# FMCSA Safety Program Effectiveness Measurement: Compliance Review Effectiveness Model Results for Carriers With Compliance Reviews in Fiscal Year 2009

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

April 2014

# FOREWORD

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 CR program. This work is part of an effort to assess the effectiveness of 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 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.

# NOTICE

# Technical Report Documentation Page

| 1. Report No.<br>**FMCSA-RRA-13-047** | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| 4. Title and Subtitle<br>**FMCSA Safety Program Effectiveness Measurement: Compliance Review Effectiveness Model Results for Carriers With Compliance Reviews in Fiscal Year 2009** | | 5. Report Date<br>**April 2014**<br>6. Performing Organization Code |
| 7. Author(s)<br>**Ohman, Jon M.** | | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>**John A. Volpe National Transportation Systems Center**<br>**Center for Safety Management Systems**<br>**Safety Measurement and Analysis Division, RVT-33**<br>**Kendall Square**<br>**Cambridge, MA 02142** | | 10. Work Unit No. (TRAIS)<br>11. Contract or Grant No. |
| 12. Sponsoring Agency Name and Address<br>**U.S. Department of Transportation**<br>**Federal Motor Carrier Safety Administration**<br>**Office of Analysis, Research, and Technology**<br>**1200 New Jersey Ave., SE**<br>**Washington, DC 20590** | | 13. Type of Report<br>**Final Report**<br>14. Sponsoring Agency Code<br>**FMCSA** |
| 15. Supplementary Notes<br>**Contracting Officer's Representative: Richard Gruberg** | | |

16. Abstract

**In FY 2009, Federal and State enforcement personnel conducted more than 15,000 compliance reviews (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 measures the direct impact of CRs on carriers that received 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 onsite CR to its crash rate in the 12 months prior to that review. The model uses crash data reported by the States and power unit data reported by carriers or obtained during CRs to calculate both the before-CR and after-CR crash rates. This report documents the benefits derived from performing CRs on motor carriers in terms of crashes avoided, as well as lives saved and injuries prevented.**

| 17. Key Words | 18. Distribution Statement | | |
|---|---|---|---|
| **Commercial motor vehicle, compliance review, CR, crash avoidance, CREM, effectiveness, safety programs** | **No restrictions** | | |
| 19. Security Classif. (of this report)<br>**Unclassified** | 20. Security Classif. (of this page)<br>**Unclassified** | 21. No. of Pages<br>**30** | 22. Price |

# SI* (MODERN METRIC) CONVERSION FACTORS

## TABLE OF APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.836 | square meters | $m^2$ |
| ac | Acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | 1,000 L shall be shown in $m^3$ | |
| fl oz | fluid ounces | 29.57 | milliliters | ml |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2,000 lb) | 0.907 | megagrams (or “metric ton”) | mg (or “t”) |
| | | **TEMPERATURE** | Temperature is in exact degrees | |
| °F | Fahrenheit | 5 × (F-32) ÷ 9<br>or (F-32) ÷ 1.8 | Celsius | °C |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-lamberts | 3.426 | candela/$m^2$ | $cd/m^2$ |
| | | **Force and Pressure or Stress** | | |
| lbf | poundforce | 4.45 | newtons | N |
| $lbf/in^2$ | poundforce per square inch | 6.89 | kilopascals | kPa |

## TABLE OF APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| ml | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| mg (or “t”) | megagrams (or “metric ton”) | 1.103 | short tons (2,000 lb) | T |
| | | **TEMPERATURE** | Temperature is in exact degrees | |
| °C | Celsius | 1.8C + 32 | Fahrenheit | °F |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| $cd/m^2$ | candela/$m^2$ | 0.2919 | foot-Lamberts | fl |
| | | **Force & Pressure Or Stress** | | |
| N | newtons | 0.225 | poundforce | lbf |
| kPa | kilopascals | 0.145 | poundforce per square inch | $lbf/in^2$ |

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003, Section 508-accessible version September 2009.)

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# ABBREVIATIONS AND ACRONYMS

| Acronym | Definition |
|---|---|
| CR | compliance review |
| CY | calendar year |
| FARS | Fatality Analysis Reporting System |
| FMCSA | Federal Motor Carrier Safety Administration |
| FMCSR | Federal Motor Carrier Safety Regulations |
| FHWA | Federal Highway Administration |
| FY | fiscal year |
| GES | General Estimates System |
| GPRA | Government Performance and Results Act of 1993 |
| MCMIS | Motor Carrier Management Information System |
| MCSAP | Motor Carrier Safety Assistance Program |
| NGA | National Governors' Association |
| NHTSA | National Highway Traffic Safety Administration |
| USDOT | U.S. Department of Transportation |

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# EXECUTIVE SUMMARY

## BACKGROUND

This report documents the methodology and results from a model that measures the effectiveness of the compliance review (CR) program, one of the key safety programs of the Federal Motor Carrier Safety Administration (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 CR Effectiveness Model and presents the results of the implementation of the model for carriers receiving CRs in fiscal year (FY) 2009. The benefits of the CR program are calculated in terms of crashes avoided, lives saved, and injuries avoided.

## METHODOLOGY OF MODEL

The onsite CR is perhaps the single greatest resource-consuming activity of FMCSA. Thousands of CRs are conducted each year. In FY 2009, Federal and State enforcement personnel conducted more than 15,000 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 CRs on carriers that received CRs, but not the "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 onsite CR to its crash rate in the 12 months prior to that review. The model uses crash data reported by the States and 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 changes in the average crash rate of the general carrier population, changes in crash reporting, and possibly other unknown factors, a control group of carriers that did not receive CRs was used. Any change in the average crash rate of the control group must be due to factors other than the effects of the CRs. 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, (i.e., the CR group). 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 could be attributed to the CRs.

The first three implementations of the model were on a calendar year (CY) basis. That is, the model was used to estimate benefits for carriers with CRs conducted in CY 2002, 2003, and

2004. Beginning with the report on carriers with CRs in FY 2005, the model has been implemented on a FY basis to align the activities of the CR program with the program's funding cycle. It is now possible to link the results of the CRs conducted during a given FY with the funding for the CR program for that FY.

The CR Effectiveness Model succeeded the CR Impact Analysis Model, which was used to estimate the benefits for carriers with CRs from CY 1998 to 2001.[1] The results from the two models are not directly comparable because the models use different methodologies and different data sources.

## IMPLEMENTATION OF MODEL FOR CARRIERS WITH CRs IN FY 2009

The CR Effectiveness Model was implemented for carriers with CRs in FY 2009 to estimate the number of crashes (and associated fatalities and injuries) avoided in the first year following their reviews (i.e., FY 2009–10).

Table 1 and Table 2 show these benefits, as well as the benefits that were estimated to have occurred in:

- FY 2005–06 for carriers with CRs in FY 2005.
- FY 2006–07 for carriers with CRs in FY 2006.
- FY 2007–08 for carriers with CRs in FY 2007
- FY 2008–09 for carriers with CRs in FY 2008.

The estimates from the model implementation for carriers with CRs in FY 2007, FY 2008, and FY 2009 were made using a control group adjustment that takes into account carrier size, a change from previous models. To allow for comparisons, the model was rerun for carriers with CRs in CY 2002–04 and FY 2005–06 using this modified control group procedure. Estimates of crashes avoided produced with this new control group adjustment were within 4 percent of the earlier estimates produced by the original control group adjustment. Since the two sets of estimates are of the same magnitude and follow the same trends, they are comparable. For this reason, previous final estimates from the model for CYs 2002–04 and FYs 2005–06 have not been changed.

[1] Reports documenting these results are available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=24.

**Table 1. Implementation of CR Effectiveness Model for Carriers With CRs FY 2005–09**

| Model Implementation for Motor Carriers With CRs in: | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 |
|---|---|---|---|---|---|
| CRs conducted | 11,431 | 14,426 | 15,530 | 14,906 | 15,807 |
| Motor carriers that received CRs and:<br>Were interstate carriers or intrastate hazardous materials carriers.<br>Were active in the 12 months before and after their CRs.<br>Had one or more power units in the 12 months before and after their CRs.<br>Had crash and power unit data that passed edit checks designed to screen out erroneous data. | 8,941 | 10,732 | 11,353 | 11,032 | 11,893 |
| Estimated percentage reduction in average crash rate due to CRs | 16.3 | 18.6 | 14.7 | 19.9 | 21.4 |

**Table 2. Estimated Results of Implementation of CR Effectiveness Model for Carriers With CRs FY 2005–09**

| Model Results (i.e., Benefits) Estimated for: | FY 2005–06 | FY 2006–07 | FY 2007–08 | FY 2008–09 | FY 2009–10 |
|---|---|---|---|---|---|
| Crashes Avoided | 2,306 | 2,860 | 2,175 | 2,886 | 2,430 |
| Fatal Crashes | 79 | 93 | 68 | 87 | 70 |
| Injury Crashes | 982 | 1,185 | 879 | 1,157 | 970 |
| Towaway Crashes | 1,245 | 1,582 | 1,228 | 1,642 | 1,390 |
| Lives Saved | 92 | 109 | 79 | 101 | 81 |
| Injuries Avoided | 1,561 | 1,866 | 1,399 | 1,853 | 1,544 |

## ADDITIONAL ANALYSIS

To further assess the effectiveness of the CR program, the results of the implementation of the model were broken down by carrier size (i.e., number of power units) and by the planned course of action (i.e., enforcement or no enforcement) for the carrier following its CR.

- A breakdown of the results of the model by carrier size showed that carriers with 1 to 5 power units had the largest reduction in their average crash rates in the 12 months following their CRs.
- The results of the model broken down by planned course of action showed that the carriers slated for an enforcement action as a result of the CR had a reduction in their average crash rate similar to those for which no enforcement actions were planned.

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# 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 at both the Federal and State levels. The Surface Transportation Assistance Act of 1982 established the Motor Carrier Safety Assistance Program (MCSAP), 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 (USDOT) to establish safety fitness standards for carriers. The USDOT, in conjunction with the States, implemented the MCSAP to fund the roadside inspection and traffic enforcement programs and the safety fitness determination process and rating system (based on onsite safety audits called compliance reviews [CRs]).

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 Federal Motor Carrier Safety Administration (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 evaluation results will ensure that agency activities are working (i.e., that they are delivering what was promised). This report is intended to assess the effectiveness of one of FMCSA's motor carrier safety programs, the CR program. The immediate objective of this effort is to measure the relative impact that the safety program activities have on preventing 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 comparing 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 assesses the CR, roadside inspection, and traffic enforcement activities performed and supported by the FMCSA. Two models have been developed to estimate the benefits of these programs: the CR 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 CR Effectiveness Model and presents the results of the implementation of the model for carriers receiving CRs in fiscal year (FY) 2009, including estimates of crashes avoided by carrier size and planned course of action.

The first three implementations of the model were on a calendar year (CY) basis. That is, the model was used to estimate annual benefits for CY 2002, 2003, and 2004, as a result of conducting CRs on motor carriers. Subsequent to CY 2004, the model has been implemented on a FY basis to align the activities of the CR program with the program's funding cycle. It is now possible to link the results of the CRs conducted during a given FY with the funding for the CR program for that FY.

The CR Effectiveness Model succeeded the CR Impact Assessment Model, which was used to estimate the benefits for carriers with CRs in CY 1998, 1999, 2000, and 2001.[1] The results from the two models are not directly comparable because the models use different methodologies and different data sources.

[1] Reports documenting these results are available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=24.

# 2. COMPLIANCE REVIEW EFFECTIVENESS MODEL

## 2.1 THE COMPLIANCE REVIEW PROCESS

The onsite CR is perhaps FMCSA's single greatest resource-consuming activity. Thousands of CRs are conducted each year. In FY 2009, Federal and State enforcement personnel conducted more than 15,000 CRs on individual motor carriers.

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 fines and sanctions may be imposed. 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 CRs on carriers that received CRs, but not the "deterrent" effects (i.e., the "threat" of having a CR) on carriers that did not actually receive CRs. In addition, the model was designed 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 have received CRs. The model compares a motor carrier's crash rate in the 12 months following an onsite CR to its crash rate in the 12 months prior to that review. The model uses crash data reported by the States and 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 THE MODEL FOR CARRIERS WITH COMPLIANCE REVIEWS IN FY 2009

A diagram of the CR Effectiveness Model, as implemented for carriers with CRs in FY 2009, is shown in Figure 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 FY 2009 occurred in both FY 2009 and FY 2010.

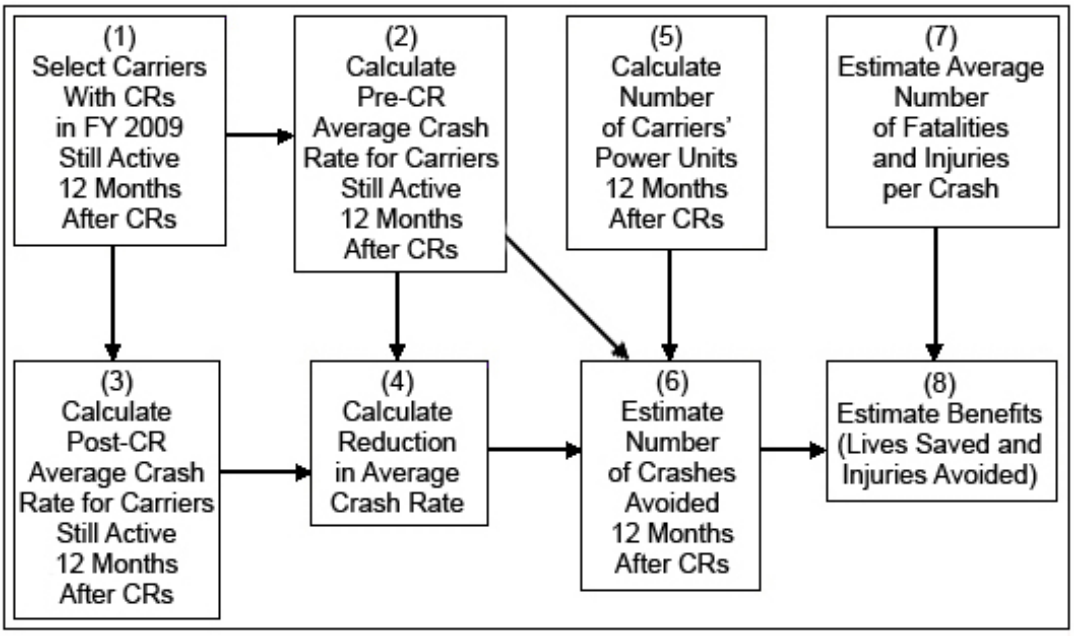


**Figure 1. Flowchart. CR Effectiveness Model**

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 CRs in FY 2009 that were still active 12 months after their CRs.**

There were 11,893 carriers that received CRs in FY 2009, were still active 12 months after their CRs (i.e., throughout their post-CR periods), and met the following conditions:

- The carrier was either an interstate carrier or an intrastate hazardous materials carrier.
- The carrier was active (i.e., engaged in motor carrier operations) throughout the pre-CR period (i.e., the 12 months before the CR).
- The carrier had one 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 FY 2009, the latest one was used.
- The carrier's crash and power unit data had to pass edit checks designed to screen out erroneous data.[1]

[1] If the ratio of pre-CR to post-CR power units or the ratio of post-CR to pre-CR power units was greater than 100, then the carrier was excluded from the analysis. If either ratio was greater than 5, then the carrier's power unit and crash data were reviewed manually to determine their validity.

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

The 11,893 carriers that received CRs in FY 2009 and were still active 12 months after their CRs had a pre-CR average crash rate of 4.924 crashes per 100 power units. This average was obtained by dividing their total number of crashes in the 12 months before their FY 2009 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 snapshot of MCMIS data corresponding to the month following the carrier's CR. As a result, the power unit data used in the rate calculation would reflect the updated power unit information collected during the recent CR (and uploaded into MCMIS).

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

The 11,893 carriers that received CRs in FY 2009 and were still active 12 months after their CRs had a post-CR average crash rate of 3.623 crashes per 100 power units. This average was obtained by dividing the total number of carriers' crashes in the 12 months after their FY 2009 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 snapshot of MCMIS data 1 year after the snapshot used to supply the carrier's pre-CR power unit data.

For example, if a carrier had a CR on August 15, 2009, then power unit data from the September 2009 MCMIS data snapshot would have been used to calculate its pre-CR average crash rate, and power unit data from the September 2010 MCMIS data snapshot would have been used to calculate its post-CR average crash rate. The carrier's pre-CR period (i.e., the 12 months prior to the CR) would have been August 15, 2008, to August 14, 2009, while its post-CR period (i.e., the 12 months after the CR) would have been August 16, 2009, to August 15, 2010. This information is shown in the timeline in Figure 2.

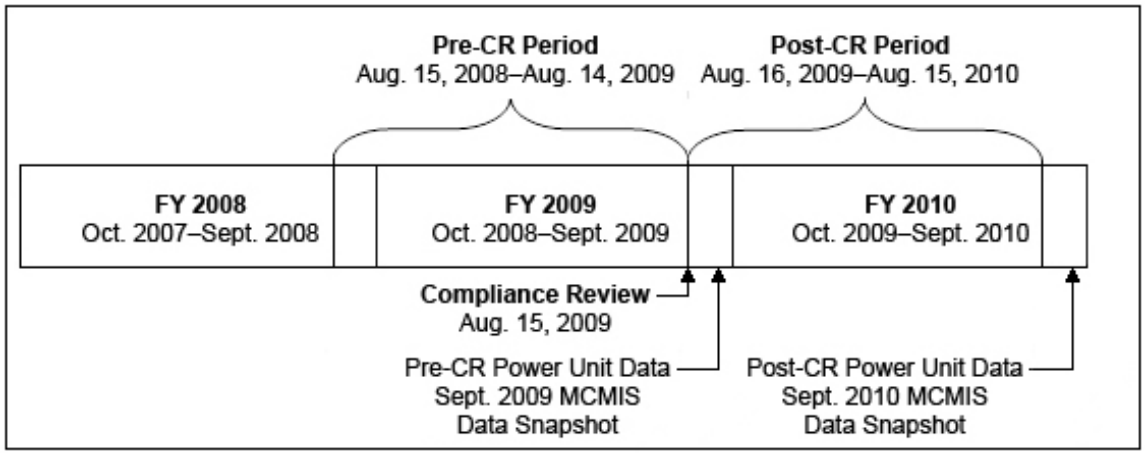


**Figure 2. Flowchart. Timeline for a Carrier With a CR on August 15, 2009**

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

**(4a) Calculate the reduction using the data for the carriers with CRs in FY 2009**.

The percentage change in the average crash rate of carriers with CRs in FY 2009 was calculated as show in Figure 3:

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

$$= \frac{3.623 - 4.924}{4.924} \times 100 = -26.42\%$$

**Figure 3. Formula. Calculate the Average Crash Rate Reduction**

**(4b) Adjust the reduction for changes in the average crash rate of 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 changes in the average crash rate of 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 factor that must be considered in the analysis of carriers that received CRs in FY 2009 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. Improved crash reporting could conceivably 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 these factors, a control group of carriers was used. Any change in the average crash rate of the control group must have been due to factors other than the effects of the CRs. 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 FY 2009. The difference resulting from this calculation represents the change in the average crash rate of the carriers that received CRs in FY 2009 that could be attributed to the CRs.

To create this control group, the population of carriers that did not receive CRs or non-ratable reviews in FY 2009 (i.e., non-CR carriers) was used. The control group was generated from non-CR carriers that also did not have any CRs or non-ratable reviews in the 4 years prior to FY 2009 (i.e., FY 2005, FY 2006, FY 2007, or FY 2008). These carriers were used to generate a control group whose data were broken-down by carrier size (see Appendix A). When the motor carrier data from the control group were weighted according to the number of CR carriers in each size

grouping, these control group carriers had a pre-CR crash rate of 1.594 crashes per 100 power units and a post-CR average crash rate of 1.514 crashes per 100 power units. (See Appendix A for an explanation of how the pre- and post-CR periods were defined for the control group.)

The percentage change in the average crash rate of the control group was calculated as follows:

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

$$\frac{1.514 - 1.594}{1.594} \times 100 = -5.02\% \text{ (i.e., a Decrease of 5.02 Percent)}$$

**Figure 4. Formula. Change in the Average Crash Rate of the Control Group**

This decrease in the average crash rate of the control group is the sum of the effects of the following:

- A change in the average crash rate of the general carrier population.
- Changes in crash reporting, and possibly other unknown factors.

The adjusted change in the average crash rate due to the CRs conducted in FY 2009 is the percentage change in the average crash rate of carrier with CRs in FY 2009 minus the percentage change in the average crash rate of the control group (i.e., -26.42 percent minus -5.02 percent equals -21.40 percent, or rounded off to a decrease of 21.4 percent).

**(5) Calculate the number of post-CR power units (i.e., the number of power units 12 months after the CRs in FY 2009).**

The 11,893 carriers that received CRs in FY 2009 and were still active 12 months after their CRs had a total of 230,646 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 FY 2009–10 as a result of the CRs conducted in FY 2009.**

The estimated number of crashes avoided in FY 2009–10 by the 11,893 carriers that received CRs in FY 2009 and were still active 12 months after their CRs was calculated as 4.924 crashes per 100 power units, times 21.4 percent, times 230,646 power units, or a total of 2,430 crashes.

Next, estimates were made for the number of crashes avoided in FY 2009–10 by the carriers receiving CRs in FY 2009 by crash severity (i.e., fatal, injury, and towaway).[2] State-reported

[2] A *fatal* crash results in at least one fatality. An *injury* crash results in no fatalities but does result in 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.

crash data from the MCMIS Crash File were used to compute these proportions. Of the crashes involving large trucks or buses in FY 2009–10, the period in which the benefits of the CRs conducted in FY 2009 would occur, 2.9 percent were fatal crashes, 39.9 percent were injury crashes, and 57.2 percent were towaway crashes.

Applying these proportions to the estimate of 2,430 crashes avoided produced the following results:

- Fatal crashes = 2,430 × 2.9% = 70.
- Injury crashes = 2,430 × 39.9% = 970.
- Towaway crashes = 2,430 × 57.2% = 1,390.

**(7) Estimate the average numbers of fatalities and injuries per crash in FY 2009–10.**

The average number of fatalities per fatal crash was estimated from State-reported crash data from the MCMIS Crash File. For crashes in FY 2009–10 involving large trucks or buses, the ratio was 1.15 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 FY 2009–10 large truck and bus crashes, the averages were as follows:

- Fatal crashes: 0.99 injuries per crash.
- Injury crashes: 1.52 injuries per crash.

**(8) Estimate the benefits (i.e., lives saved and injuries avoided) that occurred in FY 2009–10.**

The estimated number of lives saved in the crashes avoided in FY 2009–10 by the carriers with CRs in FY 2009 was calculated as number of fatal crashes avoided multiplied by the average number of fatalities per fatal crash, or 70 times 1.15, which equals 81 lives saved.

The estimated number of injuries avoided in the crashes avoided in FY 2009–10 by the carriers with CRs in FY 2009 was calculated as the number of fatal crashes avoided multiplied by the average number of injuries per fatal crash, plus the number of injury crashes avoided multiplied by the average number of injuries per injury crash, or (70 × 0.99) + (970 × 1.52) = 1,544 injuries avoided.

Table 3 and Table 4 summarize the estimated benefits that occurred in FY 2009–10 because of the CRs conducted in FY 2009 on the 11,893 carriers that were still active 12 months after their CRs and met the additional criteria listed in the table. The table also shows the estimated benefits from the CRs conducted in FY 2005, FY 2006, FY 2007, and FY 2008 (these benefits occurred in FY 2005–06, FY 2006–07, FY 2007–08, and FY 2008–09, respectively).

**Table 3. Implementation of CR Effectiveness Model for Motor Carriers With CRs FY 2005–09**

| Model Implementation for Motor Carriers With CRs in: | FY 2005 | FY 2006 | FY 2007 | FY 2008 | FY 2009 |
|---|---|---|---|---|---|
| CRs Conducted | 11,431 | 14,426 | 15,530 | 14,906 | 15,807 |
| Motor carriers that received CRs and:<br>Were interstate carriers or intrastate HM carriers.<br>Were active in the 12 months before and after their CRs.<br>Had one or more power units in the 12 months before and after their CRs.<br>Had crash and power unit data that passed edit checks designed to screen out erroneous data. | 8,941 | 10,732 | 11,353 | 11,032 | 11,893 |
| Estimated percentage reduction in average crash rate due to CRs | 16.3 | 18.6 | 14.7 | 19.9 | 21.4 |

**Table 4. Estimated Results of CR Effectiveness Model for Motor Carriers With CRs FY 2005–09**

| Model Results (i.e., Benefits) Estimated for: | FY 2005–06 | FY 2006–07 | FY 2007–08 | FY 2008–09 | FY 2009–10 |
|---|---|---|---|---|---|
| Crashes Avoided | 2,306 | 2,860 | 2,175 | 2,886 | 2,430 |
| Fatal Crashes Avoided | 79 | 93 | 68 | 87 | 70 |
| Injury Crashes Avoided | 982 | 1,185 | 879 | 1,157 | 970 |
| Towaway Crashes Avoided | 1,245 | 1,582 | 1,228 | 1,642 | 1,390 |
| Lives Saved | 92 | 109 | 79 | 101 | 81 |
| Injuries Avoided | 1,561 | 1,866 | 1,399 | 1,853 | 1,544 |

The estimates from the model implementation for carriers with CRs in FY 2007, FY 2008, and FY 2009 were made using a control group adjustment that takes into account carrier size, a change from previous models. To allow for comparisons, the model was rerun for carriers with CRs in CY 2002–04 and FY 2005–06 using this modified control group procedure. Estimates of crashes avoided produced with this new control group adjustment were within 4 percent of the earlier estimates produced by the original control group adjustment. Since the two sets of estimates are of the same magnitude and follow the same trends, they are comparable. For this reason, previous final estimates from the model for CYs 2002–04 and FYs 2005–06 have not been changed.

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# 3. ADDITIONAL ANALYSIS

## 3.1 OVERVIEW

The safety benefits calculated by the model results were broken down by carrier size (i.e., number of pre-CR power units) and the type of planned course of action (i.e., enforcement or no enforcement) after the CR.

The results of these analyses reveal 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 CR 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.

## 3.2 METHODOLOGY

The sum of the estimates of crashes avoided by each attribute (size and planned course of action) subgroup did not equal the estimate of 2,430 crashes avoided that was obtained in Section 2.3. (This result stems from the fact that both the pre-CR average crash rate and the percent reduction in the average crash rate were calculated separately for each attribute subgroup. If the product of these two parameters is not the same for each of the subgroups, then the safety benefits will not necessarily add up to the total benefits calculated in the original analysis.) Therefore, the estimates were prorated to sum to this number. For each attribute, the subgroup estimates of crashes avoided were summed to a total, which will be denoted as $X$. The subgroup estimates were prorated to the total of 2,430 by multiplying each subgroup estimate by the factor $(2{,}430 \div X)$. These prorated estimates were then used to derive the percent change in the average crash rate and the post-CR average crash rate for each subgroup.

The estimated numbers of crashes avoided, the adjusted post-CR average crash rates, and the adjusted percent changes in the average crash rates shown in Table 5 and Table 6 were all derived using this prorating procedure.

## 3.3 CARRIER SIZE

The results of the implementation of the model were broken down 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 5 shows the results of the implementation of the model for the four size subgroups:

- 1–5 power units.
- 6–20 power units.
- 21–100 power units.
- 101 or more power units.

**Table 5. Results of Implementation of Model by Carrier Size**

| Number of Pre-CR Power Units | Number of Carriers With CRs in FY 2009 | Pre-CR Average Crash Rate* | Adjusted Post-CR Average Crash Rate* | Adjusted Percent Change in Average Crash Rate | Estimated Number of Crashes Avoided in FY 2009–10 |
|---|---|---|---|---|---|
| 1–5 | 5,999 | 9.730 | 5.056 | -48.0 | 760 |
| 6–20 | 3,843 | 6.319 | 4.254 | -32.7 | 872 |
| 21–100 | 1,743 | 4.686 | 4.071 | -13.1 | 441 |
| >101 | 308 | 3.764 | 3.409 | -9.4 | 357 |
| All Carriers | 11,893 | 4.924 | 3.870 | -21.4 | 2,430 |

* Crashes per 100 power units

Table 5 shows, for each size subgroup, the number of carriers in the subgroup that received CRs in FY 2009, 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 5 also shows the estimated number of crashes avoided as a result of the CRs for each size subgroup.

The reduction in the average crash rate was inversely related to the size of the carrier. That is, the larger the carrier, the smaller the crash rate reduction. The reductions in the average crash rate ranged from 48.0 percent for carriers with 1–5 power units to 9.4 percent for carriers with 101 or more power units.

Carriers with 6–20 power units had the largest number of crashes avoided due to the program (872), followed by carriers with 1–5 power units (760).

The results of this analysis are consistent with the results of the analyses of data from the implementations of the model for carriers with CRs in CY 2002, CY 2003, CY 2004, FY 2005, FY 2006, FY 2007, and FY 2008.[1] They are also consistent with the results of analyses of data from the implementations of the previous model, the CR Impact Assessment Model.[2]

## 3.4 PLANNED COURSE OF ACTION

The results of the implementation of the model were also broken down by the course of action planned by FMCSA for the carrier following its FY 2009 CR. A carrier with a prosecution, State prosecution, or out-of-service order indicated as the planned course of action was classified as an "enforcement" carrier. A carrier with compliance monitoring, a Cooperative Safety Plan (CSP), or a Notice of Violation (NOV) indicated as the planned course of action was classified as a "non-enforcement" carrier.

These courses of action are the ones that were anticipated by FMCSA at the conclusion of the CRs that the carriers received in FY 2009 and may be different from the actions that were

[1] Reports documenting these results are available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=24.
[2] A report documenting these results is available at ai.fmcsa.dot.gov/CarrierResearchResults/Archives.asp?p=24.

actually taken. The data in the MCMIS CR File do not indicate the actual actions taken after the CRs.

Table 6 shows, for each action type, the number of carriers that received CRs in FY 2009, 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 6 also shows, for each action type, the estimated number of crashes avoided as a result of the CRs.

**Table 6. Results of Implementation of Model by Type of Planned Course of Action**

| Type of Planned Course of Action | Number of Carriers with CRs in FY 2009 | Pre-CR Average Crash Rate* | Adjusted Post-CR Average Crash Rate* | Adjusted Percent Change in Average Crash Rate | Estimated Number of Crashes Avoided in FY 2009–10 |
|---|---|---|---|---|---|
| Enforcement | 3,656 | 5.055 | 3.992 | -21.0 | 694 |
| Non-Enforcement | 8,237 | 4.871 | 3.821 | -21.6 | 1,736 |
| **Total** | **11,893** | **4.924** | **3.870** | **-21.4** | **2,430** |

* Crashes per 100 power units

Table 6 shows that it was anticipated that 3,656 (or 30.7 percent) of the 11,893 carriers that received CRs in FY 2009 would undergo enforcement actions. The "enforcement" carriers showed a crash rate reduction of 21.0 percent. The crash rate reduction for the "non-enforcement" carriers was similar: 21.6 percent. The "enforcement" carriers accounted for 694, or 28.6 percent, of the 2,430 crashes avoided in FY 2009–10.

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# APPENDIX A: CRASH AND POWER UNIT VALUES ASSIGNED TO CONTROL GROUP CARRIERS

## OVERVIEW

This section describes the criteria used to create the control group. Since control-group carriers did not receive CRs, a protocol had to be developed for assigning their crashes and power units to the pre- and post-CR time periods, which is also discussed below.

## METHODOLOGY

To create this control group, the population of carriers that did not receive CRs in FY 2009 (i.e., non-CR carriers) was used. The control group was generated from non-CR carriers that met the following additional conditions:

- The carrier was either an interstate carrier or an intrastate hazardous materials carrier.
- The carrier must have been active throughout the pre-CR period (FY 2008–09 [i.e., October 2007–September 2009]) and the post-CR period (FY 2009–10 [i.e., October 2008–September 2010]).
- The carrier must have had one or more power units throughout the pre-CR and post-CR periods (i.e., October 2007–September 2010).
- The carrier must not have had any CRs in the 4 years prior to FY 2009 (i.e., FY 2005, FY 2006, FY 2007, or FY 2008).
- The carrier's crash and power unit data had to pass various edit checks designed to screen out erroneous data.

The 502,206 carriers that met these criteria will be referred to as the eligible non-CR carrier population. These carriers were broken down into the four size subgroups (i.e., 1–5, 6–20, 21–100, and 101+ power units) used in the additional analysis in Section 3.3. The average numbers of "pre-CR" crashes, "pre-CR" power units, "post-CR" crashes, and "post-CR" power units per carrier per year for the control group carriers were calculated for each size subgroup ("pre-CR" and "post-CR" time periods for the control group are defined below). Each carrier record in the CR group data set was matched to a "pseudo" control group record, containing the above-mentioned control group summary data for the carrier's size group, resulting in a data set of 11,893 records containing not only CR data but also control group information associated with that carrier's size group. This allowed for the direct weighting of the control group data by the number of CR group carriers in each size group and also allowed for control group estimates to be generated for each planned course of action category.

## CALCULATION OF SUBGROUP AVERAGES

The average numbers of pre-CR and post-CR crashes and power units per carrier per year were calculated for each size subgroup in the eligible non-CR carrier population. The formulas used are shown in this section.

Let *x* be a size subgroup in the eligible non-CR carrier population.

Let $C_{xy}$ = the number of crashes in subgroup *x* in FY *y*, and

$P_{xy}$ = the number of power units in subgroup *x* in FY *y*, and
$N_x$ = the number of carriers in subgroup *x*.

The pre-CR period covers FY 2008 and FY 2009. Therefore, as shown in Figure 5, the average number of pre-CR crashes per carrier per year in subgroup *x* is defined as:

$$\frac{\frac{1}{2}\sum_{y=2008}^{2009}\sum_{n=1}^{N_x} C_{xy}}{N_x}$$

**Figure 5. Formula. Average Number of Pre-CR Crashes per Carrier per Year in Subgroup *x***

The post-CR period covers FY 2009 and FY 2010. Therefore, as shown in Figure 6, the average number of post-CR crashes per carrier per year in subgroup *x* is defined as:

$$\frac{\frac{1}{2}\sum_{y=2009}^{2010}\sum_{n=1}^{N_x} C_{xy}}{N_x}$$

**Figure 6. Formula. Average Number of Post-CR Crashes per Carrier per Year in Subgroup *x***

Similarly, Figure 7 shows the average number of pre-CR power units per carrier per year in subgroup *x* is defined as:

$$\frac{\frac{1}{2}\sum_{y=2008}^{2009}\sum_{n=1}^{N_x} P_{xy}}{N_x}$$

**Figure 7. Formula. Average Number of Pre-CR Power Units per Carrier per Year in Subgroup *x***

Figure 8 shows that the average number of post-CR power units per carrier per year in subgroup *x* is defined as:

$$\frac{\frac{1}{2}\sum_{y=2009}^{2010}\sum_{n=1}^{N_x} P_{xy}}{N_x}$$

**Figure 8. Formula. Average Number of Post-CR Power Units per Carrier per Year in Subgroup *x***

Table 7 shows the crash and power unit values that were assigned to the generated control group carriers. These values are the average numbers of pre-CR and post-CR crashes and power units per carrier per year in each size subgroup in the eligible non-CR carrier population. Table 7 also shows the resulting pre-CR and post-CR average crash rates for each size subgroup.

**Table 7. Crash and Power Unit Values Assigned to Control Group Carriers**

| Size Subgroup† | Pre-CR Avg. No. of Crashes | Pre-CR Avg. No. of Power Units | Pre- CR Average Crash Rate* | Post-CR Avg. No. of Crashes | Post-CR Avg. No. of Power Units | Post-CR Average Crash Rate* |
|---|---|---|---|---|---|---|
| 1 | 0.02058 | 1.7370 | 1.185 | 0.02012 | 1.7577 | 1.145 |
| 2 | 0.13455 | 9.7470 | 1.380 | 0.13161 | 9.8292 | 1.339 |
| 3 | 0.65344 | 39.7344 | 1.645 | 0.61497 | 39.8244 | 1.544 |
| 4 | 6.49908 | 389.7553 | 1.667 | 6.10055 | 384.8664 | 1.585 |

* Crashes per 100 power units

† Size Subgroup 1: 1.0–5.0 power units, Size Subgroup 2: 5.5–20.0 power units, Size Subgroup 3: 20.5–100 power units, Size Subgroup 4: ≥100.5 power units

The size subgroup definitions shown for the non-CR carriers are the same as for the carriers with CRs in FY 2009 (i.e., the CR group). The lower limits for the non-CR carrier subgroups 2, 3, and 4 are different than those for the carriers in the CR group because the numbers of pre-CR and post-CR crashes and power units for a non-CR carrier are averages of 2 FYs. For example, size subgroup 2 consists of carriers with more than 5 but no more than 20 pre-CR power units. For a non-CR carrier, the number of pre-CR power units is the average of the numbers of power units in FY 2008 and FY 2009. That number could be 5.5, which would put the carrier in subgroup 2.

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