FMCSA Safety Program Effectiveness Measurement:

Compliance Review Effectiveness Model

Results for Carriers with Compliance Reviews in 2004

March 2008

FMCSA-RRA-08-014

Prepared for:
Federal Motor Carrier Safety Administration
Office of Research and Analysis
Analysis Division, MC-RRA
1200 New Jersey Avenue, S.E.
Washington, DC 20590

Prepared by:
John A. Volpe National Transportation Systems Center
Office of Surface Transportation Programs
Motor Carrier Safety Division, RTV-3E
Kendall Square
Cambridge, MA 02142

PREFACE

This report documents the methodology and results from the Federal Motor Carrier Safety Administration's (FMCSA) Compliance Review (CR) Effectiveness Model. This model measures the effectiveness of one of the key safety programs of the FMCSA, the compliance review program. The model was developed for the FMCSA by the Research and Innovative Technology Administration's (RITA) John A. Volpe National Transportation Systems Center (the Volpe Center) in Cambridge, MA. This work is part of an effort to assess the effectiveness of the FMCSA's principal safety programs. The work also addresses the requirements of the Government Performance and Results Act (GPRA) of 1993, which obligates federal agencies to measure the results of their programs as part of the budget cycle process.

The CR Effectiveness Model is one of two models that provide a baseline of the effectiveness of FMCSA safety programs through the use of standard safety performance measures. This baseline allows the FMCSA to judge the relative performance of its programs on a periodic basis by reflecting the changes in benefits resulting from each program. The results of these analyses are also intended to provide a basis for FMCSA resource allocation and budgeting decisions that will more closely optimize the effectiveness and efficiency of its motor carrier safety programs.

In addition to the CR Effectiveness Model, the Intervention Model has been developed to measure the effectiveness of and estimate benefits resulting from roadside inspection and traffic enforcement activities. These two models have been developed to estimate the benefits of these FMCSA safety programs in terms of crashes avoided, lives saved, and injuries avoided.

Thomas Keane, Chief of the Analysis Division in the Office of Research and Analysis, manages the project for the FMCSA. The Volpe Center project manager is Kevin Gay of the Motor Carrier Safety Division. The analysis was performed by Jon Ohman with assistance from Kevin Gay and Julie Nixon, all of the of the Volpe Center. Technical support was provided by Richard Nguyen of the Volpe Center and Leon Parkin of Chenega Advanced Solutions & Engineering (CASE), LLC, under contract to the Volpe Center. Olu Ajayi of the FMCSA's Analysis Division deserves special thanks for his assistance in obtaining data that were used in the implementation of the model.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FIGURES

TABLES

EXECUTIVE SUMMARY

Background

This report documents the methodology and results from a model that measures the effectiveness of one of the key safety programs of the Federal Motor Carrier Safety Administration (FMCSA), the compliance review (CR) program. The research was conducted by the Research and Innovative Technology Administration's (RITA) John A. Volpe National Transportation Systems Center (the Volpe Center) in Cambridge, MA under a project plan agreement with the FMCSA. The work on the FMCSA Safety Program Effectiveness Measurement Project addresses the requirements of the Government Performance and Results Act (GPRA) of 1993, which obligates federal agencies to measure the results of their programs as part of the budget cycle process.

This report describes the methodology of the Compliance Review Effectiveness Model and presents the results of the implementation of the model for carriers receiving CRs in 2004. The benefits of the compliance review program are calculated in terms of crashes avoided, lives saved, and injuries avoided.

Methodology of Model

The on-site compliance review is perhaps the single greatest resource-consuming activity of the FMCSA. Thousands of CRs are conducted each year. In the year 2004, federal and state enforcement personnel conducted over 10,000 CRs on individual motor carriers. It is intended that through education, heightened safety regulation awareness, and the enforcement effects of the CR, carriers will improve the safety of their commercial vehicle operations, and, ultimately, reduce the number and severity of crashes in which they are involved.

The CR Effectiveness Model was developed to determine the effectiveness of the CR program. The model measures the direct impact of compliance reviews on carriers that received CRs, but not "deterrent" effects (i.e., the "threat" of having a CR) on carriers that did not actually receive CRs. The model is based on the individual and cumulative "before and after" changes in the safety performance of carriers that received CRs in a given year. The model compares a motor carrier's crash rate in the 12 months following an on-site compliance review to its crash rate in the 12 months prior to that review. The model uses (1) crash data reported by the states and (2) power unit data reported by carriers or obtained during CRs, to calculate both the before-CR and after-CR crash rates.

To eliminate the effects of underlying trends occurring in the general carrier population, a control group of carriers is used. This Control Group consists of all carriers that did not receive CRs during the year in question. Any change in the average crash rate of the Control Group must be due to factors affecting the entire carrier population. Thus, the change in the average crash rate of the Control Group is calculated and then subtracted from the change in the average crash rate of the carriers that received CRs in the year in question. The difference resulting from this calculation represents the change in the average crash rate of the carriers that received CRs in the year in question that was solely the result of the CRs.

The CR Effectiveness Model has been used to estimate benefits only for carriers with CRs conducted in 2002, 2003, and 2004. The model succeeded the Compliance Review Impact Analysis Model, which was used to estimate the benefits for carriers with CRs in 1998, 1999, 2000, and 2001.[1] The estimates produced by the CR Effectiveness Model will establish new benchmarks and are not directly comparable to the estimates produced by the CR Impact Assessment Model.

Implementation of Model for Carriers with Compliance Reviews in 2004

The CR Effectiveness Model was implemented for carriers with CRs in 2004 to estimate the number of crashes (and associated fatalities and injuries) avoided in the first year following the reviews, i.e., 2004-2005. Table ES-1 shows these benefits, as well as the benefits that were estimated to have occurred (1) in 2002-2003 for carriers with CRs in 2002 and (2) in 2003-2004 for carriers with CRs in 2003.

Table ES-1. Results of Implementation of Compliance Review Effectiveness Model for Carriers with Compliance Reviews in 2002, 2003, and 2004

Model Implementation for Motor Carriers with CRs in:	**2002**	**2003**	**2004**
Compliance reviews conducted	12,139	11,086	10,671
Motor carriers that received compliance reviews and: • were interstate or intrastate HM, • were active in the 12 months before and after their CRs, • had 1 or more power units in the 12 months before and after their CRs, and • had crash and power unit data that passed edit checks designed to screen out erroneous data.	9,172	8,587	8,042
Estimated percentage reduction in average crash rate due to compliance reviews	12.6	17.6	21.1
Model Results (i.e., Benefits) Estimated for:	**2002-2003**	**2003-2004**	**2004-2005**
Crashes avoided	1,426	2,276	2,720
Fatal crashes	53	77	92
Injury crashes	677	1,038	1,186
Towaway crashes	696	1,161	1,442
Lives saved	62	90	107
Injuries avoided	1,087	1,651	1,889

Additional Analysis

To further assess the effectiveness of the compliance review program, the results of the implementation of the model were broken out by carrier size (i.e., number of power units), by the state of domicile of the carrier, by carrier safety status (i.e., the carrier's SafeStat[2] category

[1] Reports documenting these results are available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=23.

[2] SafeStat (Safety Status Measurement System) is an automated, data-driven analysis system that is designed to incorporate on-road safety performance information and enforcement history with on-site compliance review information in order to measure the relative safety fitness of interstate motor carriers. A thorough description of SafeStat methodology can be found in: John A. Volpe National Transportation Systems Center, Motor Carrier Safety Assessment Division, DTS-47, *SafeStat, Motor Carrier Safety Status Measurement System, Methodology: Version 8.6*, January 2004. This document is available at ai.fmcsa.dot.gov/CarrierResearchResults/PDFs/SafeStat_method.pdf.

before receiving its CR in 2004), and by the planned course of action (i.e., enforcement or no enforcement) for the carrier.

1) The breakout of the results of the model implementation by carrier size showed that the carriers with 20 or fewer power units had the largest reduction in the average crash rate in the 12 months following their CRs.

2) The results of the implementation of the model by the state of domicile of the carrier showed that one state (Texas) had over 300 crashes avoided in 2004-2005 as a result of CRs conducted in 2004, while another state (Missouri) had over 200 crashes avoided. Five other states (Georgia, Ohio, Tennessee, Wisconsin, and Illinois) each had 100 or more crashes avoided.

3) The results of the implementation of the model by carrier safety status (i.e., the carrier's SafeStat category before receiving its CR in 2004) showed that the reduction in the average crash rate was directly related to carrier safety status. Carriers in Categories A and B (the carriers with the highest crash risk according to SafeStat), which are identified and prioritized first for CRs, had the largest reduction in their average crash rate.

4) The results of the implementation by planned course of action showed that the carriers for which enforcement actions were planned had a larger reduction in their average crash rate than did the carriers for which no enforcement actions were planned.

1. INTRODUCTION

1.1. BACKGROUND

During the 1980s, Congress passed several acts intended to strengthen motor carrier safety regulations. This led to the implementation of safety-oriented programs both at the federal and state levels. The Surface Transportation Assistance Act of 1982 established the Motor Carrier Safety Assistance Program, a grants-in-aid program to states to conduct roadside inspection and traffic enforcement programs aimed at commercial motor vehicles. The 1984 Motor Carrier Safety Act directed the U.S. Department of Transportation (U.S. DOT) to establish safety fitness standards for carriers. The U.S. DOT, in conjunction with the states, implemented the Motor Carrier Safety Assistance Program (MCSAP) to fund the roadside inspection and traffic enforcement programs and the safety fitness determination process and rating system (based on on-site safety audits called compliance reviews).

It is expected that a major benefit of these programs has been and will continue to be an improved level of safety in the operation of commercial motor vehicles. Previously, however, there was no means to measure the benefits and effectiveness of these programs. The Safety Program Effectiveness Measurement Project was established to identify major functions and operations (programs) associated with the FMCSA mission and to develop results-oriented performance measures for those functions and operations, as called for in the Government Performance and Results Act (GPRA) of 1993.

1.2. PROJECT OBJECTIVE

Program evaluation should be viewed as a continuous management process that encourages the organization to reflect periodically upon how it is implementing its programs. Program effectiveness should be reassessed in light of the mission, available resources, changing requirements, political climate, technological change, public demands, and costs. Periodic review of the results of the evaluations will ensure that the activities are working, i.e., that they are delivering what was promised. This report is intended to satisfy the desire of the FMCSA to verify the effectiveness of one of its motor carrier safety programs, the compliance review program. The immediate objective of this effort is to measure how much of an impact the safety program activities have on avoiding crashes involving motor carriers and reducing resulting injuries and fatalities.

One of the main objectives of the Safety Program Effectiveness Measurement Project is to provide a baseline of the effectiveness of the selected programs through the use of standard safety performance measures. This baseline allows the FMCSA to judge the relative performance of its programs on a periodic basis by reflecting the benefits resulting from each program. The results of these analyses are intended to provide a basis for FMCSA resource

allocation and budgeting decisions that will more closely optimize the effectiveness and efficiency of its motor carrier safety programs.

1.3. PROJECT SCOPE

The scope of this overall effort is limited to the major identifiable operational FMCSA programs and their effectiveness in reducing crashes and avoiding injuries and fatalities. Currently the Safety Program Effectiveness Measurement Project includes the compliance review, roadside inspection, and traffic enforcement activities and programs performed and supported by the FMCSA. Two models have been developed to estimate the benefits of these programs: the Compliance Review Effectiveness Model and the Intervention Model (for roadside inspections and traffic enforcements). The benefits of these programs are calculated in terms of crashes avoided, lives saved, and injuries avoided.

An objective of the project is to continue to improve these models and update the results on a recurring basis. The models will serve the program-specific requirement to measure program effectiveness as well as the broader function of supporting annual budget requirements and helping to determine the best resource allocation among program elements.

This report describes the methodology of the Compliance Review Effectiveness Model and presents the results of the implementation of the model for carriers receiving compliance reviews (CRs) in 2004, including estimates of crashes avoided by carrier size, state of domicile, carrier safety status, and planned course of action.

The CR Effectiveness Model has been used to estimate benefits only for carriers with CRs conducted in 2002, 2003, and 2004. The model succeeded the Compliance Review Impact Assessment Model, which was used to estimate the benefits for carriers with CRs in 1998, 1999, 2000, and 2001.[1] The results from the two models are not directly comparable, because the estimates produced by the CR Effectiveness Model will establish new benchmarks, which may differ from the level of the estimates produced by the CR Impact Assessment Model.

[1] Reports documenting these results are available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=23.

2. COMPLIANCE REVIEW EFFECTIVENESS MODEL

2.1. COMPLIANCE REVIEWS

The on-site compliance review (CR) is perhaps the single greatest resource-consuming activity of the FMCSA. Thousands of CRs are conducted each year. In the year 2004, federal and state enforcement personnel conducted over 10,000 CRs on individual motor carriers. In addition to actually conducting CRs, the FMCSA invests in: extensive analysis of the requirements of the Federal Motor Carrier Safety Regulations (FMCSR), enhancements to the design of the CR to better assess safety performance and compliance with the FMCSR, continued safety investigator training, enhancements to prioritization methodologies such as SafeStat[1] to determine who should receive CRs, and enhancements to information systems to report and store the results of the CRs that are conducted.

When performing CRs, FMCSA and state safety investigators spend many hours examining the safety records of individual motor carriers to assess their compliance and safety performance. The investigators also discuss their findings with the carriers' safety managers to improve understanding of their safety programs. After a review is completed, the carrier is assigned a safety rating (i.e., satisfactory, conditional, or unsatisfactory). If serious violations are discovered, an enforcement case is initiated and a fine may be imposed. The CR results are also incorporated, with other safety data (i.e., crashes, roadside inspection results, moving violations, and closed enforcement cases), into SafeStat to reassess the carrier's safety status. It is intended that through education, heightened safety regulation awareness, and the enforcement effects of the CR, carriers will improve the safety of their commercial vehicle operations, and, ultimately, reduce the number and severity of crashes in which they are involved.

2.2. METHODOLOGY OF THE MODEL

The CR Effectiveness Model was developed to determine the effectiveness of the CR program. The model measures the direct impact of compliance reviews on carriers that received CRs, but not "deterrent" effects (i.e., the "threat" of having a CR) on carriers that did not actually receive CRs. In addition, the model was developed to estimate only the benefits that occur in the 12 months following a CR. The model is based on the individual and cumulative "before and after" changes in the safety performance of carriers that received CRs. The model compares a motor carrier's crash rate in the 12 months following an on-site compliance review to its crash rate in

[1] SafeStat (Safety Status Measurement System) is an automated, data-driven analysis system that is designed to incorporate on-road safety performance information and enforcement history with on-site compliance review information in order to measure the relative safety fitness of interstate motor carriers. A thorough description of SafeStat methodology can be found in: John A. Volpe National Transportation Systems Center, Motor Carrier Safety Assessment Division, DTS-47, *SafeStat, Motor Carrier Safety Status Measurement System, Methodology: Version 8.6,* January 2004. This document is available at ai.fmcsa.dot.gov/CarrierResearchResults/PDFs/SafeStat_method.pdf.

the 12 months prior to that review. The model uses (1) crash data reported by the states and (2) power unit data obtained during CRs or from updated Form MCS-150 information submitted by carriers, to calculate both the before-CR and after-CR crash rates. The data are stored in the FMCSA's Motor Carrier Management Information System (MCMIS).

2.3. RESULTS OF IMPLEMENTATION OF MODEL FOR CARRIERS WITH COMPLIANCE REVIEWS IN 2004

A diagram of the CR Effectiveness Model, as implemented for carriers with CRs in 2004, is shown in Figure 2-1. The model estimates the number of crashes (and associated fatalities and injuries) avoided in the 12 months following the CRs. Thus, the benefits from the CRs conducted in 2004 occurred in both 2004 and 2005.

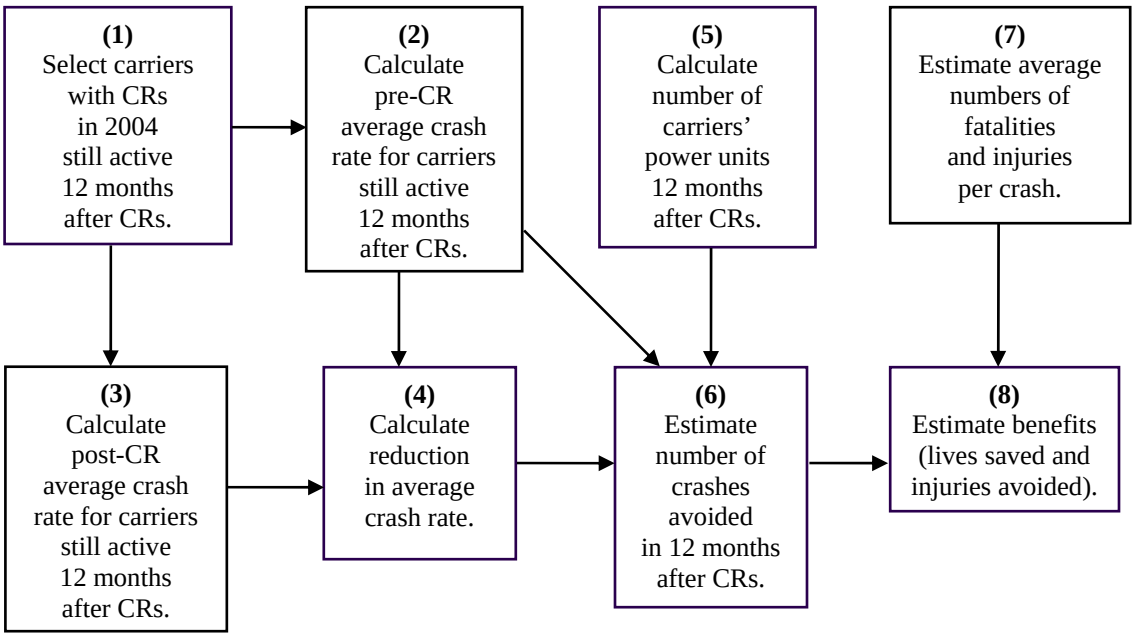

Figure 2-1. Compliance Review Effectiveness Model

A step-by-step description of the implementation procedure follows. The step numbers (shown in parentheses) correspond to the numbers in parentheses in the diagram.

(1) Select carriers with one or more compliance reviews (CRs) in 2004 that were still active 12 months after their CRs.

There were 8,042 carriers that received CRs in 2004, were still active 12 months after their CRs (i.e., throughout their post-CR periods), and met the following conditions:

- The carrier had to be either interstate or intrastate HM (hazardous materials).
- The carrier must have been active throughout the pre-CR period (i.e., the 12 months before the CR).
- The carrier must have had 1 or more power units throughout the pre-CR and post-CR periods (i.e., the 12 months before and after the CR).
- If the carrier had more than one CR in 2004, the latest one was used.
- The carrier's crash and power unit data had to pass edit checks designed to screen out erroneous data.

(2) Calculate the pre-CR average crash rate.

The 8,042 carriers that received CRs in 2004 and were still active 12 months after their CRs had a pre-CR average crash rate of 5.904 crashes per 100 power units. This average was obtained by dividing the total number of carriers' crashes in the 12 months before their 2004 CRs by their total number of power units and then multiplying by 100. In the rate calculation for each carrier, the power unit data were taken from the SafeStat run for the month following the carrier's CR. That way, the power unit data used in the rate calculation would reflect the power unit data collected during the CR.

(3) Calculate the post-CR average crash rate.

The 8,042 carriers that received CRs in 2004 and were still active 12 months after their CRs had a post-CR average crash rate of 4.871 crashes per 100 power units. This average was obtained by dividing the total number of carriers' crashes in the 12 months after their 2004 CRs by their total number of power units and then multiplying by 100. In the rate calculation for each carrier, the power unit data were taken from the SafeStat run one year after the run used to calculate the carrier's pre-CR crash rate.

For example, if a carrier had a CR on January 21, 2004, then power unit data from the February 2004 SafeStat run would have been used to calculate its pre-CR crash rate, and power unit data from the February 2005 SafeStat run would have been used to calculate its post-CR crash rate. The carrier's pre-CR period (i.e., the 12 months prior to the CR) would have been January 21, 2003 to January 20, 2004, while its post-CR period (i.e., the 12 months after the CR) would have been January 22, 2004 to January 21, 2005. This information is shown in the timeline in Figure 2-2.

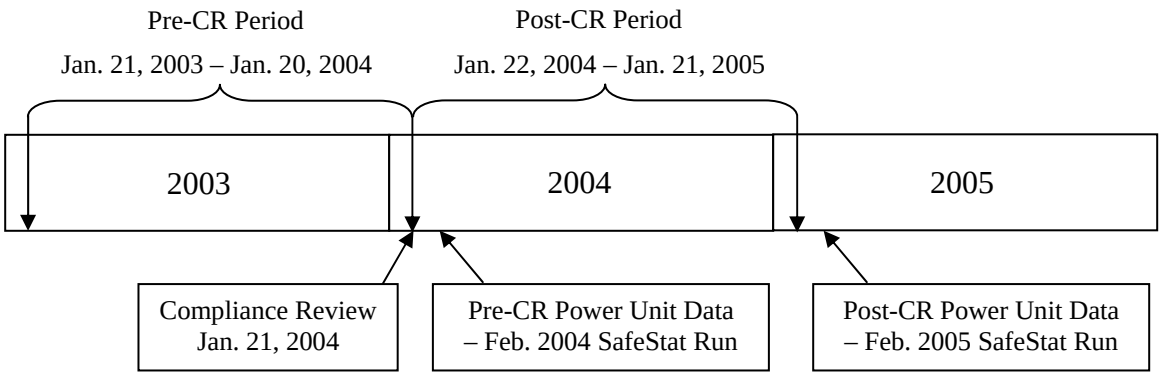

Figure 2-2. Timeline for a Carrier with a Compliance Review on January 21, 2004

(4) Calculate the reduction in the average crash rate.

(4a) Calculate the reduction using the data for the carriers with CRs in 2004.

The percentage change in the average crash rate of carriers with CRs in 2004 was calculated as follows:

$$\frac{\text{Post-CR Average Crash Rate} - \text{Pre-CR Average Crash Rate}}{\text{Pre-CR Average Crash Rate}} \text{ X } 100$$

$$= \frac{4.871 - 5.904}{5.904} \text{ X } 100$$

$$= -17.50\% \text{ (i.e., a decrease of 17.50 percent)}$$

(4b) Adjust the reduction for underlying factors in the general carrier population.

The change in the average crash rate of the carriers that received CRs (i.e., the CR Group) calculated in Step 4a above is not yet adjusted for underlying factors occurring in the general carrier population. For example, if the average crash rate of all carriers had decreased during the same period in which the CR Group's average crash rate decreased, then the reduction in the CR Group's average crash rate calculated in Step 4a would have been exaggerated. That is, not all of the reduction would have been the result of the CRs. Conversely, if the average crash rate of the general carrier population had increased during this period, then the reduction in the CR Group's average crash rate calculated in Step 4a would have been less than the actual crash rate reduction due to the CRs.

Another underlying factor that must be considered in the analysis of carriers that received CRs in 2004 is improved crash reporting. Over the past several years, the FMCSA has made a concerted effort to improve the timeliness and completeness of crash reporting by the states. As a result,

crashes are being reported earlier and more completely. This improved crash reporting will tend to increase the post-CR average crash rate and produce a smaller crash rate reduction in the CR Group's average crash rate than actually occurred.

To eliminate the effects of underlying factors, a control group of carriers was selected. This Control Group consisted of all carriers that did not receive CRs in 2004. Any change in the average crash rate of the Control Group must have been due to factors affecting the entire carrier population. Thus, the change in the average crash rate of the Control Group was calculated and then subtracted from the change in the average crash rate of the carriers that received CRs in 2004. The difference resulting from this calculation represents the change in the average crash rate of the carriers that received CRs in 2004 that was solely the result of the CRs.

To be eligible for the Control Group, a carrier had to meet the following conditions:

- The carrier had to be either interstate or intrastate HM.
- The carrier must have been active throughout the pre-CR period (i.e., January 2003 to December 2004) and the post-CR period (i.e., January 2004 to December 2005).
- The carrier must have had 1 or more power units throughout the pre-CR and post-CR periods (i.e., January 2003 to December 2005).
- The carrier's crash and power unit data had to pass various edit checks designed to screen out erroneous data.

There were 477,571 carriers that met these criteria.

The change in the average crash rate of the Control (i.e., non-CR) Group was calculated as follows:

$$\text{Percent Change in Average Crash Rate} = \frac{\text{Post-CR Average Crash Rate} - \text{Pre-CR Average Crash Rate}}{\text{Pre-CR Average Crash Rate}} \times 100$$

The pre-CR crash rate is the average crash rate for the entire pre-CR period, i.e., 2003-2004, while the post-CR crash rate is the average crash rate for the entire post-CR period, i.e., 2004-2005. The pre-CR and post-CR average crash rates were calculated as follows:[2]

$$\text{Pre-CR Average Crash Rate} = \frac{\text{Crashes in 2003} + \text{Crashes in 2004}}{\text{Power Units in 2003} + \text{Power Units in 2004}}$$

$$\text{Post-CR Average Crash Rate} = \frac{\text{Crashes in 2004} + \text{Crashes in 2005}}{\text{Power Units in 2004} + \text{Power Units in 2005}}$$

[2] The pre-CR average crash rate is actually the weighted average of the average crash rates for 2003 and 2004. The post-CR average crash rate is actually the weighted average of the average crash rates for 2004 and 2005. A detailed derivation of these formulas can be found in Appendix A.

The 477,571 carriers in the Control Group had a pre-CR average crash rate of 2.065 crashes per 100 power units and a post-CR average crash rate of 2.140 crashes per 100 power units.

The percentage change in the average crash rate of the Control Group was calculated as follows:

$$\frac{\text{Post-CR Average Crash Rate} - \text{Pre-CR Average Crash Rate}}{\text{Pre-CR Average Crash Rate}} \text{ X } 100$$

$$= \frac{2.140 - 2.065}{2.065} \text{ X } 100$$

= +3.63% (i.e., an increase of 3.63 percent)

This increase in the average crash rate of the Control Group (and therefore, the general carrier population) is the sum of the effects of (1) any change in the average crash rate of the general carrier population and (2) other underlying factors in the general carrier population (e.g., changes in crash reporting). To determine how much of the increase was due to each element, a separate set of calculations was performed. The calculations showed that there was a 6.22 percent decrease in the average crash rate of the general carrier population. Therefore, the 3.63 percent increase in the average crash rate of the Control Group (and therefore, the general carrier population) was the sum of a 6.22 percent decrease in the crash rate of the general carrier population and a 9.85 percent increase due to other underlying factors in the general carrier population (e.g., changes in crash reporting). These calculations are shown in Appendix B.

Therefore, the adjusted change in the average crash rate due to the CRs conducted in 2004 was:

Percentage Change in Average Crash Rate of Carriers with CRs in 2004

– Percentage Change in Average Crash Rate of Control Group

= (–17.50) – (3.63)

= –21.1% (i.e., a decrease of 21.1 percent)

(5) Calculate the number of post-CR power units, i.e., the number of power units 12 months after the CRs in 2004.

The 8,042 carriers that received CRs in 2004 and were still active 12 months after their CRs had a total of 218,332 power units 12 months after their CRs. This number was used to calculate the post-CR average crash rate in Step 3.

(6) Estimate the number of crashes avoided in 2004-2005 as a result of the CRs conducted in 2004.

The estimated number of crashes avoided in 2004-2005 by the 8,042 carriers that received CRs in 2004 and were still active 12 months after their CRs was calculated as follows:

Pre-CR Average Crash Rate X Crash Rate Reduction (%) X Post-CR Power Units

= 5.904 crashes per 100 power units X 21.1% X 218,332 power units

= 2,720 crashes

Next, estimates were made of the number of crashes avoided in 2004-2005 by the carriers receiving CRs in 2004 by severity, i.e., fatal, injury, and towaway.[3] State-reported crash data in the MCMIS were used to compute these proportions. Of the crashes involving large trucks or motorcoaches (i.e., cross-country or intercity buses) in 2004-2005, the period in which the benefits of the CRs conducted in 2004 would occur, 3.4 percent were fatal crashes, 43.6 percent were injury crashes, and 53.0 percent were towaway crashes.

Applying these proportions to the estimate of 2,720 crashes avoided produced the following results:

Fatal crashes	=	2,720	X	3.4%	=	92
Injury crashes	=	2,720	X	43.6%	=	1,186
Towaway crashes	=	2,720	X	53.0%	=	1,442

(7) Estimate the average numbers of fatalities and injuries per crash in 2004-2005.

The average number of fatalities per fatal crash was estimated from data from the Fatality Analysis Reporting System (FARS), which is maintained by the National Highway Traffic Safety Administration (NHTSA). The benefits of the CRs conducted in 2004 occurred in the period 2004-2005. For crashes in 2004-2005 involving large trucks or motorcoaches, the ratio was 1.16 fatalities per fatal crash.

The number of injuries per crash involves fatal as well as injury crashes, since fatal crashes can also result in injuries. State-reported crash data from the MCMIS Crash File were used to estimate the average numbers of injuries in fatal and injury crashes. For 2004-2005 large truck and motorcoach crashes, the averages were as follows:

- Fatal crashes: 1.07 injuries per crash
- Injury crashes: 1.51 injuries per crash

[3] A *fatal* crash results in at least one fatality. An *injury* crash results in no fatalities, but bodily injury to at least one person who, as a result of the injury, immediately receives medical treatment away from the scene of the crash. A *towaway* crash results in no fatalities or injuries requiring transport for immediate medical attention, but in one or more motor vehicles incurring disabling damage as a result of the crash, requiring the vehicle(s) to be transported away from the scene by a tow truck or other motor vehicle.

(8) Estimate the benefits (i.e., lives saved and injuries avoided) that occurred in 2004-2005.

The estimated number of lives saved in the crashes avoided in 2004-2005 by the carriers with CRs in 2004 was calculated as follows:

Number of fatal crashes avoided X Average number of fatalities per fatal crash

= 92 X 1.16

= 107 lives saved

The estimated number of injuries avoided in the crashes avoided in 2004-2005 by the carriers with CRs in 2004 was calculated as follows:

Number of fatal crashes avoided X Average number of injuries per fatal crash
+
Number of injury crashes avoided X Average number of injuries per injury crash

= (92 X 1.07) + (1,186 X 1.51)

= 1,889 injuries avoided

Table 2-1 summarizes the estimated benefits that occurred in 2004-2005 as a result of the CRs conducted in 2004 on the 8,042 carriers that were still active 12 months after their CRs and met the additional criteria listed in the table. The table also shows (1) the estimated benefits from the CRs conducted in 2002 that occurred in 2002-2003 and (2) the estimated benefits from the CRs conducted in 2003 that occurred in 2003-2004.

Table 2-1. Results of Implementation of Compliance Review Effectiveness Model for Carriers with Compliance Reviews in 2002, 2003, and 2004

Model Implementation for Motor Carriers with CRs in:	**2002**	**2003**	**2004**
Compliance reviews conducted	12,139	11,086	10,671
Motor carriers that received compliance reviews and: • were interstate or intrastate HM, • were active in the 12 months before and after their CRs, • had 1 or more power units in the 12 months before and after their CRs, and • had crash and power unit data that passed edit checks designed to screen out erroneous data.	9,172	8,587	8,042
Estimated percentage reduction in average crash rate due to compliance reviews	12.6	17.6	21.1
Model Results (i.e., Benefits) Estimated for:	**2002-2003**	**2003-2004**	**2004-2005**
Crashes avoided	1,426	2,276	2,720
Fatal crashes	53	77	92
Injury crashes	677	1,038	1,186
Towaway crashes	696	1,161	1,442
Lives saved	62	90	107
Injuries avoided	1,087	1,651	1,889

3. ADDITIONAL ANALYSIS

3.1. OVERVIEW

The results of the implementation of the model were broken out by carrier size (i.e., number of power units), by the state of domicile of the carrier, by carrier safety status (i.e., the carrier's SafeStat category before receiving its CR in 2004), and by the planned course of action (i.e., enforcement or no enforcement).

The results of these analyses revealed the types of carriers that will most likely respond positively to CRs. By focusing on carriers that are likely to respond positively to CRs, the effectiveness of the compliance review program may be improved. Alternative treatment approaches may be suggested for carriers that are at risk, but will most likely not respond positively to CRs.

The sums of the estimates of crashes avoided by power unit group, state of domicile, SafeStat category group, and planned course of action group did not equal the estimate of 2,720 crashes avoided that was obtained in Section 2.3. Therefore, the estimates were prorated to sum to this number. The estimated numbers of crashes avoided, the post-CR average crash rates, and the percent changes in the average crash rates shown in Tables 3-1, 3-2, 3-3, and 3-4 were all derived using this prorating procedure.

3.2. CARRIER SIZE

The results of the implementation of the model were broken out by carrier size as measured by the number of power units at the time of the CR, i.e., the number of pre-CR power units.

Table 3-1 shows the results of the implementation of the model for the four power unit groups:

- 1 to 5 power units,
- 6 to 20 power units,
- 21 to 100 power units, and
- 101 or more power units.

Table 3-1 shows, for each power unit group, the number of carriers in the group that received CRs in 2004, the pre-CR average crash rate, the adjusted post-CR average crash rate, and the adjusted percent change in the average crash rate after receiving the CRs. Table 3-1 also shows, for each power unit group, the estimated number of crashes avoided as a result of the CRs.

Table 3-1. Results of Implementation of Model by Carrier Size

Number of Pre-CR Power Units	Number of Carriers with CRs in 2004	Pre-CR Average Crash Rate*	Post-CR Average Crash Rate*	Percent Change in Average Crash Rate	Estimated Number of Crashes Avoided in 2004–2005
1 – 5	3,506	13.281	6.468	–51.3	781
6 – 20	2,833	8.219	5.352	–34.9	912
21–100	1,378	6.217	5.069	–18.5	672
≥101	325	4.521	4.216	–6.7	355
All Carriers	8,042	5.904	4.658	–21.1	2,720

* – Crashes per 100 power units

The smaller carriers, those with 20 or fewer power units, had the greatest reduction in the average crash rate as well as the largest number of estimated crashes avoided as a result of the program. For carriers with 1-5 power units, the post-CR average crash rate showed a decrease of 51.3 percent from the pre-CR average crash rate, resulting in 781 crashes avoided. For carriers with 6-20 power units, the crash rate decrease was 34.9 percent, resulting in 912 crashes avoided.

For carriers with 21-100 power units, the post-CR average crash rate showed a decrease of 18.5 percent, resulting in 672 crashes avoided. Carriers with 101 or more power units had a decrease of 6.7 percent in their average crash rate and a decrease of 355 crashes.

The results of this analysis are consistent with (1) the results of the analyses of data from the implementations of the model for carriers with CRs in 2002 and 2003,[1] and (2) the results of analyses of data from the implementations of the previous model, the Compliance Review Impact Assessment Model.[2]

3.3. STATE OF DOMICILE OF CARRIER

Table 3-2 shows the results of the implementation of the model broken out by the carrier's state of domicile. For a state's results to be published in the table, it had to have at least 50 carriers with CRs in 2004. Nine states,[3] the District of Columbia, and Puerto Rico did not meet this requirement. Their data were combined and are shown in the row labeled "Other States and Possessions." Since there were not enough Canadian or Mexican carriers receiving CRs in 2004 to summarize at the province/state level, these results were summarized at the national level.

Table 3-2 shows, for each state (or country), the number of carriers that received CRs in 2004, the pre-CR average crash rate, the adjusted post-CR average crash rate, and the adjusted percent change in the average crash rate after receiving the CRs. Table 3-2 also shows, for each state (or

[1] Reports documenting these results are available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=23.

[2] A report documenting these results is available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=23.

[3] Alaska, Connecticut, Delaware, Hawaii, Maine, New Hampshire, Oregon, Rhode Island, and Vermont

country), the estimated number of crashes avoided as a result of the CRs. (Note: A number in parentheses indicates an increase in the number of crashes.)

Table 3-2 shows that one state, Texas (315), had more than 300 crashes avoided in 2004-2005 due to CRs performed in 2004, while another state, Missouri (211) had more than 200 crashes avoided. Five other states (Georgia, Ohio, Tennessee, Wisconsin, and Illinois) each had 100 or more crashes avoided. Two states showed increases in the number of crashes in 2004-2005 for carriers that received CRs in 2004.

There are several factors that affect the state estimates of crashes avoided. The equation that is used to calculate the number of crashes avoided consists of three factors: the pre-CR average crash rate, the percentage reduction in the average crash rate due to the CRs, and the number of post-CR power units. The states with the largest numbers of crashes avoided are usually among the states with the highest numbers of post-CR power units, which is a function of the number of carriers receiving CRs. The more carriers in a state that receive reviews, the greater the number of post-CR power units that results, which increases the potential for a large number of crashes to be avoided. For example, Ohio had a reduction in its average crash rate of only 13.3 percent, but had 129 crashes avoided because it had 417 carriers with CRs in 2004. On the other hand, Idaho had a reduction in its average crash rate of 45.9 percent, but had only 41 crashes avoided because it had only 67 carriers with CRs in 2004.

Another factor that influenced the state results was the proportion of the carriers with zero crashes in the pre-CR period in each state that received CRs in 2004. Of the total of 8,042 carriers that received reviews in 2004, 4,241, or 52.7 percent, had pre-CR crash rates of zero. Thus, the crash rates of these carriers could either stay the same or increase, but not decrease. If a state had an especially high percentage of these carriers, it would make it difficult for that state's average crash rate to decrease significantly. For example, the state of North Dakota had an increase in its average crash rate of 5.1 percent. One reason for this increase is that 68.1 percent of the carriers in North Dakota that received CRs in 2004 had pre-CR crash rates of zero.

In addition, the relatively low number of carriers in each state that received CRs in 2004 makes the state results subject to the influence of a few large carriers, i.e., carriers with large numbers of power units. As shown in Table 3-1, there were 325 carriers with 101 or more power units that received CRs in 2004. While these carriers made up only 4.0 percent of the 8,042 carriers being analyzed, they accounted for 53.4 percent of the total post-CR power units. Thus, the data from a single large carrier could greatly affect an individual state's results.

Table 3-2. Results of Implementation of Model by State of Domicile of Carrier

State/Country of Domicile	Number of Carriers with CRs in 2004	Pre-CR Average Crash Rate*	Post-CR Average Crash Rate*	Percent Change in Average Crash Rate	Estimated Number of Crashes Avoided in 2004-2005
Alabama	218	7.765	6.513	–16.1	67
Arizona	167	5.039	3.607	–28.4	36
Arkansas	140	8.036	6.217	–22.6	68
California	271	6.382	4.706	–26.2	78
Colorado	174	5.814	3.384	–41.8	63
Florida	182	7.740	6.296	–18.7	40
Georgia	311	6.887	4.827	–29.9	141
Idaho	67	6.958	3.764	–45.9	41
Illinois	245	7.108	5.935	–16.5	100
Indiana	260	5.928	5.212	–12.1	86
Iowa	88	6.485	4.619	–28.8	27
Kansas	373	5.524	4.082	–26.1	55
Kentucky	159	6.693	5.045	–24.6	61
Louisiana	128	7.410	4.353	–41.2	57
Maryland	90	2.967	2.533	–14.6	26
Massachusetts	70	5.157	4.756	–7.8	7
Michigan	165	6.628	4.947	–25.4	82
Minnesota	261	4.913	4.105	–16.4	86
Mississippi	161	9.980	6.620	–33.7	74
Missouri	319	7.271	5.596	–23.0	211
Montana	52	6.102	5.777	–5.3	5
North Carolina	289	9.146	7.051	–22.9	75
North Dakota	91	3.676	3.862	+5.1	(4)
Nebraska	120	5.877	4.911	–16.4	30
Nevada	52	5.410	5.723	+5.8	(2)
New Jersey	196	5.191	4.159	–19.9	60
New Mexico	73	3.981	2.500	–37.2	28
New York	139	6.973	4.672	–33.0	47
Ohio	417	4.211	3.649	–13.3	129
Oklahoma	156	5.499	5.193	–5.6	12
Pennsylvania	86	7.773	5.959	–23.3	29
South Carolina	155	7.917	6.047	–23.6	43
South Dakota	57	5.817	3.862	–33.6	17
Tennessee	214	7.952	6.418	–19.3	111
Texas	653	5.214	4.144	–20.5	315
Utah	161	6.584	5.351	–18.7	91
Virginia	56	7.087	5.578	–21.3	18
Washington	265	4.066	2.654	–34.7	67
West Virginia	103	6.340	4.800	–24.3	26
Wisconsin	249	7.031	5.370	–23.6	108
Wyoming	84	2.657	1.947	–26.7	6
Other States & Possessions†	253	5.526	4.111	–25.6	66
Canada	117	6.025	4.150	–31.1	37
Mexico	155	0.348	0.392	+12.5	0
Total	8,042	5.904	4.658	–21.1	2,720

* – Crashes per 100 power units

† – Alaska, Connecticut, District of Columbia, Delaware, Hawaii, Maine, New Hampshire, Oregon, Puerto Rico, Rhode Island, and Vermont

3.4. CARRIER SAFETY STATUS

One of the primary methods of prioritizing carriers for CRs is to use SafeStat results. Carriers are assessed in four Safety Evaluation Areas (SEAs): Accident, Driver, Vehicle, and Safety Management. Carriers are placed in SafeStat categories if they are found to be deficient in one or more SEAs. Carriers with the most extensive deficiencies are placed in Categories A and B and are assigned the highest priority for CRs, followed by carriers in Category C, carriers in Categories D-G, and finally, carriers not in any category (i.e., carriers not deficient in any SEAs).

The purpose of the analysis in this section is to determine the impact of carrier safety status prior to CRs on crash rate reduction after the CRs. In other words, determine if carriers with the highest priority for CRs show the greatest improvement, i.e., the largest crash rate reduction, following their CRs.

The results of the CR Effectiveness Model were broken out by SafeStat category group based on each carrier's SafeStat category prior to receiving its 2004 CR. Table 3-3 shows, for each SafeStat category group, the number of carriers in the group that received CRs in 2004, the pre-CR average crash rate, the adjusted post-CR average crash rate, and the adjusted percent change in the average crash rate after receiving the CRs. Table 3-3 also shows, for each SafeStat category group, the estimated number of crashes avoided as a result of the CRs.

Table 3-3. Results of Implementation of Model by Carrier Safety Status

SafeStat Category Group	Number of Carriers with CRs in 2004	Pre-CR Average Crash Rate*	Post-CR Average Crash Rate*	Percent Change in Average Crash Rate	Estimated Number of Crashes Avoided in 2004–2005
A–B	3,348	9.041	6.114	–32.4	1,879
C	998	4.237	3.876	–8.5	67
D–G	1,965	6.169	5.323	–13.7	494
None	1,731	3.561	3.198	–10.2	280
All Carriers	8,042	5.904	4.658	–21.1	2,720

* – Crashes per 100 power units

Carriers in Categories A and B, the carriers with the highest priority for CRs, had the highest pre-CR average crash rate as well as the greatest percent reduction in their average crash rate. Their post-CR average crash rate showed a decrease of 32.4 percent. The carriers in this group accounted for 1,879 crashes avoided in 2004-2005, which is over two-thirds (69.1%) of the total of 2,720 crashes avoided.

Carriers in Category C showed a decrease of 8.5 percent in their average crash rate. The pre-CR average crash rate for this group was much lower than for the carriers in Categories A and B, probably because none of the carriers in Category C were deficient in the Accident SEA.

Carriers in Categories D-G showed a decrease of 13.7 percent in their average crash rate. Carriers not in any SafeStat category showed a decrease of 10.2 percent in their average crash rate.

3.5. PLANNED COURSE OF ACTION

The results of the implementation of the model were also broken out by the course of action planned by the FMCSA for the carrier following its 2004 CR. A carrier with prosecution or an out-of-service order indicated as the planned course of action was classified as an "enforcement" carrier. A carrier with only compliance monitoring indicated as the planned course of action was classified as a "non-enforcement" carrier.

It should be noted that these courses of action are the ones that were anticipated by the FMCSA at the conclusions of the CRs that the carriers received in 2004, and may be different from the actions that were actually taken. The data in the MCMIS Compliance Review File do not indicate the actual actions taken after the CRs.

Table 3-4 shows, for each action type group, the number of carriers in the group that received CRs in 2004, the pre-CR average crash rate, the adjusted post-CR average crash rate, and the adjusted percent change in the average crash rate after receiving the CRs. Table 3-4 also shows, for each action type group, the estimated number of crashes avoided as a result of the CRs.

Table 3-4. Results of Implementation of Model by Type of Planned Course of Action

Type of Planned Course of Action	Number of Carriers with CRs in 2004	Pre-CR Average Crash Rate*	Post-CR Average Crash Rate*	Percent Change in Average Crash Rate	Estimated Number of Crashes Avoided in 2004–2005
Enforcement	2,252	6.452	4.822	–25.3	881
Non-Enforcement	5,790	5.726	4.607	–19.5	1,839
Total	8,042	5.904	4.658	–21.1	2,720

* – Crashes per 100 power units

Table 3-4 shows that it was anticipated that 2,252 (or 28.0 percent) of the 8,042 carriers that received CRs in 2004 would undergo enforcement actions. The "enforcement" carriers showed a crash rate reduction of 25.3 percent, compared to a 19.5 percent reduction for the "non-enforcement" carriers. The "enforcement" carriers accounted for 881, or 32.4 percent, of the crashes avoided in 2004-2005.

It should be noted that unlike all the other estimates in this report, these estimates were calculated without the use of the Control Group, since this variable applies only to carriers that received CRs. As explained in Section 3.1, the estimated numbers of crashes avoided in Table 3-4 were calculated in the same manner as the estimated numbers of crashes avoided in Tables 3-1, 3-2, and 3-3. The numbers in each table were prorated to sum to the estimate of 2,720 crashes avoided. The only difference is that the estimates in Table 3-4 were not calculated using the Control Group.

APPENDIX A
CALCULATION OF PRE-CR AND POST-CR
AVERAGE CRASH RATES FOR CONTROL GROUP

The pre-CR and post-CR average crash rates for the Control (i.e., non-CR) Group are actually the weighted averages of the average crash rates of the individual years, as shown by the following derivation.

The weighted average of the crash rates of two individual years is calculated by the equation:

Weighted Average Crash Rate

$$= \frac{\sum_{n=1}^{2} W_n R_n}{\sum_{n=1}^{2} W_n}$$

where R_n = the average crash rate for year n, and
W_n = the weight for year n.

R_n, the average crash rate for year n, is defined as:

$$= \frac{C_n}{P_n}$$

where C_n = the number of crashes in year n, and
P_n = the number of power units in year n.

In this case, W_n, the weight for year n, is defined as Pn, the number of power units in year n.

Therefore, the weighted average of the crash rates for years 1 and 2

$$= \frac{\sum_{n=1}^{2} P_n (\frac{C_n}{P_n})}{\sum_{n=1}^{2} P_n}$$

$$= \frac{\sum_{n=1}^{2} C_n}{\sum_{n=1}^{2} P_n}$$

Therefore, the weighted average of the average crash rates for the Control Group for 2003 and 2004

$$= \frac{\text{Crashes in 2003 + Crashes in 2004}}{\text{Power Units in 2003 + Power Units in 2004}}$$

= Pre-CR Average Crash Rate for the Control Group

Also, the weighted average of the average crash rates for the Control Group for 2004 and 2005

$$= \frac{\text{Crashes in 2004 + Crashes in 2005}}{\text{Power Units in 2004 + Power Units in 2005}}$$

= Post-CR Average Crash Rate for the Control Group

APPENDIX B
ALLOCATION OF CHANGE IN AVERAGE CRASH RATE OF CONTROL GROUP TO CHANGE IN CRASH RATE AND OTHER UNDERLYING FACTORS

The 477,571 carriers in the Control Group had a pre-CR average crash rate of 2.065 crashes per 100 power units and a post-CR average crash rate of 2.140 crashes per 100 power units.

The percentage change in the average crash rate of the Control Group was calculated as follows:

$$\frac{\text{Post-CR Average Crash Rate} - \text{Pre-CR Average Crash Rate}}{\text{Pre-CR Average Crash Rate}} \text{ X } 100$$

$$= \frac{2.140 - 2.065}{2.065} \text{ X } 100$$

= +3.63% (i.e., an increase of 3.63 percent)

This increase in the average crash rate of the Control Group, and therefore, the general carrier population, is the sum of the effects of (1) any change in the average crash rate of the general carrier population and (2) other underlying factors in the general carrier population (e.g., changes in crash reporting). To determine how much of the increase was due to each element, the change in the average crash rate of the general carrier population was calculated.

To verify if the crash rate actually increased during the period in which the benefits from the CRs conducted in 2004 would have occurred (i.e., 2004-2005), data independent of the state-reported crash data used in the CR Effectiveness Model were used to calculate the large truck crash rates for the periods 2003-2004 and 2004-2005. The percentage change in the two crash rates was then calculated.

These crash rates were calculated using large truck crash data from the Fatality Analysis Reporting System (FARS) and the General Estimates System (GES), which are maintained by the National Highway Traffic Safety Administration (NHTSA). Counts of fatal crashes were obtained from the FARS, which contains data on a census of fatal crashes. Counts of injury crashes and property-damage-only crashes were obtained from the GES, which produces crash estimates from a national probability sample of all police-reported crashes. Crashes are included in the sample whether or not they are reported by the states to the FMCSA.

The NHTSA crash classification system differs from the National Governors' Association (NGA) standard used by the states to report crashes to the FMCSA. In both systems, a fatal crash is defined as a crash resulting in at least one fatality, although the NHTSA rule specifically requires that at least one death occur within 30 days of the crash. For non-fatal crashes, the differences are much greater.

The NGA categories of non-fatal crashes are *injury* and *towaway*:

- An *injury* crash is a crash that results in no fatalities, but bodily injury to at least one person who, as a result of the injury, immediately receives medical treatment away from the scene of the crash.
- A *towaway* crash is a crash that results in no fatalities or injuries requiring transport for immediate medical attention, but in one or more motor vehicles incurring disabling damage as a result of the crash, requiring the vehicle(s) to be transported away from the scene by a tow truck or other motor vehicle.

The NHTSA categories of non-fatal crashes are *injury* and *property-damage-only*:

- An *injury* crash is a crash that results in no fatalities, but in which one person was reported to have: (1) an incapacitating injury, (2) a visible but not incapacitating injury, (3) a possible, but not visible injury, or (4) an injury of unknown severity.
- A *property-damage-only* crash is a crash that results in no fatalities or injuries, but in property damage.

The NHTSA non-fatal crash categories include many more crashes of lower severity than do the NGA non-fatal crash categories. Since it is the change in crash rates that is being measured, rather than the crash rates themselves, using the FARS and GES data should provide a reasonable indication of the change in the NGA crash rate calculated using the FMCSA's MCMIS data.

Power unit data were obtained from the Federal Highway Administration (FHWA). The FHWA collects truck registration data from the 50 states and the District of Columbia. The data obtained were the numbers of large trucks registered in the U.S. in 2003, 2004, and 2005.

The change in the average crash rate of the general carrier population, as measured by the FARS and GES data, is calculated as follows:

$$\text{Percent Change in Average Crash Rate} = \frac{\text{Post-CR Average Crash Rate} - \text{Pre-CR Average Crash Rate}}{\text{Pre-CR Average Crash Rate}} \times 100$$

The pre-CR crash rate is the average crash rate for the entire pre-CR period, i.e., 2003-2004, while the post-CR crash rate is the average crash rate for the entire post-CR period, i.e., 2004-2005. The pre-CR and post-CR average crash rates are calculated as follows:

$$\text{Pre-CR Average Crash Rate} = \frac{\text{Crashes in 2003} + \text{Crashes in 2004}}{\text{Large Trucks Reg. in 2003} + \text{Large Trucks Reg. in 2004}} \times 100$$

$$\text{Post-CR Average Crash Rate} = \frac{\text{Crashes in 2004} + \text{Crashes in 2005}}{\text{Large Trucks Reg. in 2004} + \text{Large Trucks Reg. in 2005}} \times 100$$

The general carrier population had a pre-CR average crash rate of 5.244 crashes per 100 power units and a post-CR average crash rate of 4.937 crashes per 100 power units.

The percentage change in the average crash rate of the general carrier population was calculated as follows:

$$= \frac{\text{Post-CR Average Crash Rate} - \text{Pre-CR Average Crash Rate}}{\text{Pre-CR Average Crash Rate}} \text{ X } 100$$

$$= \frac{4.937 - 5.244}{5.244} \text{ X } 100$$

= –6.22% (i.e., a decrease of 6.22 percent)

Thus, the combined data from the NHTSA and FHWA suggest that the actual change in the crash rate for large trucks from 2003-2004 to 2004-2005 was a decrease of 6.22 percent. This result suggests that the apparent increase in the crash rate obtained for the Control Group in this analysis resulted from increases in the completeness of crash reporting in various states, rather than an actual change in motor carrier behavior.

Therefore, the increase in the crash rate of the Control Group caused by changes in other underlying factors (e.g., changes in crash reporting) in the general carrier population was:

= Percentage Change in Average Crash Rate of Control Group (from state-reported data)

– Percentage Change in Average Crash Rate of General Carrier Population (from FARS and GES data)

= 3.63% – (–6.22%)

= 9.85%

Therefore, the 3.63 percent increase in the average crash rate of the control group, and therefore, the general carrier population, was the sum of a 6.22 percent decrease in the crash rate of the general carrier population and a 9.85 percent increase due to other underlying factors in the general carrier population (e.g., changes in crash reporting).