1. Randomly select safety entities (crashes) from the study population/region.
2. Sample size should be sufficient to be "representative" of types of crashes in region of interest (additional work needed).
3. Collect crash, location, and EMS data.
4. Conduct *Iterative Crash Re-construction Analyses* on each safety entity and countermeasure.

STEP 2 (cntd): Current AMF's

5. Complete Countermeasure Effectiveness Forms
6. Add AMF to database
7. Conduct multivariate classification of database: *What variables are associated (statistically) with low AMF's?*
8. Develop distributions of AMF's for each countermeasure

STEP 2 (cntd): Current AMF's

Survey Response	NA	-1	0	+1	+2	+3
Description	Can not determine effect of counter-measure	Would worsen severity of crash	Would have no effect on crash	Would not prevent crash, but may reduce severity	Would not prevent crash, but would reduce severity	Would prevent the crash
Theta	50%	1.33	1.0	0.67	0.33	0.0

Examples: Effect of intersection lighting on multi-vehicle crash

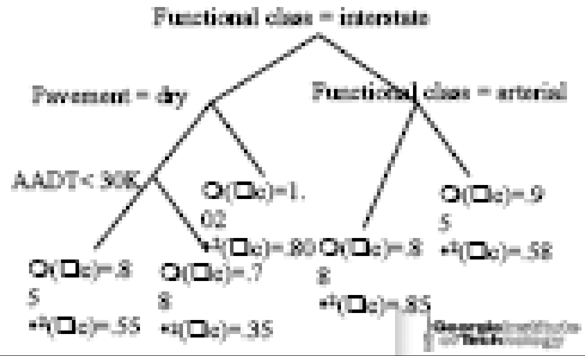
Effect of rumble strips on auto-pedestrian crash

STEP 2 (cntd): Current AMF's

Crash	Counter-measure	Road Class	AADT	AMFs	Light-ing	Med. width
1	1	inter	20k	0.67	1	45
2	1	art	11k	0.0	0	1
3	1	coll	15k	1.0	0	12
. . .	. . .	. . .	. . .	. . .	. . .	. . .
97	1	coll	5k	NA	1	15
98	1	art	5k	0.33	0	1
99	1	int	30k	0.67	1	30
100	1	int	25k	1.33	0	60

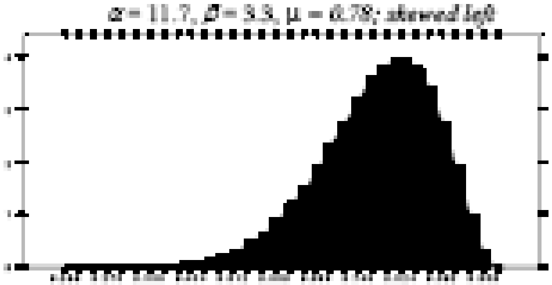
STEP 2 (cntd): Current AMF's

Countermeasure: Widen paved shoulder



STEP 2 (cntd): Current AMF's

"Current" Beta Distribution of Theta
Based on Iterative Crash Reconstruction Analysis
$\alpha = 11.7$, $\beta = 3.3$, $\mu = 0.78$; *skewed left*



STEP 3: Bayesian Updating

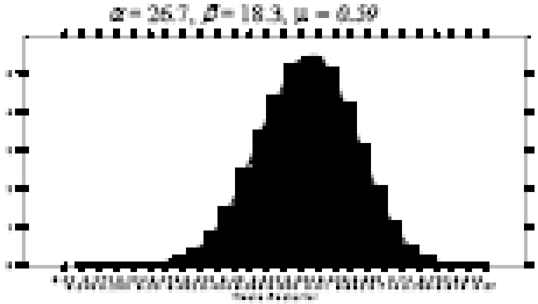
1. Combine current and prior estimates of theta into posterior estimate of theta.
2. Obtain posterior credible interval of theta (not confidence interval) for each countermeasure.

$$Pr(theta|Data) = \frac{Pr(theta)Pr(Data|theta)}{Pr(Data)} \propto Pr(theta)Pr(Data|theta)$$

STEP 3 (cntd): Bayesian Updating

"Posterior" Beta Distribution of Theta

$\alpha = 26.7$, $\beta = 18.3$, $\mu = 0.59$



Step 4: Ranking Countermeasures

1. Most probable theta and conditions common to "Effective" countermeasures are known.
2. An estimate of these characteristics is obtained from a census of crash data in the region.

   e.g. Suppose there were 20 fatal multi-vehicle crashes on two-lane rural highway intersections, without lighting, during night time, posted speed > 45, un-protected left-turns, and medians > 25 feet (conditions where installation of lighting is effective)

Step 4 (cntd): Ranking Countermeasures

1. Apply the equation:
   n_i=(# safety related events) x (1 – theta)
   = expected decrease in safety related events

   Example:
   n_i= (46 fatal crashes) x (fatalities/fatal crash)(1-0.60)
   = 23 reduced fatalities (most likely)
2. Reduce the "pool" of crashes by n_i (as appropriate)
3. Cycle through countermeasures evaluated.

Step 4 (cntd): Ranking Countermeasures

Counter-measure of interest	ideal conditions for effective countermeasure	number of candidate sites with "ideal" condition	most probable improvement in safety (e.g. accidents/ per year)
add intersection lighting	two-lane rural posted speed > 45 median > 25 feet	46	9 fatalities, 21 injuries, 55 PDO

Conclusions

1. Additional work is needed:
   - sample size requirements
   - consistency of *Iterative Crash Reconstruction*
   - dealing with research artifacts in Meta Analysis
   - Presenting/packaging the methodology
   - Automating the process
   - Sensitivity analysis of input assumptions

Georgia Institute of Technology

Conclusions (cntd)

1. Method formally includes results from past studies.
2. Method incorporates engineering judgment on local conditions into analysis.
3. Interpretation of results is superior to classical statistical results.
4. A host of countermeasures can be assessed and ranked.

Georgia Institute of Technology