Characterizing commercial vehicle safety in rural Montana
by Patricia Walsh Burke

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering
Montana State University

Abstract:
This investigation focused on characterizing commercial vehicle safety in rural Montana on the basis of driver, vehicle, cargo, carrier, operating environment and crash characteristics using advanced statistical modeling methods. Montana, like other rural states experiences unique challenges in regards to commercial vehicle safety. Crashes typically involve a single vehicle, occur at higher speeds, are more severe and take longer to be detected.

In order to address these challenges, researchers utilized statistical modeling to characterize commercial vehicle safety levels on the basis of the various characteristics. Model interpretation was intended to assist public agencies in focusing scarce regulatory and enforcement resources on commercial vehicles highest at-risk for safety-related problems. The agencies would then be able to perform their duties more effectively and efficiently by addressing safety problems in a preventative rather than reactionary manner. An ordered probit model was used to model the 6524 crashes that took place over a seven-year period.

The results of this investigation were directly interpretable in regards to magnitude and direction. Independent variables that were found to have a significant influence on the severity of a crash included driver characteristics (age, condition-normal, condition-asleep, driver state residence), vehicle characteristics (vehicle configuration-single unit 2-axle), cargo characteristics (household goods), carrier characteristics (carrier physical address-Canadian Territories, number of trip leased and intrastate drivers, latest review-compliance review), operating environment characteristics (crash years 1996-1999, crash months-July, August, September and December, crash time-9am to 10am, light conditions-dark but lit) and crash characteristics (number of vehicles involved, specific crash counties). In addition, utilizing the ordered probit method to model crash severity proved to be successful as the significance of the variables were high as denoted through t-statistics and the overall goodness of fit was good ($p2 = 0.57$).

In conclusion, focusing enforcement efforts toward variables that were found to increase the severity of a crash including specific driver state residences, vehicle configurations, carrier physical addresses, number of trip-leased drivers and the months of July, August, September and December would be the most effective and efficient method to improve commercial vehicle safety in Montana.

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APPROVAL

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Patricia Walsh Burke

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

Dr. Jodi L. Carson — Jodi L. Carson (Signature) — 4/18/01 Date

Approved for the Department of Civil Engineering

Dr. Donald Rabern — Don Rabern (Signature) — 4/18/01 Date

Approved for the College of Graduate Studies

Dr. Bruce McLeod — Bruce R. McLeod (Signature) — 4-18-01 Date

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ABSTRACT

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In order to address these challenges, researchers utilized statistical modeling to characterize commercial vehicle safety levels on the basis of the various characteristics. Model interpretation was intended to assist public agencies in focusing scarce regulatory and enforcement resources on commercial vehicles highest at-risk for safety-related problems. The agencies would then be able to perform their duties more effectively and efficiently by addressing safety problems in a preventative rather than reactionary manner. An ordered probit model was used to model the 6524 crashes that took place over a seven-year period.

The results of this investigation were directly interpretable in regards to magnitude and direction. Independent variables that were found to have a significant influence on the severity of a crash included driver characteristics (age, condition-normal, condition-asleep, driver state residence), vehicle characteristics (vehicle configuration-single unit 2-axle), cargo characteristics (household goods), carrier characteristics (carrier physical address-Canadian Territories, number of trip leased and intrastate drivers, latest review-compliance review), operating environment characteristics (crash years 1996-1999, crash months-July, August, September and December, crash time-9am to 10am, light conditions-dark but lit) and crash characteristics (number of vehicles involved, specific crash counties). In addition, utilizing the ordered probit method to model crash severity proved to be successful as the significance of the variables were high as denoted through t-statistics and the overall goodness of fit was good ($\rho^2 = 0.57$).

In conclusion, focusing enforcement efforts toward variables that were found to increase the severity of a crash including specific driver state residences, vehicle configurations, carrier physical addresses, number of trip-leased drivers and the months of July, August, September and December would be the most effective and efficient method to improve commercial vehicle safety in Montana.

CHAPTER 1

INTRODUCTION

Despite the fact that they are less frequent than other types of vehicular crashes, commercial vehicle crashes receive considerable attention in the U.S. due to their high severity and resulting economic loss. At a national level, the Federal Motor Carrier Safety Administration (FMCSA) has set stringent goals focused on enhancing commercial vehicle safety through reduced crash severity levels and improved: (1) consistency and effectiveness of enforcement, (2) identification and targeting of those at high-risk and (3) research efforts to enhance and promote commercial vehicle safety practices.

Montana, as with other predominantly rural states, faces somewhat unique challenges with respect to commercial vehicle safety. Unlike commercial vehicle crashes that occur in urban areas, rural commercial vehicle crashes typically involve a single vehicle, occur at higher speeds, are more severe and take longer to be detected and responded to. Further, available regulatory and enforcement resources for commercial vehicle safety monitoring are limited. Montana's large geographic expanse challenges post-crash improvements that could limit the occurrence of fatalities, such as reduced emergency medical response times to the crash. Hence, efforts to improve commercial vehicle safety in Montana must focus on commercial vehicle crash *prevention,* targeting those at highest risk for a severe crash.

The objective of this research is to characterize commercial vehicle safety levels in Montana on the basis of driver, vehicle, cargo, carrier and other characteristics (i.e., roadway geometry, traffic volumes, etc.) using advanced statistical modeling methods. As an example, if the commercial vehicle safety-related data were to indicate low safety levels for out-of-state drivers, carriers with small vehicle fleets and haulers of flatbed trailers, both roadside and on-site carrier-based safety inspections could be performed with these characteristics in mind. On the roadside, regulatory and enforcement personnel could adjust their selection of commercial vehicles for roadside safety inspections; currently vehicles are selected for safety inspections on the basis of historical accident or safety records. As part of a more detailed carrier-based safety inspection program, regulatory and enforcement personnel could increase the frequency of safety inspections for carriers possessing the characteristics that show a lower safety level.

Ultimately, an understanding of the driver, vehicle, cargo, carrier and other characteristics that are most likely to result in a crash, particularly a severe crash, can assist regulatory and enforcement agencies in addressing safety problems in a *preventative* rather than reactionary manner. An additional benefit of this effort, and certainly of concern to public agencies in predominantly rural states, is the ability to make better use of existing resources. Resources are typically more limited and geographic expanses greater in rural states. Having the ability to focus scarce regulatory and enforcement resources on commercial vehicles highest at risk for safety-related problems, public agencies can perform their duties more effectively and efficiently without additional personnel.

Note, that only large trucks having a gross vehicle weight (GVW) of 10,000 pounds or greater are considered in this investigation; buses are excluded. Differences with respect to cargo and passenger transport vehicles between safety protocol, regulation and enforcement activities for and vehicle-handling characteristics were thought to confound this investigation. Further, the proportion of bus-involved crashes is small compared to that of large truck-involved crashes.

This Chapter details the problem at hand nationally and with respect to Montana's commercial vehicle crashes, describes the study area, and provides background information pertaining to existing Federal, State and industry efforts to improve commercial vehicle safety.

Following this introductory material, Chapter 2 describes findings from recent literature pertaining to commercial vehicle safety. Chapter 3 describes this effort's methodology in identifying influential driver, vehicle, cargo, carrier and operating environment characteristics. Chapter 4 expounds on the findings of this investigation and Chapter 5 contains recommendations for implementation and future work.

Problem Description

In 1999, there were more than 452,000 traffic crashes involving large trucks in the U.S. These crashes accounted for approximately 13 percent of all traffic-related fatalities and 4 percent of all injuries. (1) Contributing to this elevated level of severity are the physical characteristics of large trucks: (1) the difference in mass between large trucks and non-trucks results in a near instantaneous velocity change upon impact, (2) the high

rigidity of a commercial vehicle's structure results in energy dissipation through the collapse of the smaller vehicle, and (3) the height of the truck results in damage to the upper and weaker parts of the smaller vehicle.

Despite this high rate of severity, truck-involved crash *rates* (i.e., crash frequency) tend to be lower than that of non-trucks because:

- trucks typically travel more interurban miles,
- trucks register higher mileage in general,
- truck drivers are generally more skilled, and
- vehicle maintenance of trucks is generally stricter. (2)

Given these noted observations of truck crash severity and frequency, much of the effort towards improved commercial vehicle safety focuses on severity levels. In the FMCSA's draft *2010 Strategy*, the primary goals relate to improving commercial vehicle crash severity: (1) reduce the number of injuries in large truck-related crashes by 20 percent by fiscal year 2008 and (2) reduce the number of large truck-related crash fatalities 50 percent by fiscal year 2009.

Nationally, efforts to improve commercial vehicle safety will be challenged by contrary traffic and industry trends:

- increasing international trade will lead to more intermodal freight shipments and north-south, cross-border traffic for long haul trucks;
- continued and growing demand for real-time visibility of shipments and just-in-time freight delivery will heighten competitive pressures already placed on drivers and carriers;

- growth in e-commerce will impact truck distances traveled and travel patterns (e-commerce, particularly business-to-consumer, favors transportation in smaller lot sizes delivered by carriers with nationwide distribution systems); and
- declining availability of commercial vehicle drivers will result in more new drivers with less experience. (1)

The effectiveness of these safety improvement measures is further challenged in a predominantly rural state such as Montana that experiences significant commercial vehicle traffic, a large geographic expanse and limited regulatory and enforcement resources.

Uniqueness of Montana's Commercial Vehicle Crashes

Each year, approximately 1,000 commercial vehicle crashes occur within the State of Montana. Between January 1, 1993 and December 31, 1999, 6,583 commercial vehicle crashes occurred; 6,524 involving large trucks (see Figure 1). As noted previously, Montana's commercial vehicle crashes typically involve a single vehicle, occur at higher speeds, take longer to be detected and responded to and are more severe than nationally reported averages.

Vehicular Involvement. Given Montana's rural environment and low traffic volumes, one would expect a higher proportion of single-vehicle rather than multiple-vehicle crashes as compared to national averages. For the four-year time span (1993 to 1999) large truck-involved crashes in Montana comprised 46 percent single-vehicle crashes and

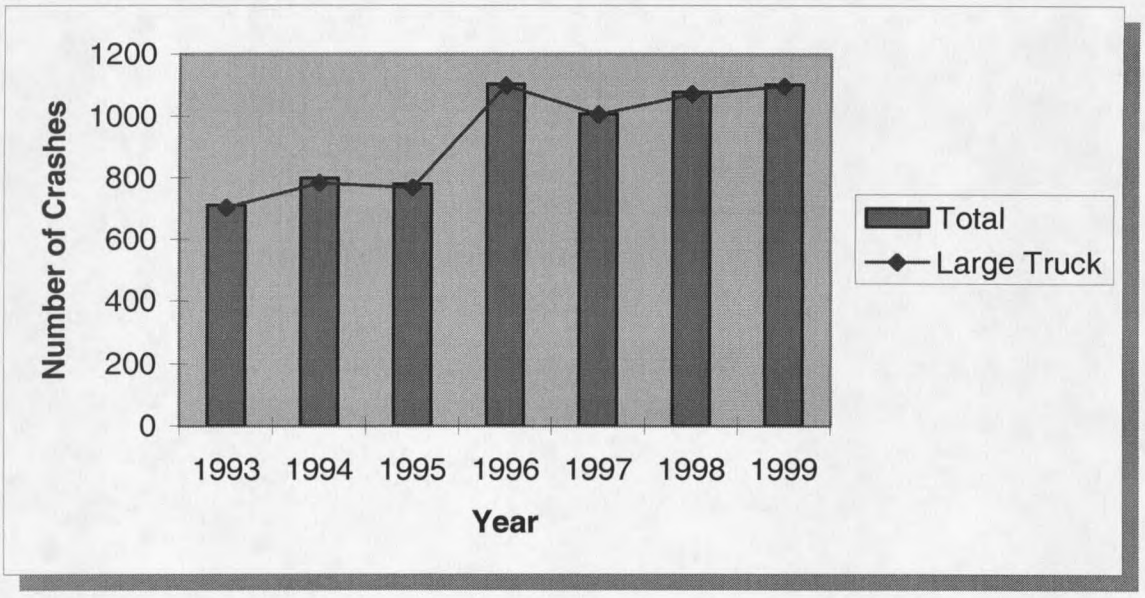

Figure 1. Montana's Commercial Vehicle Crashes, 1993-1999.

54 percent multiple-vehicle crashes. Figure 2 demonstrates the uniqueness of Montana's crashes as compared to national averages for this same time period. Nationally, large truck-involved crashes comprised only 28 percent single-vehicle crashes and 72 percent multiple-vehicle crashes. (3)

Speed. In general, vehicular crashes involving large trucks occur at higher speeds in Montana than they do nationally. Data from the Fatal Accident Reporting System (FARS) for the year 1999 illustrates that 60 percent of all fatal crashes in Montana occurred at speeds of 60 MPH or greater, while only 31 percent of fatal crashes nationally occurred at comparable speeds (see Figure 3). (3)