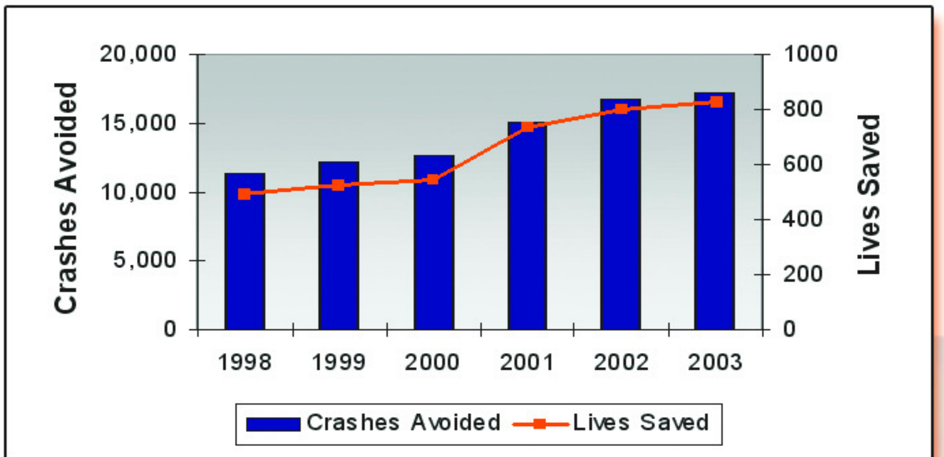
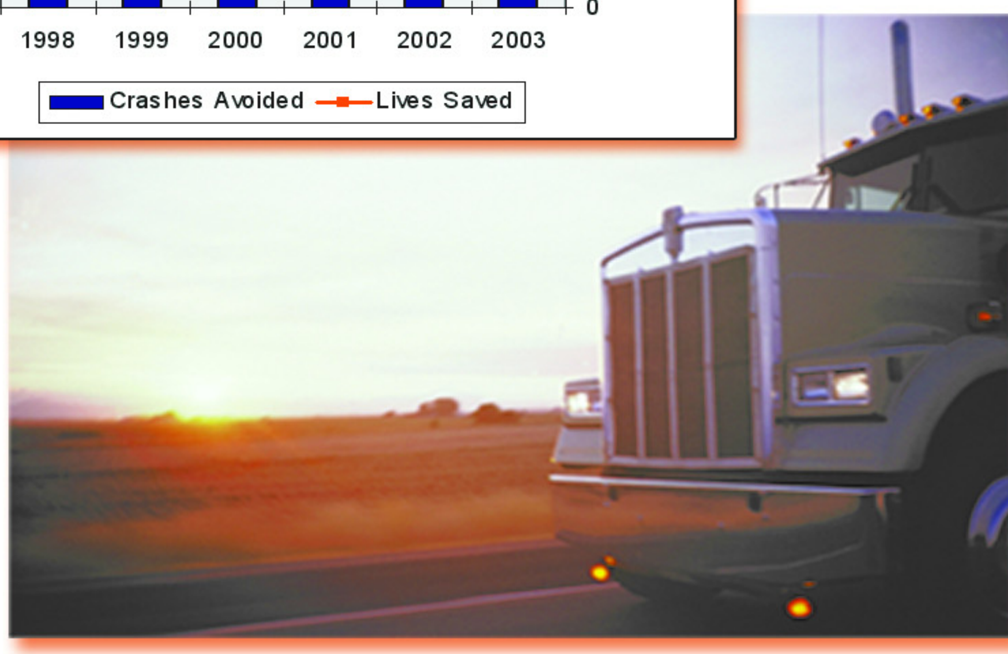
FMCSA Safety Program Effectiveness Measurement: Intervention Model

Roadside Inspection and Traffic Enforcement Effectiveness Annual Report

Results for 2001, 2002, and 2003

December 2004





Publication: FMCSA-RI-04-029

Prepared for: Federal Motor Carrier Safety Administration
Office of Information Management, Analysis Division
400 Seventh Street, S.W.
Washington, DC 20590

Prepared by: John A. Volpe National Transportation Systems Center
Office of Systems and Economic Assessment
Motor Carrier Safety Assessment Division, DTS-47
Kendall Square
55 Broadway
Cambridge, MA 02142

Preface

This report documents the methodology and results from an improved model to measure the effectiveness of two of the key safety programs of the Federal Motor Carrier Safety Administration (FMCSA). The research was conducted by the Research and Special Programs Administration's (RSPA) John A. Volpe National Transportation Systems Center (the Volpe Center) in Cambridge, MA under a project plan agreement with the FMCSA. The work on FMCSA Program Performance Measures addresses the requirements of the Government Performance and Results Act (GPRA) of 1993, which obligates federal agencies to measure the effectiveness of their programs as part of the budget cycle process.

Work on FMCSA Program Performance Measures was initiated during FY 93. In December 1994, a report titled “Office of Motor Carriers Safety Program - Performance Measurement” was prepared. That report provided a comprehensive breakdown of Office of Motor Carriers (OMC) safety programs and activities and described about a dozen potential evaluation models. (Note: The OMC later became the FMCSA.) Based on the OMC's review, the Volpe Center revised the report and recommended four evaluation models to assess the key OMC programs: roadside inspections conducted by participating states under the Motor Carrier Safety Assistance Program (MCSAP), on-site compliance reviews conducted by the OMC field offices and the states, commercial vehicle traffic enforcement also performed by the states under the MCSAP, and a comprehensive assessment of combined effects. Two initial evaluation models covering the roadside inspection program and the compliance review program were described in detail in a December 1998 report titled “OMC Safety Program Performance Measures.” A review panel was convened to evaluate these models and made recommendations for improvement. The Volpe Center incorporated these recommendations together with other Volpe Center defined improvements into two “second-generation” models that measure the effectiveness of these two programs. This report describes the implementation of the Intervention Model, which covers not only the roadside inspection program, but also the traffic enforcement program.

At the FMCSA, the project is managed by Dale Sienicki, Division Chief of the Analysis Division in the Office of Information Management. The Volpe Center project manager is Donald Wright, Chief of the Motor Carrier Safety Assessment Division in the Office of System and Economic Assessment. The analysis was performed at the Volpe Center by Kevin Gay, Nancy Kennedy, and Julie Nixon of the Volpe Center, and Dennis Piccolo and Kha Nguyen of EG&G Services, under contract to the Volpe Center.

Acronym List

Acronym	Full Name
CDL	Commercial Driver's License
CMV	Commercial Motor Vehicle
CVSA	Commercial Vehicle Safety Alliance
FARS	Fatality Analysis Reporting System
FMCSA	Federal Motor Carrier Safety Administration
GPRA	Government Performance and Results Act
HM	Hazardous Materials
MCMIS	Motor Carrier Management Information System
MCSAP	Motor Carrier Safety Assistance Program
NAS	North American Standard
NHTSA	National Highway Traffic Safety Administration
OMC	Office of Motor Carriers
OOS	Out of Service
RI	Roadside Inspection
RSPA	Research and Special Programs Administration
TE	Traffic Enforcement
U.S. DOT	United States Department of Transportation

Contents

List of Tables

List of Figures

Executive Summary

Brief Description

The Intervention Model is designed to provide the Federal Motor Carrier Safety Administration (FMCSA) with a means to gauge the effectiveness of two of its safety programs - roadside inspections and traffic enforcements - in preventing crashes involving interstate motor carriers and in reducing related fatalities and injuries. The model is also intended to be a tool that the FMCSA can use periodically to measure the relative performance of its programs, and to analyze the effects of implementing program changes.

The model measures program effectiveness in terms of safety, commercial vehicle crashes prevented, lives saved, and injuries avoided. Although the methodology is believed to be sound and roadside inspection results are judged to be complete and accurate, the model has known limitations. It lacks empirical data regarding driver behavior and the contribution that vehicle defects and driver faults have on crash causation. In lieu of empirical data, the model defaults to other means (including expert judgment) and establishes a benchmark to measure roadside inspection and traffic enforcement program effectiveness.

The model is based on the premise that the two programs - roadside inspection and traffic enforcement - directly and indirectly contribute to a reduction in crashes. As a result, the model includes two submodels that are used for measuring these different effects. Direct effects are based on the assumption that vehicle and/or driver defects discovered and then corrected as the results of interventions reduce the probability that these vehicles/drivers will be involved in subsequent crashes. The model calculates direct-effect-prevented crashes according to the number and type of violations detected and corrected during an intervention.

Indirect effects are considered to be the by-products of the carriers' increased awareness of FMCSA programs and the potential consequences that these programs pose if steps are not taken to ensure and/or maintain higher levels of safety. This change in behavior will result in higher levels of compliance, fewer future violations, and therefore, a reduction in the number of crashes.

Critical to the model is its ability to link vehicle and driver defects detected during roadside inspections and/or traffic enforcements to crash probabilities. Currently available research and expert judgments provided the basis for establishing these linkages and assigning probabilities. Since there is little in the way of empirical data to support these probabilities, the values developed are intentionally conservative so as not to overstate the safety benefits of the programs.

Major investigations focusing on special large truck crash data collections and crash reconstruction analysis are currently being sponsored by the FMCSA will assist in improving crash probabilities. The model's methodology will enable the incorporation of the results of these efforts once they become available.

This model, which measures the effectiveness of the roadside inspection and traffic enforcement programs, when combined with the Compliance Review Effectiveness Model, forms a powerful performance measurement capability that will facilitate a combined-effects assessment of the three FMCSA safety programs. The expectation is that the combined-effects assessment results will further guide FMCSA decision-making when directing resources to achieve optimal program effectiveness.

Enhancements

With each implementation of the model, it is important to identify any modifications to the methodology of the Intervention Model that might impact any comparisons between historical results (1998 - 2000) and the new results (2001 - 2003). There has been one modification to the model since the last implementation, and the belief is that it will not adversely affect any comparisons or analysis with historical data.

Indirect Effects. The model enhancement is the ability to compute indirect effects for a particular year without having to wait for the subsequent year of data. Prior to the enhancement, intervention data from 2003 and 2004 was required to compute the indirect effects for 2003, which implies that results could not be computed until the middle of 2005. After a detailed analysis of the 1998 - 2000 results of the indirect component of the model, an enhancement was recommended and approved that allows results to be published in the year following the intervention data (i.e. in 2004 for 2003 data). The details of this analysis and subsequent enhancement are covered in “Indirect-Effect Approach” on page 34.

Program Benefits

The model was implemented to estimate three years of safety benefits (2001, 2002, and 2003). The 2001 - 2002 safety benefits are based on data current through March of 2004, while the 2003 safety benefits are based on data current through June of 2004.

National Level. The national level program safety benefits, which are crashes avoided, lives saved, and injuries avoided, for 2001 through 2003 are displayed in Table ES-1, Table ES-2, and Table ES-3. These tables also present the historical results (from previous implementations of the model 1998 - 2000) in order to provide additional data for comparison. These results were taken directly from the September 2002 report “Intervention Model: Roadside Inspection and Traffic Enforcement Effectiveness Assessment.”

Table ES-1. Roadside Inspection Benefits 1998 - 2003

	1998	1999	2000	2001	2002	2003
Crashes Avoided	8,612	9,119	9,362	11,294	12,235	12,667
Lives Saved	369	391	402	550	568	534
Injuries Avoided	5,902	6,250	6,416	8,689	9,240	9,647

Table ES-2. Traffic Enforcement Benefits 1998 - 2003

	1998	1999	2000	2001	2002	2003
Crashes Avoided	2,800	3,021	3,306	3,844	4,602	4,484
Lives Saved	120	130	142	187	214	189
Injuries Avoided	1,919	2,071	2,265	2,957	3,476	3,415

Table ES-3. Total Benefits 1998 - 2003†

	1998	1999	2000	2001	2002	2003
Crashes Avoided	11,412	12,140	12,688	15,138	16,837	17,151
Lives Saved	489	521	544	738	781	722
Injuries Avoided	7,821	8,321	8,681	11,646	12,716	13,062

†. The totals in this table may not match sums from the previous two tables due to rounding

It should be noted that the program benefits have increased every year since 1998 with the largest jump in benefits occurring from 2000 to 2001. In 2003, the number of lives saved is actually lower than the 2002 number even though more crashes were and injuries were avoided in 2003. This is a result of a change in the crash severity statistics from 2002 to 2003. For the 2002 results, 4.0% was used for the share of crashes that were fatal, but in 2003 this number dropped to 3.6%, which leads to a smaller number of lives saved. These values were calculated from the Motor Carrier Management Information System (MCMIS) and the Fatality Analysis Reporting System (FARS) data, and a full discussion of the methodology can be found in "Program Benefits" on page 38.

Additionally, it is useful to analyze the number of interventions in each of the years. Table ES-4 and Figure ES-1 provide tabular and graphical breakdowns of the number of interventions per year by type of intervention.

Table ES-4. Intervention Breakdown

	1998	1999	2000	2001	2002	2003
Roadside Inspections with No Violations	571,731	621,962	651,949	758,297	849,422	828,195
Roadside Inspections with Violation(s)	1,128,791	1,161,786	1,181,039	1,292,489	1,406,499	1,387,567
Traffic Enforcements with Violation(s)	516,048	579,219	620,226	695,619	762,561	791,157
Total Interventions	**2,216,570**	**2,362,967**	**2,453,214**	**2,746,405**	**3,018,482**	**3,006,919**

By analyzing the intervention breakdown it is clear that the increase in program benefits is at least partly due to the increase in the number of interventions performed. The number of interventions performed per year increased continually until 2003, with a significant jump from the year 2000 to 2001. Almost 300,000 more interventions were performed in 2001 than in 2000. It appears the trend has leveled off with the 2003 data being virtually identical to the 2002 data.

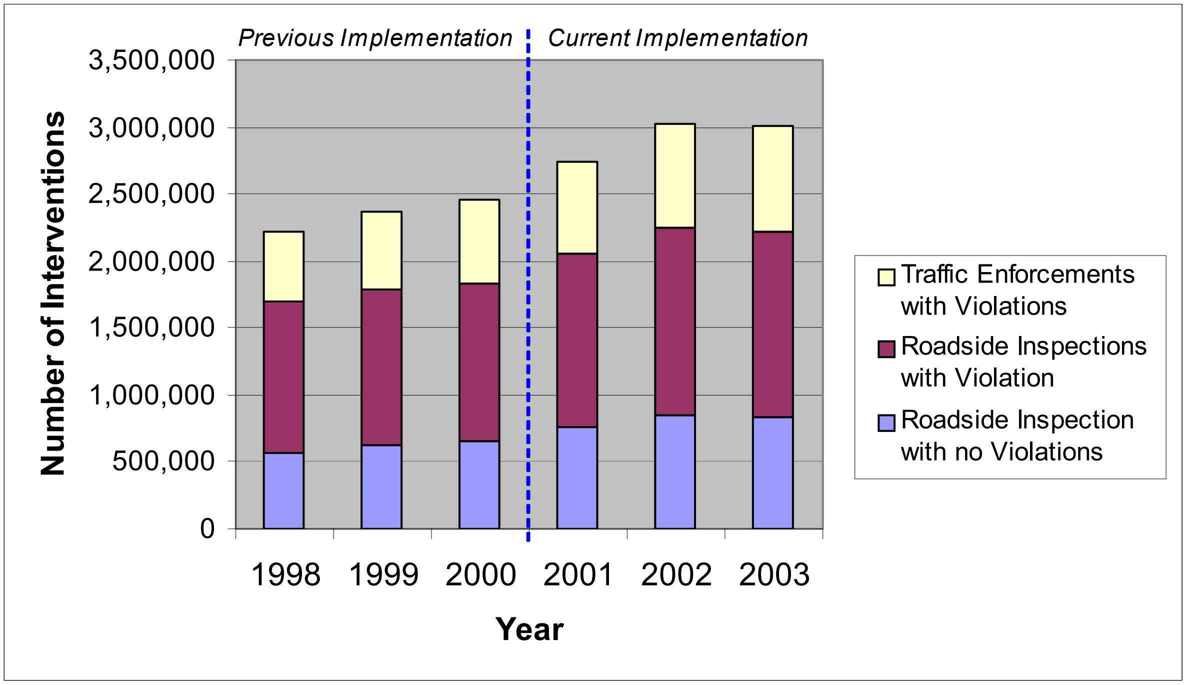


Figure ES-1. Analysis of Interventions by Type

Intervention Model

Introduction

Project 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 (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 (U.S. DOT) to establish safety fitness standards for carriers. The U.S. DOT, along with the states, responded by implementing the MCSAP to fund 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.

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 two of its motor carrier safety programs, the roadside inspection and traffic enforcement programs. 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.

Project Scope

The scope of this overall effort is limited to the major identifiable 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 enforcement). 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 run them 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 Intervention Model and presents the final results from the implementation of the model for carriers receiving a roadside inspection or traffic enforcement in 2001, 2002, and 2003.

Report Structure

This report includes descriptions of the evolution of the Intervention Model, the effects that it measures, and how the model is to be applied. The report also explains concepts driving the development process and affecting the model structure. Report sections include:

- Background on an earlier model, known as Safe-Miles, with an explanation of its limitations (“Background: Safe Miles” on page 2),
- An overview of the model with descriptions of the calculation of direct and indirect effects (“Methodology” on page 4),
- A discussion of future model enhancements (“Future Enhancements” on page 11),
- A mathematical description of the model (“Intervention Model Technical Documentation” on page 25), and
- Detailed information on the types and classification of violations critical to running the model (“Violations” on page 43).

Model Description

Background: Safe Miles

Overview. The Safe-Miles Model was also developed to measure the effectiveness of the roadside inspection program and preceded the Intervention Model. It is discussed here by way of background, since the Intervention Model borrows substantially from the experience with the Safe-Miles Model. Included is a discussion of the direct and indirect effects approach first used in that model as well as the model's limitations leading to the development of the "second-generation" Intervention Model.

The Safe-Miles Model employed a two-step analysis process to perform the evaluation. Instances were recorded in which vehicles and/or drivers were taken out of service during roadside inspections. Next, subsequent travel by the out-of-service (OOS) vehicles and drivers, once conditions were corrected, was converted into "safe miles" and estimates were made concerning crashes avoided during the "safe-miles" period.

Direct-effect benefits were accumulated from the point at which vehicles or drivers with OOS conditions were detected and removed from service. A three-month "safe" post-inspection period for vehicles was incorporated into the model. This time frame was considered appropriate since the Commercial Vehicle Safety Alliance (CVSA) has a three-month period after a vehicle receives a satisfactory inspection that it is exempt from additional inspections.[1] Lacking an empirical basis with which to govern the duration of the direct effect findings for drivers, the post-inspection safe period for corrected driver OOS defects was shortened to a more conservative period of two months.

Indirect effects are an equally important element of the roadside inspection program. The very existence of the program (as well as its magnitude) is believed to act as a deterrent. Knowledge of the program results in motor carrier managers making procedural changes that result in improvements in vehicle maintenance and inspection and in driver qualifications and behavior. These indirect effects, although assumed substantial, are much more difficult to quantify. The indirect effects are estimated in the Safe-Miles Model by assuming that carriers with a high frequency of (that is, greater exposure to) either vehicle or driver inspections, as a result of the enforcement of the roadside inspection program, change their behavior and voluntarily improve their safety, resulting in lower vehicle or driver OOS rates.

Direct effects (crashes avoided) were added to indirect effects to derive total roadside inspection program benefits. These benefits were also expressed as estimates in dollar terms by using crash cost factors. There was no traffic enforcement component in the Safe-Miles Model.

Limitations. The 1998 Volpe Center report - "OMC Safety Program Performance Measures" - identified the following limitations associated with the Safe-Miles Model:

---

[1] Except under the following circumstances: 1) A North American Commercial Vehicle Critical Safety Item or OOS violation is detected, 2) When a Level IV (Special Inspection) exercise is involved, 3) When a statistically-based random inspection technique is being employed to validate an individual jurisdiction or regional OOS percentage, or 4) When inspections are conducted to maintain CVSA inspection quality assurance. Commercial Vehicle Safety Alliance website, http://www.cvsa.org/Inspections/CVSA_Decals/cvsa_decals.html, 2001.

- No observed evidence existed for the establishment of a driver safe-miles period. In future empirical studies of driver behavior, post-OOS violation detection would be required to establish the reliability of the two-month interval that was used.
- Each violation was considered in isolation. This precluded any heightening of the safety risk as a result of the presence of multiple violations found during an inspection.
- The lack of crash causation statistics hindered the ability to estimate the contribution of specified vehicle and driver defects to crash likelihood.

The deterrence component of the model (indirect effects) relied on measured changes in OOS rates of carriers that had multiple inspections as a foundation for calculating indirect effects from roadside inspections. However, overall improved preparation and compliance of drivers and vehicles motivated by the presence of a roadside inspection program were thought to be greater than improvements that could be measured by the model.

The research team defined the Intervention Model as a means to remedy these limitations. As with the Safe-Miles Model, the Intervention Model includes direct and indirect effect components; however, it:

- Eliminates the empirically weak “safe-miles” concept,
- Makes allowances for inspections with multiple violations, and
- Uses recent crash causation research to estimate the contribution of vehicle and driver faults to crash causation.

The model also considers total inspection results. This means that it includes non-OOS violations, although with a lesser-assigned weight, in its calculations. Finally, the Intervention Model remedies a Safe-Miles omission by including traffic enforcements in its analysis. The benefits of the Intervention Model are expressed as crashes, fatalities, and injuries avoided.

Methodology

The Intervention Model was developed to determine the effectiveness of the roadside inspection and traffic enforcement programs in reducing motor carrier crashes. The roadside inspection program consists of roadside inspections performed by qualified safety inspectors following the guidelines of the North American Standard, which was developed by the Commercial Vehicle Safety Alliance in cooperation with the FMCSA. Most roadside inspections are conducted by state personnel under a grant program (MCSAP) administered by the FMCSA. There are five levels of inspections including a vehicle component, a driver component or both. The traffic enforcement program is based on the enforcement of twenty-one moving violations noted in conjunction with a roadside inspection. Violations are included in the driver violation portion of the roadside inspection checklist.[2] Figure 1 provides an overview of the Intervention Model.

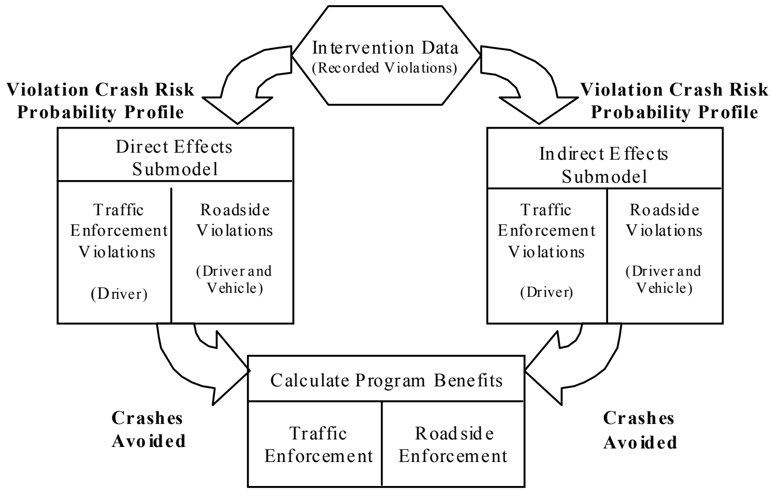


Figure 1. Intervention Model Overview

As with the Safe-Miles Model, this model is based on the premise that the two programs - roadside inspection and traffic enforcement - directly and indirectly contribute to the reduction of crashes. As a result, the model includes two submodels that are used for measuring these different effects. Direct effects are based on the assumption that vehicle and/or driver defects discovered and then corrected as the results of interventions reduce the probability that these vehicles/drivers will be involved in subsequent crashes. Indirect effects are considered to be the by-products of the carriers' increased awareness of FMCSA programs and the potential consequences that these programs pose if steps are not taken to ensure and/or maintain high levels of safety.

Crash Risk Probabilities. In the model, the assumption is made that observed deficiencies (OOS and non-OOS violations) discovered at the time of roadside inspections and/or traffic enforcements can be converted into crash risk probabilities. This assumption is based on the premise that detected defects represent varying degrees of mechanical or judgmental faults, and, further, that some are more likely than others to play a contributory role in motor vehicle crashes. The assumption is that these deficiencies can be noted and ranked into discrete risk categories, each of which possesses a probability that reflects the crash risk that it poses. The process by which the resulting Violation Crash Risk Probability Profile (VCRPP) is formed appears in Figure 2.

The development of risk categories for violations relied upon a recent study conducted by Cycla Corporation.[3] Each violation was classified according to the risk caused by the conditions of the violation. Cycla's report defined risk as "the likeli-

[2] For a complete list of driver and vehicle violations associated with the roadside inspections and traffic enforcement, see "Violations" on page 43.

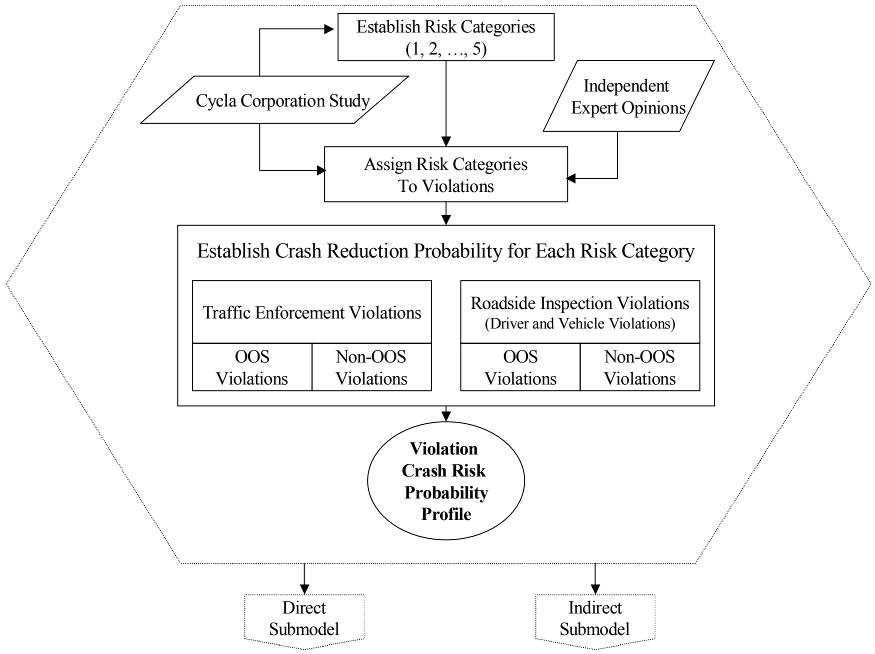


Figure 2. Violation Crash Risk Profile

hood of a violation leading to a crash" and, subsequently, divided the violations into five categories based on the level of risk. The risk categories and their descriptions are as follows:

- Risk Category 1 - The violation is the potential single, immediate factor leading to a crash or fatalities/injuries from a given crash.
- Risk Category 2 - The violation is the potential single, eventual factor leading to a crash or fatalities/injuries from a given crash.
- Risk Category 3 - The violation is a potential contributing factor leading to a crash or fatalities/injuries from a given crash.
- Risk Category 4 - The violation is an unlikely potential contributing factor leading to a crash or fatalities/injuries from a given crash.
- Risk Category 5 - The violation has little or no connection to crashes or the prevention of fatalities/injuries.

While covering most inspection violations, Cycla's assignment of violations to risk categories was incomplete. This required Volpe Center analysts to make violation

[3] Cycla Corporation, Risk-based Evaluation of Commercial Motor Vehicle Roadside Violations: Process and Results, July 1998. Note: The twenty-one traffic enforcement violations used in the model were also included in the Cycla evaluation.

assignments for those driver or vehicle violations not included in the Cycla risk assessment. These assignments were made based on comparability with the Cycla list.

In the Cycla study, recommended weights were given to each of the risk categories, as shown in Table 1. The heaviest weight (1,000) was assigned to Risk Category 1 since these violations are considered to represent a significant safety hazard. Risk Categories 2 through 5 were given lesser weights (100, 10, 1, and 0.1, respectively). Cycla justifies this by stating that since "each relative numerical weight represents a different order of magnitude of likelihood, the weights decrease by a factor of ten." The Cycla study cautions, however, that the values do not refer to any "absolute" risk level. (The detailed list of roadside inspection violations and traffic enforcement violations are separated into tables by risk categories in the section entitled "Violations" on page 43. Each table indicates the source of the categorization - either Cycla or Volpe Center.)

To execute the model, Volpe Center analysts converted Cycla's relative numerical weights into crash reduction probabilities.[4] Each probability is an estimate of the portion of a crash avoided when an inspection uncovers a particular violation. For example, if a violation carried a probability of 0.001, inspectors would have to discover that violation 1,000 times in order for the model to "take credit" for avoiding a crash. Since driver-related errors are thought to be more of a factor in crash causation relative to mechanical defects, traffic enforcement violations were assigned higher probabilities. Based on expert judgments formed from the results of previous studies and available data, traffic enforcement violations are considered 4 times more likely to result in a crash than roadside inspection violations.[5]

Table 1. Relative Weights for Driver and Vehicle Categories[†]

Risk Category	Category Description	Relative Weight
1	Violation is the potential single, immediate factor leading to a crash or fatalities/injuries from a given crash.	1,000
2	Violation is the potential single, eventual factor leading to a crash or fatalities/injuries from a given crash.	100
3	Violation is a potential contributing factor leading to a crash or fatalities/injuries from a given crash.	10
4	Violation is an unlikely potential contributing factor leading to a crash or fatalities/injuries from a given crash.	1
5	Violation has little or no connection to crashes or the prevention of fatalities/injuries.	0.1

†. Ibid, p. 21.

4 See "Violation Crash Risk Probability Profile" on page 26 for the explanation of how the relative weights from Cycla were converted into crash risk probabilities.

5 Based on preliminary findings from crash causation studies conducted by the University of Michigan Transportation Research Institute.

Direct Effects. This section describes the methodology employed to estimate the number of direct-effect crashes avoided.

Conceptually, the approach at the heart of the Direct Effects Submodel is straightforward. Since the occurrence of a single violation implies a certain degree of crash risk, each inspection that uncovers at least one violation can be interpreted as having reduced the risk linked with its noted violation(s). The model expresses this risk reduction in terms of the likelihood of a crash being avoided by each inspection violation that was noted and corrected. For an individual intervention, the avoided crash probability will be dependent upon the number and type of violations. Multiple violations, of course, will have a compounding effect, thereby increasing the likelihood of a prevented crash. By accounting separately for the two types of violations (roadside and traffic enforcement) and summing the portions of crashes avoided for all inspections within each group, it is possible to estimate direct-effect crashes that have been avoided due to the programs. Figure 3 depicts the process used to determine program direct effects.

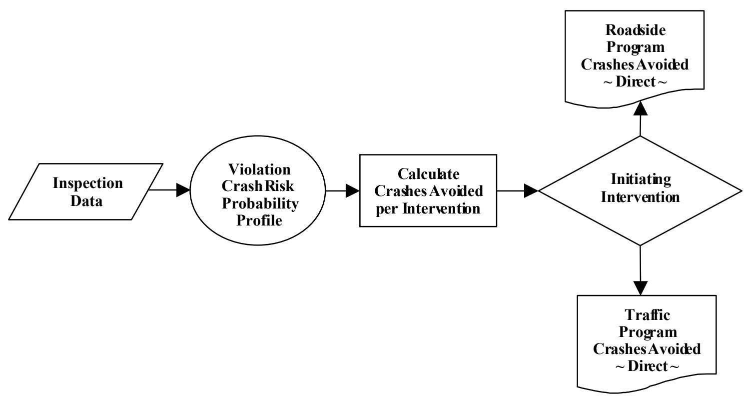


Figure 3. Direct Effect Approach

Four steps make-up the direct-effect approach.

(1) One year of inspection data is extracted from the Motor Carrier Management Information System (MCMIS) database. The MCMIS contains information compiled from federal and state safety agencies. Each intervention has its own set of associated driver and/or vehicle violations.

(2) An inspection's violations are matched to the Violation Crash Risk Probability Profile, whereby a list of crash reduction probabilities becomes attached to that inspection. This list becomes the basis for calculating the inspection's effect on avoiding a crash.

(3) The likelihood of an avoided crash for each inspection is calculated by using the crash reduction probabilities of the inspection. An inspection with multiple violations will have a greater likelihood of an avoided crash than will an inspection with a single violation, assuming all the violations are in the same

risk category. This result reflects the belief that multiple violations compound the safety hazard posed from driver deficiencies and/or vehicle defects.

(4) Once each inspection has been assigned its probability of avoiding a crash, the inspections are grouped by their initiating intervention. An inspection with a traffic enforcement driver violation is classified as traffic enforcement with a driver and/or vehicle roadside inspection component(s). All other inspections are classified as entirely driver and/or vehicle roadside inspections. Direct-effect crashes-avoided totals are simply the summation of 1) the portions of crashes avoided for all traffic enforcement violations and 2) the summation of the portions of crashes avoided for all roadside inspection violations.

Indirect Effects. The fundamental premise of the indirect-effect approach is that once carriers have been exposed to the combination of roadside inspection and traffic enforcement actions, they will change their behavior. This change in behavior will result in higher levels of compliance, fewer future violations, and, therefore, a reduction in the number of crashes. This section presents a summary of the methods used in the model to arrive at program indirect effects. The deterrent-effects part of the model - that is, the Indirect Effects Submodel - follows a similar pattern to that of the Direct Effects Submodel.

Indirect effects, by their nature, defy measurement. However, changes in behavior represented by changes in the number of violations recorded for a carrier over time can be used to identify and evaluate the results of the indirect effects. In other words, if a carrier receives fewer and fewer violations as it is subjected to more inspections, it will be determined that compliance behavior has been affected and the resulting likelihood of crashes has been reduced. To measure these effects, multiple successive years of intervention data are required.

The Indirect Effects Submodel compares the results of inspections carrier by carrier from one year to the next in order to measure the effects of the exposure to having inspections on compliance. A carrier's performance in a base year is compared to its performance in a subsequent year. What is sought is an improvement, i.e., a reduction, in the likelihood of a crash resulting from increasingly fewer violations being recorded. The difference between the totals is calculated as the indirect-effect crashes-avoided. Depending upon the initiating intervention, it is tallied as indirect-effect crashes avoided for either the roadside inspection or traffic enforcement programs. Figure 4 illustrates the processes involved in assessing the indirect effects of the model.

The indirect effects calculation is similar to that of the direct effects. Steps 1 and 2 are equivalent, with one exception, to their counterparts in the Direct Effects Submodel. The Indirect Effects Submodel uses two years of MCMIS intervention data, whereas the Direct Effects Submodel uses one. Step 3 creates year one and year two average fractional crashes-avoided figures for each carrier. The two figures are compared and improvements are noted. Step 4 separates inspections and attributes the results to the initiating intervention. Traffic enforcement driver moving violations are assigned to the traffic enforcement program. All others (including driver and vehicle inspections

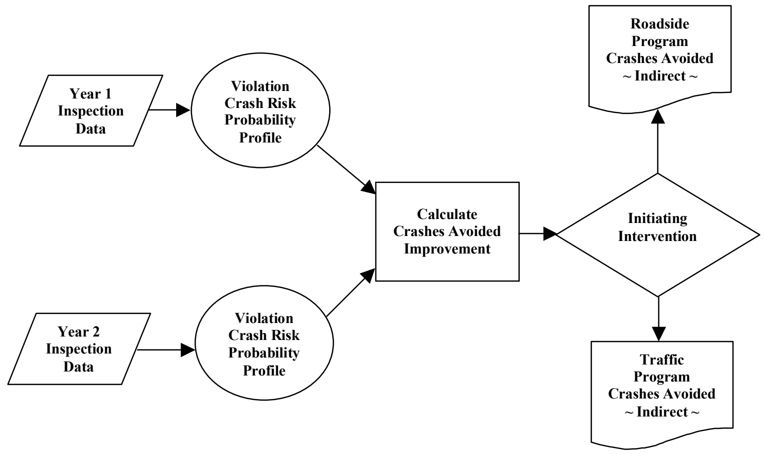


Figure 4. Indirect Effects Approach

done in conjunction with traffic stops) are assigned to the roadside inspection program. Indirect-effect crashes-avoided totals are the summation of the improvements in calculated crashes avoided.[6]

Program Benefits. The model also estimates program benefits expressed in terms of lives saved and injuries avoided. Figure 5 illustrates the overall approach that is used by the model to determine these program safety benefits that are attributable to the roadside inspection and traffic enforcement programs.

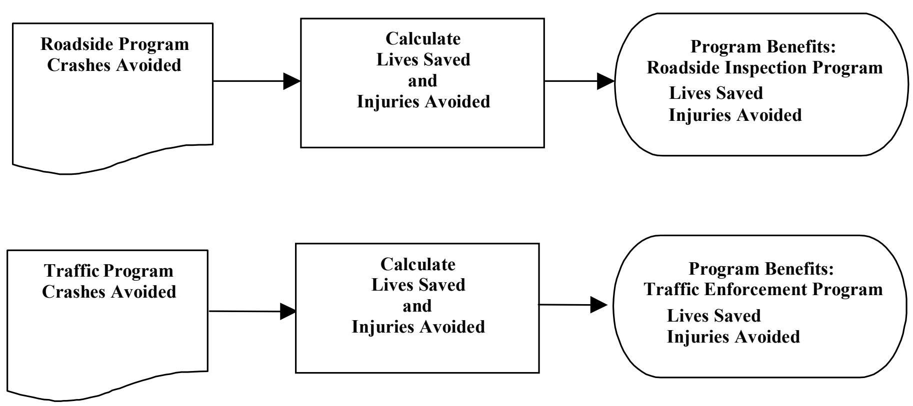


Figure 5. Program Benefits Determination

Limitations

It is believed that FMCSA safety program elements provide a deterrent to carriers exposed to the programs, thereby causing changes in driver behavior and carrier oper-

---

6 Readers should note that the allocation of violations to programs actually occurs earlier in the indirect-effect calculation process. To simplify the presentation, however, the submodel has been presented in the form appearing above. This does not materially affect the model outline.

ations that lead to improvements in the level of motor carrier safety. At the same time, it is recognized that motor carriers are affected by exogenous influences, such as those attributable to the highway environment, that may intervene, impact or have some bearing on motor carrier safety. However, there is no accounting for these other influences and their associated consequences (i.e., fatalities and injuries) in this effort.

Additionally, it is recognized that the crash risk probabilities established in the model lack empirical data. Given this limitation, it was decided that these probabilities should be conservative in nature since it is preferable to understate the safety benefits rather than overstate them.

Future Enhancements

While the foundation behind the Intervention Model is solid, additional model improvements are still planned. They include improving the model inputs, such as the crash probabilities and improved analysis capabilities.

Strengthen Crash Risk Probabilities. The Intervention Model is conservative in developing crash risk reduction probability estimates for individual violations as well as for individual inspections with multiple violations. Though the model clearly recognizes that multiple vehicle and driver problems occurring simultaneously greatly enhance the likelihood of a future crash, more empirical data on the compounding impact of multiple defects could result in much more accurate estimates of crash probabilities.

While the Cycla effort to differentiate among violations based on their respective risk category provides a means to estimate the prospect that a crash would occur had the vehicle/driver not been stopped, further data on linkages between vehicle/driver problems and crash occurrences would improve the model's accuracy. The FMCSA and the National Highway Traffic Safety Administration (NHTSA) are currently conducting detailed post-crash investigations on a sample of crashes.[7] The objective of this study is to obtain information on crash causation including connections to vehicle and driver problems.

Improve Output Capabilities. The Intervention Model analyzes in excess 3 million interventions and 6 million associated violations in a typical run. Obviously, some level of aggregation of the results of this analysis is necessary. Currently, results are aggregated to a national level, a state level, and state/intervention type (roadside inspection or traffic enforcement) level. By modifying the underlying architecture of the model, it will allow the output data to be aggregated to any level supported by MCMIS. This includes carrier size, inspection level, SafeStat category, etc.

Implementation Results

The model was implemented to estimate three years of safety benefits (2001, 2002, and 2003). The 2001 - 2002 safety benefits are based on data current through March of 2004, while the 2003 safety benefits are based on data current through June of 2004.

---

7 The Federal Motor Carrier Safety Administration and National Highway Traffic Safety Administration are conducting the Large Truck Crash Causation Study.

National Level. The national level program safety benefits, which are crashes avoided, lives saved, and injuries avoided, for 2001 through 2003 are displayed in Table 2, Table 3, and Table 4. These tables also present the historical results (from previous implementations of the model 1998 - 2000) in order to provide additional data for comparison. These results were taken directly from the September 2002 report “Intervention Model: Roadside Inspection and Traffic Enforcement Effectiveness Assessment.”

Table 2. Roadside Inspection Benefits 1998 - 2003

	1998	1999	2000	2001	2002	2003
Crashes Avoided	8,612	9,119	9,362	11,294	12,235	12,667
Lives Saved	369	391	402	550	568	534
Injuries Avoided	5,902	6,250	6,416	8,689	9,240	9,647

Table 3. Traffic Enforcement Benefits 1998 - 2003

	1998	1999	2000	2001	2002	2003
Crashes Avoided	2,800	3,021	3,306	3,844	4,602	4,484
Lives Saved	120	130	142	187	214	189
Injuries Avoided	1,919	2,071	2,265	2,957	3,476	3,415

Table 4. Total Benefits 1998 - 2003[†]

	1998	1999	2000	2001	2002	2003
Crashes Avoided	11,412	12,140	12,688	15,138	16,837	17,151
Lives Saved	489	521	544	738	781	722
Injuries Avoided	7,821	8,321	8,681	11,646	12,716	13,062

†. The totals in this table may not match sums from the previous two tables due to rounding

It should be noted that the program benefits have increased every year since 1998 with the largest jump in benefits occurring from 2000 to 2001. In 2003, the number of lives saved is actually lower than the 2002 number even though more crashes were and injuries were avoided in 2003. This is a result of a change in the crash severity statistics from 2002 to 2003. For the 2002 results, 4.0% was used as the share of fatal crashes, but in 2003 this number dropped to 3.6%, which leads to a smaller number of lives saved. These values were calculated from MCMIS and FARS data, and a full discussion of the methodology can be found in “Program Benefits” on page 38.

Additionally, it is useful to analyze the number of interventions in each of the years. Table 5 and Figure 6 provide tabular and graphical breakdowns of the number of interventions per year by type of intervention.

Table 5. Intervention Breakdown

	1998	1999	2000	2001	2002	2003
Roadside Inspections with No Violations	571,731	621,962	651,949	758,297	849,422	828,195
Roadside Inspections with Violation(s)	1,128,791	1,161,786	1,181,039	1,292,489	1,406,499	1,387,567
Traffic Enforcements with Violation(s)	516,048	579,219	620,226	695,619	762,561	791,157
Total Interventions	**2,216,570**	**2,362,967**	**2,453,214**	**2,746,405**	**3,018,482**	**3,006,919**

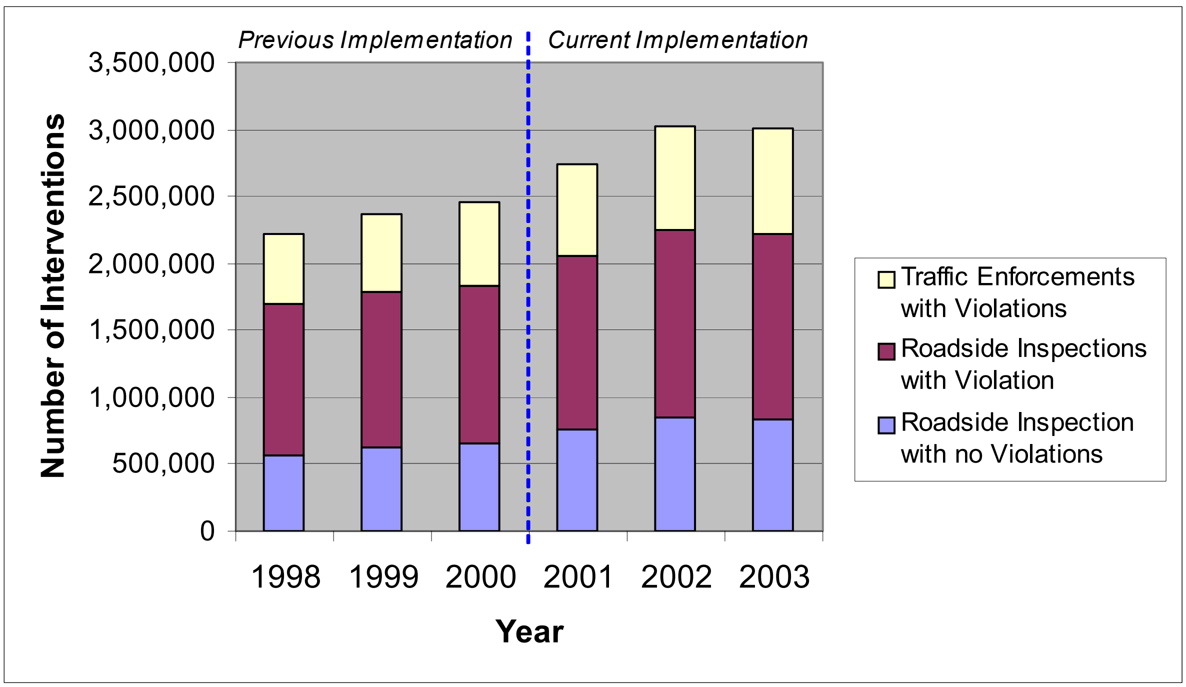


Figure 6. Analysis of Interventions by Type

By analyzing the intervention breakdown it is clear that the increase in program benefits is at least partly due to the increase in the number of interventions performed. The number of interventions performed per year increased continually until 2003, with a significant jump from the year 2000 to 2001. Almost 300,000 more interventions were performed in 2001 than in 2000. It appears the trend has leveled off with the 2003 data being virtually identical to the 2002 data.

State Level. The model's flexibility lends itself to finer divisions of examination, such as scrutiny by state, which then can be used to guide the allocation of MCSAP resources and the design of state safety programs. Because many states manage their intervention program differently, it is also important to analyze state level totals as well as the national totals. The national totals have the ability to obscure state level trends that may occur because of the differences in how the programs are administered.

Figure 7 through Figure 15 provide detailed results for interventions conducted:

- in all fifty states,
- in the District of Columbia
- in American Samoa, Guam, and the Northern Mariana Islands (denoted by State of OT), and
- by federal staff (denoted by US).

These figures provide intervention counts, total estimated benefits (crashes avoided, lives saved, injuries avoided), and normalized estimated benefits (benefits per thousand interventions.

State	Interventions			Estimated Totals				Estimates per 1,000 Roadside Inspections			
	Total	# with Violations	% of Total	Crashes Avoided	Lives Saved	Injuries Avoided	Rank	Crashes Avoided	Lives Saved	Injuries Avoided	Rank
AK	6,690	3,515	52.5%	27.20	1.33	20.93	48	4.07	0.20	3.13	40
AL	36,914	32,981	89.3%	262.96	12.81	202.30	26	7.12	0.35	5.48	16
AR	62,375	36,222	58.1%	167.67	8.17	128.99	34	2.69	0.13	2.07	50
AZ	44,829	42,020	93.7%	666.53	32.47	512.78	4	14.87	0.72	11.44	2
CA	488,378	250,806	51.4%	598.62	29.16	460.53	5	1.23	0.06	0.94	52
CO	59,492	44,726	75.2%	311.25	15.16	239.45	13	5.23	0.25	4.02	30
CT	19,856	18,096	91.1%	223.02	10.87	171.58	29	11.23	0.55	8.64	3
DC	2,119	1,244	58.7%	6.25	0.30	4.81	52	2.95	0.14	2.27	48
DE	4,673	3,727	79.8%	31.76	1.55	24.44	47	6.80	0.33	5.23	20
FL	57,887	46,774	80.8%	373.16	18.18	287.08	18	6.45	0.31	4.96	22
GA	36,601	34,520	94.3%	349.23	17.01	268.67	19	9.54	0.46	7.34	7
HI	5,566	2,559	46.0%	23.08	1.12	17.75	51	4.15	0.20	3.19	38
IA	70,797	59,245	83.7%	219.83	10.71	169.12	25	3.11	0.15	2.39	47
ID	8,196	7,561	92.3%	89.69	4.37	69.00	41	10.94	0.53	8.42	5
IL	92,909	69,067	74.3%	532.21	25.93	409.44	8	5.73	0.28	4.41	28
IN	62,751	58,478	93.2%	430.08	20.95	330.87	12	6.85	0.33	5.27	18
KS	52,085	39,976	76.8%	225.20	10.97	173.25	30	4.32	0.21	3.33	36
KY	79,916	46,431	58.1%	291.56	14.20	224.30	14	3.65	0.18	2.81	43
LA	53,663	44,523	83.0%	205.11	9.99	157.80	32	3.82	0.19	2.94	42
MA	20,643	15,698	76.0%	161.83	7.88	124.50	36	7.84	0.38	6.03	14
MD	94,501	65,026	68.8%	376.10	18.32	289.34	9	3.98	0.19	3.06	41
ME	6,664	5,497	82.5%	42.71	2.08	32.86	44	6.41	0.31	4.93	23
MI	39,515	36,210	91.6%	443.79	21.62	341.41	15	11.23	0.55	8.64	4
MN	43,331	33,060	76.3%	657.78	32.05	506.05	6	15.18	0.74	11.68	1
MO	74,298	57,803	77.8%	645.63	31.46	496.70	2	8.69	0.42	6.69	12
MS	39,681	18,849	47.5%	131.56	6.41	101.21	35	3.32	0.16	2.55	46
MT	48,729	26,584	54.6%	131.78	6.42	101.38	33	2.70	0.13	2.08	49
NC	66,477	54,720	82.3%	230.78	11.24	177.54	28	3.47	0.17	2.67	44
ND	16,902	9,219	54.5%	36.92	1.80	28.41	46	2.18	0.11	1.68	51
NE	18,155	13,718	75.6%	87.03	4.24	66.95	38	4.79	0.23	3.69	31
NH	5,426	4,675	86.2%	47.15	2.30	36.28	45	8.69	0.42	6.69	11
NJ	48,906	40,671	83.2%	428.10	20.86	329.34	17	8.75	0.43	6.73	10
NM	62,101	47,150	75.9%	255.15	12.43	196.29	24	4.11	0.20	3.16	39
NV	13,160	10,009	76.1%	109.26	5.32	84.06	39	8.30	0.40	6.39	13
NY	85,966	53,611	62.4%	375.53	18.30	288.90	11	4.37	0.21	3.36	35
OH	77,280	55,550	71.9%	492.64	24.00	379.00	3	6.37	0.31	4.90	24
OK	16,163	12,741	78.8%	106.08	5.17	81.61	40	6.56	0.32	5.05	21
OR	52,677	39,562	75.1%	227.51	11.08	175.03	27	4.32	0.21	3.32	37
PA	70,718	58,649	82.9%	485.62	23.66	373.60	7	6.87	0.33	5.28	17
RI	3,802	3,006	79.1%	21.84	1.06	16.80	50	5.74	0.28	4.42	27
SC	41,103	33,890	82.5%	222.08	10.82	170.85	31	5.40	0.26	4.16	29
SD	29,524	23,396	79.2%	140.03	6.82	107.73	37	4.74	0.23	3.65	32
TN	61,749	53,894	87.3%	386.54	18.83	297.37	20	6.26	0.30	4.82	25
TX	201,796	170,118	84.3%	2,161.32	105.30	1,662.74	1	10.71	0.52	8.24	6
US	40,714	33,556	82.4%	298.83	14.56	229.89	10	7.34	0.36	5.65	15
UT	29,060	22,103	76.1%	264.64	12.89	203.59	22	9.11	0.44	7.01	9
VA	38,813	28,668	73.9%	264.69	12.90	203.63	23	6.82	0.33	5.25	19
VT	4,549	4,081	89.7%	26.89	1.31	20.69	49	5.91	0.29	4.55	26
WA	74,452	62,347	83.7%	341.27	16.63	262.55	21	4.58	0.22	3.53	33
WI	29,414	22,627	76.9%	277.83	13.54	213.74	16	9.45	0.46	7.27	8
WV	20,807	12,443	59.8%	69.03	3.36	53.11	43	3.32	0.16	2.55	45
WY	19,056	13,450	70.6%	86.01	4.19	66.17	42	4.51	0.22	3.47	34
OT	4,576	3,056	66.8%	69.69	3.40	53.62		15.23	0.74	11.72	
Total	**2,746,405**	**1,988,108**	**72.4%**	**15,138.06**	**737.53**	**11,646.02**		**342.02**	**16.66**	**263.12**	

Figure 7. 2001 State Level TE & RI Program Benefits

	Total	Roadside Inspections				Estimated Totals				Estimates per 1,000 Roadside Inspections			
State	**Initiating Interventions**	**Number**	**% of Total**	**# with DR/VH**	**% of Total**	**Crashes Avoided**	**Lives Saved**	**Injuries Avoided**	**Rank**	**Crashes Avoided**	**Lives Saved**	**Injuries Avoided**	**Rank**
AK	6,690	5,929	88.6%	2,754	41.2%	20.83	1.02	16.03	48	3.51	0.17	2.70	42
AL	36,914	23,439	63.5%	19,506	52.8%	176.46	8.60	135.76	26	7.53	0.37	5.79	18
AR	62,375	45,460	72.9%	19,307	31.0%	117.12	5.71	90.10	34	2.58	0.13	1.98	50
AZ	44,829	22,707	50.7%	19,898	44.4%	412.06	20.08	317.00	4	18.15	0.88	13.96	2
CA	488,378	427,758	87.6%	190,186	38.9%	409.26	19.94	314.85	5	0.96	0.05	0.74	52
CO	59,492	49,628	83.4%	34,862	58.6%	267.65	13.04	205.91	13	5.39	0.26	4.15	32
CT	19,856	13,987	70.4%	12,227	61.6%	165.02	8.04	126.96	29	11.80	0.57	9.08	5
DC	2,119	1,840	86.8%	965	45.5%	5.30	0.26	4.08	52	2.88	0.14	2.22	48
DE	4,673	3,554	76.1%	2,608	55.8%	24.31	1.18	18.70	47	6.84	0.33	5.26	21
FL	57,887	34,786	60.1%	23,673	40.9%	249.16	12.14	191.68	18	7.16	0.35	5.51	19
GA	36,601	22,633	61.8%	20,552	56.2%	244.13	11.89	187.82	19	10.79	0.53	8.30	8
HI	5,566	4,619	83.0%	1,612	29.0%	13.46	0.66	10.36	51	2.91	0.14	2.24	47
IA	70,797	54,533	77.0%	42,981	60.7%	180.00	8.77	138.48	25	3.30	0.16	2.54	44
ID	8,196	5,184	63.3%	4,549	55.5%	63.13	3.08	48.57	41	12.18	0.59	9.37	4
IL	92,909	46,652	50.2%	22,810	24.6%	305.00	14.86	234.64	8	6.54	0.32	5.03	24
IN	62,751	24,584	39.2%	20,311	32.4%	272.69	13.29	209.78	12	11.09	0.54	8.53	6
KS	52,085	33,738	64.8%	21,629	41.5%	152.44	7.43	117.28	30	4.52	0.22	3.48	35
KY	79,916	66,572	83.3%	33,087	41.4%	262.21	12.78	201.73	14	3.94	0.19	3.03	38
LA	53,663	33,120	61.7%	23,980	44.7%	127.09	6.19	97.77	32	3.84	0.19	2.95	40
MA	20,643	10,728	52.0%	5,783	28.0%	93.92	4.58	72.25	36	8.75	0.43	6.74	13
MD	94,501	80,303	85.0%	50,828	53.8%	300.51	14.64	231.19	9	3.74	0.18	2.88	41
ME	6,664	4,866	73.0%	3,699	55.5%	32.35	1.58	24.89	44	6.65	0.32	5.12	23
MI	39,515	12,853	32.5%	9,548	24.2%	259.81	12.66	199.87	15	20.21	0.98	15.55	1
MN	43,331	24,980	57.6%	14,709	33.9%	394.89	19.24	303.80	6	15.81	0.77	12.16	3
MO	74,298	55,310	74.4%	38,815	52.2%	482.18	23.49	370.95	2	8.72	0.42	6.71	14
MS	39,681	37,851	95.4%	17,019	42.9%	112.09	5.46	86.23	35	2.96	0.14	2.28	46
MT	48,729	43,624	89.5%	21,479	44.1%	117.66	5.73	90.51	33	2.70	0.13	2.07	49
NC	66,477	49,471	74.4%	37,714	56.7%	166.65	8.12	128.21	28	3.37	0.16	2.59	43
ND	16,902	12,369	73.2%	4,686	27.7%	27.53	1.34	21.18	46	2.23	0.11	1.71	51
NE	18,155	13,464	74.2%	9,027	49.7%	74.45	3.63	57.28	38	5.53	0.27	4.25	31
NH	5,426	3,362	62.0%	2,611	48.1%	30.83	1.50	23.72	45	9.17	0.45	7.05	11
NJ	48,906	28,748	58.8%	20,513	41.9%	258.40	12.59	198.79	17	8.99	0.44	6.91	12
NM	62,101	43,358	69.8%	28,407	45.7%	186.19	9.07	143.24	24	4.29	0.21	3.30	37
NV	13,160	9,661	73.4%	6,510	49.5%	73.18	3.57	56.30	39	7.57	0.37	5.83	17
NY	85,966	73,770	85.8%	41,415	48.2%	284.31	13.85	218.73	11	3.85	0.19	2.97	39
OH	77,280	66,391	85.9%	44,661	57.8%	416.48	20.29	320.41	3	6.27	0.31	4.83	27
OK	16,163	9,004	55.7%	5,582	34.5%	68.49	3.34	52.69	40	7.61	0.37	5.85	16
OR	52,677	37,182	70.6%	24,067	45.7%	172.45	8.40	132.67	27	4.64	0.23	3.57	34
PA	70,718	54,509	77.1%	42,440	60.0%	346.99	16.91	266.94	7	6.37	0.31	4.90	26
RI	3,802	2,511	66.0%	1,715	45.1%	14.91	0.73	11.47	50	5.94	0.29	4.57	29
SC	41,103	21,705	52.8%	14,492	35.3%	147.83	7.20	113.73	31	6.81	0.33	5.24	22
SD	29,524	18,588	63.0%	12,460	42.2%	93.03	4.53	71.57	37	5.00	0.24	3.85	33
TN	61,749	25,775	41.7%	17,920	29.0%	241.15	11.75	185.52	20	9.36	0.46	7.20	10
TX	201,796	192,399	95.3%	160,721	79.6%	2,079.44	101.31	1,599.76	1	10.81	0.53	8.31	7
US	40,714	40,272	98.9%	33,114	81.3%	287.20	13.99	220.95	10	7.13	0.35	5.49	20
UT	29,060	22,481	77.4%	15,524	53.4%	191.97	9.35	147.69	22	8.54	0.42	6.57	15
VA	38,813	30,232	77.9%	20,087	51.8%	189.53	9.23	145.81	23	6.27	0.31	4.82	28
VT	4,549	2,761	60.7%	2,293	50.4%	18.00	0.88	13.84	49	6.52	0.32	5.01	25
WA	74,452	40,473	54.4%	28,368	38.1%	224.90	10.96	173.02	21	5.56	0.27	4.27	30
WI	29,414	24,964	84.9%	18,177	61.8%	259.78	12.66	199.86	16	10.41	0.51	8.01	9
WV	20,807	18,034	86.7%	9,670	46.5%	58.79	2.86	45.23	43	3.26	0.16	2.51	45
WY	19,056	13,854	72.7%	8,248	43.3%	61.97	3.02	47.68	42	4.47	0.22	3.44	36
OT	4,576	4,210	92.0%	2,690	58.8%	59.27	2.89	45.60		14.08	0.69	10.83	
Total	**2,746,405**	**2,050,786**	**74.7%**	**1,292,489**	**47.1%**	**11,294.46**	**550.27**	**8,689.06**		**369.48**	**18.00**	**284.25**	

Figure 8. 2001 State Level Roadside Inspection Program Benefits

State	Total Initiating Interventions	Traffic Enforcements Number	Traffic Enforcements % of Total	Estimated Totals Crashes Avoided	Estimated Totals Lives Saved	Estimated Totals Injuries Avoided	Estimated Totals Rank	Per 1,000 Traffic Enforcements Crashes Avoided	Per 1,000 Traffic Enforcements Lives Saved	Per 1,000 Traffic Enforcements Injuries Avoided	Per 1,000 Traffic Enforcements Rank
AK	6,690	761	11.4%	6.37	0.31	4.90	51	8.37	0.41	6.44	15
AL	36,914	13,475	36.5%	86.50	4.21	66.54	15	6.42	0.31	4.94	23
AR	62,375	16,915	27.1%	50.54	2.46	38.88	29	2.99	0.15	2.30	47
AZ	44,829	22,122	49.3%	254.48	12.40	195.77	2	11.50	0.56	8.85	3
CA	488,378	60,620	12.4%	189.35	9.23	145.67	4	3.12	0.15	2.40	46
CO	59,492	9,864	16.6%	43.60	2.12	33.54	31	4.42	0.22	3.40	32
CT	19,856	5,869	29.6%	58.00	2.83	44.62	27	9.88	0.48	7.60	8
DC	2,119	279	13.2%	0.95	0.05	0.73	52	3.39	0.17	2.61	45
DE	4,673	1,119	23.9%	7.45	0.36	5.74	49	6.66	0.32	5.13	22
FL	57,887	23,101	39.9%	124.00	6.04	95.40	11	5.37	0.26	4.13	26
GA	36,601	13,968	38.2%	105.10	5.12	80.85	13	7.52	0.37	5.79	17
HI	5,566	947	17.0%	9.61	0.47	7.39	46	10.15	0.49	7.81	7
IA	70,797	16,264	23.0%	39.83	1.94	30.64	32	2.45	0.12	1.88	50
ID	8,196	3,012	36.7%	26.55	1.29	20.43	36	8.82	0.43	6.78	9
IL	92,909	46,257	49.8%	227.21	11.07	174.80	3	4.91	0.24	3.78	30
IN	62,751	38,167	60.8%	157.40	7.67	121.09	8	4.12	0.20	3.17	34
KS	52,085	18,347	35.2%	72.76	3.54	55.98	22	3.97	0.19	3.05	37
KY	79,916	13,344	16.7%	29.34	1.43	22.58	35	2.20	0.11	1.69	51
LA	53,663	20,543	38.3%	78.02	3.80	60.03	17	3.80	0.19	2.92	39
MA	20,643	9,915	48.0%	67.91	3.31	52.24	25	6.85	0.33	5.27	21
MD	94,501	14,198	15.0%	75.58	3.68	58.15	19	5.32	0.26	4.10	27
ME	6,664	1,798	27.0%	10.36	0.50	7.97	44	5.76	0.28	4.43	24
MI	39,515	26,662	67.5%	183.98	8.96	141.54	5	6.90	0.34	5.31	20
MN	43,331	18,351	42.4%	262.89	12.81	202.25	1	14.33	0.70	11.02	2
MO	74,298	18,988	25.6%	163.46	7.96	125.75	7	8.61	0.42	6.62	12
MS	39,681	1,830	4.6%	19.47	0.95	14.98	38	10.64	0.52	8.19	5
MT	48,729	5,105	10.5%	14.13	0.69	10.87	41	2.77	0.13	2.13	48
NC	66,477	17,006	25.6%	64.12	3.12	49.33	26	3.77	0.18	2.90	40
ND	16,902	4,533	26.8%	9.39	0.46	7.22	47	2.07	0.10	1.59	52
NE	18,155	4,691	25.8%	12.58	0.61	9.67	42	2.68	0.13	2.06	49
NH	5,426	2,064	38.0%	16.33	0.80	12.56	40	7.91	0.39	6.09	16
NJ	48,906	20,158	41.2%	169.70	8.27	130.55	6	8.42	0.41	6.48	14
NM	62,101	18,743	30.2%	68.97	3.36	53.06	24	3.68	0.18	2.83	42
NV	13,160	3,499	26.6%	36.08	1.76	27.76	34	10.31	0.50	7.93	6
NY	85,966	12,196	14.2%	91.21	4.44	70.17	14	7.48	0.36	5.75	18
OH	77,280	10,889	14.1%	76.15	3.71	58.59	18	6.99	0.34	5.38	19
OK	16,163	7,159	44.3%	37.60	1.83	28.92	33	5.25	0.26	4.04	28
OR	52,677	15,495	29.4%	55.06	2.68	42.36	28	3.55	0.17	2.73	43
PA	70,718	16,209	22.9%	138.63	6.75	106.65	10	8.55	0.42	6.58	13
RI	3,802	1,291	34.0%	6.93	0.34	5.33	50	5.37	0.26	4.13	25
SC	41,103	19,398	47.2%	74.24	3.62	57.12	21	3.83	0.19	2.94	38
SD	29,524	10,936	37.0%	47.00	2.29	36.16	30	4.30	0.21	3.31	33
TN	61,749	35,974	58.3%	145.40	7.08	111.86	9	4.04	0.20	3.11	36
TX	201,796	9,397	4.7%	81.87	3.99	62.99	16	8.71	0.42	6.70	11
US	40,714	442	1.1%	11.63	0.57	8.95	43	26.31	1.28	20.24	1
UT	29,060	6,579	22.6%	72.67	3.54	55.91	23	11.05	0.54	8.50	4
VA	38,813	8,581	22.1%	75.16	3.66	57.82	20	8.76	0.43	6.74	10
VT	4,549	1,788	39.3%	8.89	0.43	6.84	48	4.97	0.24	3.83	29
WA	74,452	33,979	45.6%	116.38	5.67	89.53	12	3.42	0.17	2.63	44
WI	29,414	4,450	15.1%	18.04	0.88	13.88	39	4.05	0.20	3.12	35
WV	20,807	2,773	13.3%	10.24	0.50	7.88	45	3.69	0.18	2.84	41
WY	19,056	5,202	27.3%	24.04	1.17	18.50	37	4.62	0.23	3.56	31
OT	4,576	366	8.0%	10.42	0.51	8.02		28.48	1.39	21.91	
Total	**2,746,405**	**695,619**	**25.3%**	**3,843.60**	**187.26**	**2,956.96**		**363.53**	**17.71**	**279.67**	

Figure 9. 2001 State Level Traffic Enforcement Program Benefits

State	Interventions			Estimated Totals				Estimates per 1,000 Roadside Inspections			
	Number	# with Violations	% of Total	Crashes Avoided	Lives Saved	Injuries Avoided	Rank	Crashes Avoided	Lives Saved	Injuries Avoided	Rank
AK	7,713	4,224	54.8%	38.79	1.80	29.30	45	5.03	0.23	3.80	30
AL	35,271	31,773	90.1%	250.72	11.63	189.35	27	7.11	0.33	5.37	16
AR	69,541	41,271	59.3%	221.91	10.30	167.59	30	3.19	0.15	2.41	48
AZ	42,938	40,323	93.9%	712.05	33.04	537.75	3	16.58	0.77	12.52	1
CA	497,968	254,093	51.0%	662.65	30.75	500.44	4	1.33	0.06	1.00	52
CO	59,962	44,798	74.7%	332.57	15.43	251.16	21	5.55	0.26	4.19	28
CT	24,414	22,542	92.3%	315.75	14.65	238.46	22	12.93	0.60	9.77	3
DC	6,348	3,812	60.1%	18.26	0.85	13.79	52	2.88	0.13	2.17	50
DE	4,837	3,894	80.5%	35.55	1.65	26.85	47	7.35	0.34	5.55	15
FL	64,767	52,673	81.3%	418.37	19.41	315.96	16	6.46	0.30	4.88	20
GA	46,268	44,238	95.6%	565.89	26.26	427.37	9	12.23	0.57	9.24	4
HI	6,498	3,167	48.7%	28.62	1.33	21.61	50	4.40	0.20	3.33	35
IA	69,978	58,532	83.6%	229.12	10.63	173.04	29	3.27	0.15	2.47	46
ID	8,794	7,911	90.0%	82.31	3.82	62.16	42	9.36	0.43	7.07	10
IL	95,929	72,695	75.8%	602.77	27.97	455.22	7	6.28	0.29	4.75	22
IN	68,478	63,110	92.2%	453.57	21.05	342.54	13	6.62	0.31	5.00	18
KS	59,977	44,602	74.4%	256.44	11.90	193.66	26	4.28	0.20	3.23	36
KY	107,036	49,949	46.7%	309.56	14.36	233.78	23	2.89	0.13	2.18	49
LA	53,005	38,704	73.0%	195.97	9.09	148.00	32	3.70	0.17	2.79	42
MA	19,300	14,560	75.4%	115.19	5.34	86.99	39	5.97	0.28	4.51	27
MD	93,489	63,286	67.7%	384.25	17.83	290.19	17	4.11	0.19	3.10	39
ME	6,772	5,691	84.0%	41.21	1.91	31.12	44	6.09	0.28	4.60	26
MI	53,321	48,923	91.8%	553.69	25.69	418.15	10	10.38	0.48	7.84	6
MN	45,749	35,173	76.9%	595.33	27.62	449.60	8	13.01	0.60	9.83	2
MO	75,260	57,849	76.9%	762.71	35.39	576.00	2	10.13	0.47	7.65	8
MS	43,608	22,008	50.5%	146.49	6.80	110.63	35	3.36	0.16	2.54	44
MT	41,715	23,944	57.4%	134.55	6.24	101.61	36	3.23	0.15	2.44	47
NC	55,904	46,028	82.3%	211.92	9.83	160.04	31	3.79	0.18	2.86	41
ND	14,257	8,366	58.7%	30.79	1.43	23.25	48	2.16	0.10	1.63	51
NE	25,634	17,940	70.0%	118.90	5.52	89.80	38	4.64	0.22	3.50	31
NH	5,328	4,147	77.8%	35.57	1.65	26.87	46	6.68	0.31	5.04	17
NJ	57,352	47,402	82.7%	607.87	28.20	459.07	6	10.60	0.49	8.00	5
NM	74,338	57,230	77.0%	308.21	14.30	232.76	24	4.15	0.19	3.13	38
NV	15,291	12,411	81.2%	152.46	7.07	115.14	34	9.97	0.46	7.53	9
NY	126,956	69,927	55.1%	418.43	19.41	316.00	15	3.30	0.15	2.49	45
OH	76,312	61,632	80.8%	617.15	28.64	466.08	5	8.09	0.38	6.11	13
OK	15,089	11,885	78.8%	91.93	4.27	69.43	40	6.09	0.28	4.60	25
OR	53,193	38,523	72.4%	242.67	11.26	183.26	28	4.56	0.21	3.45	33
PA	83,112	66,654	80.2%	550.15	25.53	415.48	11	6.62	0.31	5.00	19
RI	4,379	3,454	78.9%	27.46	1.27	20.74	51	6.27	0.29	4.74	23
SC	37,324	30,780	82.5%	172.85	8.02	130.54	33	4.63	0.21	3.50	32
SD	27,109	21,602	79.7%	120.61	5.60	91.09	37	4.45	0.21	3.36	34
TN	54,410	47,657	87.6%	348.10	16.15	262.89	19	6.40	0.30	4.83	21
TX	213,669	181,800	85.1%	2,180.54	101.18	1,646.76	1	10.21	0.47	7.71	7
US	83,194	67,219	80.8%	440.76	20.45	332.87	14	5.30	0.25	4.00	29
UT	36,609	26,350	72.0%	293.42	13.61	221.59	25	8.01	0.37	6.05	14
VA	40,655	31,620	77.8%	334.97	15.54	252.97	20	8.24	0.38	6.22	12
VT	4,806	4,311	89.7%	29.47	1.37	22.26	49	6.13	0.28	4.63	24
WA	116,236	93,686	80.6%	459.50	21.32	347.02	12	3.95	0.18	2.99	40
WI	42,548	34,628	81.4%	364.91	16.93	275.59	18	8.58	0.40	6.48	11
WV	20,819	12,640	60.7%	71.46	3.32	53.97	43	3.43	0.16	2.59	43
WY	20,939	14,671	70.1%	89.32	4.14	67.46	41	4.27	0.20	3.22	37
OT	4,083	2,752	67.4%	53.79	2.50	40.63		13.18	0.61	9.95	
Total	**3,018,482**	**2,169,060**	**71.9%**	**16,837.52**	**781.26**	**12,715.86**		**341.41**	**15.84**	**257.84**	

Figure 10. 2002 State Level TE & RI Program Benefits

State	Total Initiating Intervention	Roadside Inspections				Estimated Totals				Estimates per 1,000 Roadside Inspections			
		Number	% of Total	# with DR/VH	% of Total	Crashes Avoided	Lives Saved	Injuries Avoided	Rank	Crashes Avoided	Lives Saved	Injuries Avoided	Rank
AK	7,713	6,552	84.9%	3,063	39.7%	28.00	1.30	21.15	45	4.27	0.20	3.23	36
AL	35,271	22,275	63.2%	18,777	53.2%	167.54	7.77	126.53	29	7.52	0.35	5.68	17
AR	69,541	49,926	71.8%	21,656	31.1%	152.89	7.09	115.47	30	3.06	0.14	2.31	47
AZ	42,938	21,752	50.7%	19,137	44.6%	428.23	19.87	323.40	5	19.69	0.91	14.87	1
CA	497,968	435,130	87.4%	191,255	38.4%	476.53	22.11	359.88	3	1.10	0.05	0.83	52
CO	59,962	49,220	82.1%	34,056	56.8%	280.97	13.04	212.19	18	5.71	0.26	4.31	28
CT	24,414	16,739	68.6%	14,867	60.9%	230.92	10.71	174.39	22	13.80	0.64	10.42	3
DC	6,348	5,242	82.6%	2,706	42.6%	14.33	0.66	10.82	52	2.73	0.13	2.06	50
DE	4,837	3,094	64.0%	2,151	44.5%	25.18	1.17	19.01	46	8.14	0.38	6.15	14
FL	64,767	40,122	61.9%	28,028	43.3%	277.74	12.89	209.75	20	6.92	0.32	5.23	18
GA	46,268	30,417	65.7%	28,387	61.4%	404.42	18.77	305.42	7	13.30	0.62	10.04	4
HI	6,498	5,269	81.1%	1,938	29.8%	16.16	0.75	12.20	51	3.07	0.14	2.32	46
IA	69,978	51,796	74.0%	40,350	57.7%	178.73	8.29	134.98	27	3.45	0.16	2.61	41
ID	8,794	4,987	56.7%	4,104	46.7%	57.15	2.65	43.16	42	11.46	0.53	8.65	6
IL	95,929	49,577	51.7%	26,343	27.5%	342.60	15.90	258.74	10	6.91	0.32	5.22	19
IN	68,478	29,651	43.3%	24,283	35.5%	284.50	13.20	214.86	17	9.59	0.45	7.25	11
KS	59,977	39,311	65.5%	23,936	39.9%	169.85	7.88	128.27	28	4.32	0.20	3.26	35
KY	107,036	93,255	87.1%	36,168	33.8%	279.70	12.98	211.24	19	3.00	0.14	2.27	48
LA	53,005	33,668	63.5%	19,367	36.5%	115.40	5.35	87.15	34	3.43	0.16	2.59	42
MA	19,300	9,824	50.9%	5,084	26.3%	64.45	2.99	48.68	40	6.56	0.30	4.95	23
MD	93,489	78,502	84.0%	48,299	51.7%	289.94	13.45	218.97	16	3.69	0.17	2.79	39
ME	6,772	4,916	72.6%	3,835	56.6%	31.24	1.45	23.60	44	6.36	0.29	4.80	25
MI	53,321	18,458	34.6%	14,060	26.4%	315.27	14.63	238.09	13	17.08	0.79	12.90	2
MN	45,749	25,472	55.7%	14,896	32.6%	334.11	15.50	252.32	12	13.12	0.61	9.91	5
MO	75,260	47,557	63.2%	30,146	40.1%	478.99	22.23	361.74	2	10.07	0.47	7.61	10
MS	43,608	42,664	97.8%	21,064	48.3%	139.28	6.46	105.18	32	3.26	0.15	2.47	43
MT	41,715	37,285	89.4%	19,514	46.8%	119.41	5.54	90.18	33	3.20	0.15	2.42	45
NC	55,904	41,740	74.7%	31,864	57.0%	152.61	7.08	115.25	31	3.66	0.17	2.76	40
ND	14,257	10,332	72.5%	4,441	31.1%	22.99	1.07	17.36	48	2.22	0.10	1.68	51
NE	25,634	20,760	81.0%	13,066	51.0%	103.97	4.82	78.52	36	5.01	0.23	3.78	31
NH	5,328	3,920	73.6%	2,739	51.4%	25.03	1.16	18.90	47	6.38	0.30	4.82	24
NJ	57,352	34,235	59.7%	24,285	42.3%	351.24	16.30	265.26	9	10.26	0.48	7.75	8
NM	74,338	50,918	68.5%	33,810	45.5%	216.00	10.02	163.13	23	4.24	0.20	3.20	37
NV	15,291	9,944	65.0%	7,064	46.2%	95.19	4.42	71.89	37	9.57	0.44	7.23	12
NY	126,956	110,362	86.9%	53,333	42.0%	304.05	14.11	229.62	14	2.76	0.13	2.08	49
OH	76,312	59,206	77.6%	44,526	58.3%	457.65	21.24	345.62	4	7.73	0.36	5.84	15
OK	15,089	8,035	53.3%	4,831	32.0%	55.11	2.56	41.62	43	6.86	0.32	5.18	20
OR	53,193	41,581	78.2%	26,911	50.6%	189.39	8.79	143.03	26	4.55	0.21	3.44	32
PA	83,112	64,959	78.2%	48,501	58.4%	391.38	18.16	295.58	8	6.03	0.28	4.55	27
RI	4,379	3,093	70.6%	2,168	49.5%	16.95	0.79	12.80	50	5.48	0.25	4.14	29
SC	37,324	18,660	50.0%	12,116	32.5%	113.54	5.27	85.75	35	6.08	0.28	4.60	26
SD	27,109	17,202	63.5%	11,695	43.1%	77.78	3.61	58.74	38	4.52	0.21	3.41	33
TN	54,410	19,220	35.3%	12,467	22.9%	198.13	9.19	149.63	24	10.31	0.48	7.79	7
TX	213,669	202,999	95.0%	171,130	80.1%	2,082.44	96.63	1,572.68	1	10.26	0.48	7.75	9
US	83,194	82,390	99.0%	66,415	79.8%	428.09	19.86	323.30	6	5.20	0.24	3.92	30
UT	36,609	28,374	77.5%	18,115	49.5%	194.52	9.03	146.90	25	6.86	0.32	5.18	21
VA	40,655	30,961	76.2%	21,926	53.9%	237.71	11.03	179.52	21	7.68	0.36	5.80	16
VT	4,806	2,749	57.2%	2,254	46.9%	18.83	0.87	14.22	49	6.85	0.32	5.17	22
WA	116,236	66,694	57.4%	44,144	38.0%	296.07	13.74	223.59	15	4.44	0.21	3.35	34
WI	42,548	37,153	87.3%	29,233	68.7%	335.47	15.57	253.35	11	9.03	0.42	6.82	13
WV	20,819	18,193	87.4%	10,014	48.1%	59.30	2.75	44.79	41	3.26	0.15	2.46	44
WY	20,939	15,881	75.8%	9,613	45.9%	65.46	3.04	49.43	39	4.12	0.19	3.11	38
OT	4,083	3,699	90.6%	2,368	58.0%	42.72	1.98	32.26		11.55	0.54	8.72	
Total	**3,018,482**	**2,255,921**	**74.7%**	**1,406,499**	**46.6%**	**12,235.17**	**567.71**	**9,240.12**		**359.71**	**16.69**	**271.66**	

Figure 11. 2002 State Level Roadside Inspection Program Benefits

State	Total Initiating Intervention	Traffic Enforcements		Estimated Totals				Estimates per 1,000 Traffic Enforcements			
		Number	% of Total	Crashes Avoided	Lives Saved	Injuries Avoided	Rank	Crashes Avoided	Lives Saved	Injuries Avoided	Rank
AK	7,713	1,161	15.1%	10.79	0.50	8.15	44	9.29	0.43	7.02	13
AL	35,271	12,996	36.8%	83.18	3.86	62.82	23	6.40	0.30	4.83	22
AR	69,541	19,615	28.2%	69.02	3.20	52.12	25	3.52	0.16	2.66	44
AZ	42,938	21,186	49.3%	283.82	13.17	214.34	1	13.40	0.62	10.12	2
CA	497,968	62,838	12.6%	186.12	8.64	140.56	7	2.96	0.14	2.24	49
CO	59,962	10,742	17.9%	51.60	2.39	38.97	30	4.80	0.22	3.63	32
CT	24,414	7,675	31.4%	84.84	3.94	64.07	22	11.05	0.51	8.35	6
DC	6,348	1,106	17.4%	3.93	0.18	2.97	52	3.55	0.16	2.68	43
DE	4,837	1,743	36.0%	10.37	0.48	7.83	48	5.95	0.28	4.49	24
FL	64,767	24,645	38.1%	140.64	6.53	106.21	14	5.71	0.26	4.31	25
GA	46,268	15,851	34.3%	161.47	7.49	121.95	10	10.19	0.47	7.69	9
HI	6,498	1,229	18.9%	12.46	0.58	9.41	42	10.14	0.47	7.66	10
IA	69,978	18,182	26.0%	50.39	2.34	38.06	32	2.77	0.13	2.09	50
ID	8,794	3,807	43.3%	25.16	1.17	19.00	37	6.61	0.31	4.99	21
IL	95,929	46,352	48.3%	260.17	12.07	196.48	4	5.61	0.26	4.24	26
IN	68,478	38,827	56.7%	169.07	7.84	127.68	8	4.35	0.20	3.29	36
KS	59,977	20,666	34.5%	86.59	4.02	65.39	21	4.19	0.19	3.16	39
KY	107,036	13,781	12.9%	29.86	1.39	22.55	35	2.17	0.10	1.64	51
LA	53,005	19,337	36.5%	80.57	3.74	60.85	24	4.17	0.19	3.15	41
MA	19,300	9,476	49.1%	50.74	2.35	38.32	31	5.35	0.25	4.04	29
MD	93,489	14,987	16.0%	94.30	4.38	71.22	19	6.29	0.29	4.75	23
ME	6,772	1,856	27.4%	9.97	0.46	7.53	49	5.37	0.25	4.05	28
MI	53,321	34,863	65.4%	238.42	11.06	180.06	6	6.84	0.32	5.16	20
MN	45,749	20,277	44.3%	261.22	12.12	197.28	3	12.88	0.60	9.73	3
MO	75,260	27,703	36.8%	283.71	13.16	214.26	2	10.24	0.48	7.73	8
MS	43,608	944	2.2%	7.21	0.33	5.44	51	7.64	0.35	5.77	17
MT	41,715	4,430	10.6%	15.14	0.70	11.44	39	3.42	0.16	2.58	45
NC	55,904	14,164	25.3%	59.31	2.75	44.79	26	4.19	0.19	3.16	40
ND	14,257	3,925	27.5%	7.81	0.36	5.90	50	1.99	0.09	1.50	52
NE	25,634	4,874	19.0%	14.93	0.69	11.28	40	3.06	0.14	2.31	48
NH	5,328	1,408	26.4%	10.55	0.49	7.97	46	7.49	0.35	5.66	18
NJ	57,352	23,117	40.3%	256.63	11.91	193.81	5	11.10	0.52	8.38	5
NM	74,338	23,420	31.5%	92.21	4.28	69.64	20	3.94	0.18	2.97	42
NV	15,291	5,347	35.0%	57.27	2.66	43.25	28	10.71	0.50	8.09	7
NY	126,956	16,594	13.1%	114.38	5.31	86.38	15	6.89	0.32	5.21	19
OH	76,312	17,106	22.4%	159.50	7.40	120.45	11	9.32	0.43	7.04	12
OK	15,089	7,054	46.7%	36.82	1.71	27.81	34	5.22	0.24	3.94	30
OR	53,193	11,612	21.8%	53.28	2.47	40.24	29	4.59	0.21	3.47	35
PA	83,112	18,153	21.8%	158.77	7.37	119.90	12	8.75	0.41	6.61	15
RI	4,379	1,286	29.4%	10.51	0.49	7.94	47	8.17	0.38	6.17	16
SC	37,324	18,664	50.0%	59.30	2.75	44.79	27	3.18	0.15	2.40	47
SD	27,109	9,907	36.5%	42.83	1.99	32.34	33	4.32	0.20	3.26	37
TN	54,410	35,190	64.7%	149.96	6.96	113.25	13	4.26	0.20	3.22	38
TX	213,669	10,670	5.0%	98.09	4.55	74.08	17	9.19	0.43	6.94	14
US	83,194	804	1.0%	12.67	0.59	9.57	41	15.76	0.73	11.90	1
UT	36,609	8,235	22.5%	98.90	4.59	74.69	16	12.01	0.56	9.07	4
VA	40,655	9,694	23.8%	97.26	4.51	73.45	18	10.03	0.47	7.58	11
VT	4,806	2,057	42.8%	10.64	0.49	8.04	45	5.17	0.24	3.91	31
WA	116,236	49,542	42.6%	163.44	7.58	123.43	9	3.30	0.15	2.49	46
WI	42,548	5,395	12.7%	29.44	1.37	22.23	36	5.46	0.25	4.12	27
WV	20,819	2,626	12.6%	12.15	0.56	9.18	43	4.63	0.21	3.50	34
WY	20,939	5,058	24.2%	23.87	1.11	18.02	38	4.72	0.22	3.56	33
OT	4,083	384	9.4%	11.07	0.51	8.36		28.84	1.34	21.78	
Total	**3,018,482**	**762,561**	**25.3%**	**4,602.34**	**213.55**	**3,475.74**		**371.16**	**17.22**	**280.30**	

Figure 12. 2002 State Level Traffic Enforcement Program Benefits

	Interventions			Estimated Totals				Estimates per 1,000 Roadside Inspections			
State	**Number**	**# with Violations**	**% of Total**	**Crashes Avoided**	**Lives Saved**	**Injuries Avoided**	**Rank**	**Crashes Avoided**	**Lives Saved**	**Injuries Avoided**	**Rank**
AK	8,473	4,475	52.8%	44.12	1.86	33.60	46	5.21	0.22	3.97	28
AL	28,202	28,534	101.2%	199.42	8.40	151.88	32	7.07	0.30	5.39	16
AR	62,919	39,214	62.3%	236.31	9.95	179.98	27	3.76	0.16	2.86	44
AZ	37,794	38,045	100.7%	651.71	27.45	496.34	5	17.24	0.73	13.13	1
CA	486,322	299,068	61.5%	1,002.73	42.23	763.68	2	2.06	0.09	1.57	52
CO	68,760	46,256	67.3%	399.45	16.82	304.22	15	5.81	0.24	4.42	26
CT	21,957	22,181	101.0%	260.93	10.99	198.73	25	11.88	0.50	9.05	3
DC	3,499	3,266	93.3%	9.63	0.41	7.33	52	2.75	0.12	2.10	50
DE	4,368	3,411	78.1%	30.68	1.29	23.36	49	7.02	0.30	5.35	17
FL	69,461	51,129	73.6%	417.28	17.58	317.80	13	6.01	0.25	4.58	24
GA	99,961	58,132	58.2%	953.76	40.17	726.38	3	9.54	0.40	7.27	7
HI	5,079	2,896	57.0%	20.12	0.85	15.32	51	3.96	0.17	3.02	39
IA	70,240	55,941	79.6%	209.25	8.81	159.36	31	2.98	0.13	2.27	49
ID	8,709	8,508	97.7%	82.12	3.46	62.55	42	9.43	0.40	7.18	8
IL	87,858	64,075	72.9%	450.36	18.97	342.99	11	5.13	0.22	3.90	29
IN	57,119	56,518	98.9%	392.27	16.52	298.75	17	6.87	0.29	5.23	18
KS	62,125	43,702	70.3%	236.72	9.97	180.28	26	3.81	0.16	2.90	43
KY	97,006	49,147	50.7%	292.73	12.33	222.94	23	3.02	0.13	2.30	48
LA	51,768	42,314	81.7%	228.31	9.62	173.88	28	4.41	0.19	3.36	34
MA	21,241	13,216	62.2%	128.23	5.40	97.66	37	6.04	0.25	4.60	23
MD	95,576	64,777	67.8%	439.81	18.52	334.96	12	4.60	0.19	3.50	32
ME	8,666	6,628	76.5%	57.49	2.42	43.79	43	6.63	0.28	5.05	19
MI	58,473	49,407	84.5%	514.76	21.68	392.04	9	8.80	0.37	6.70	12
MN	35,137	32,184	91.6%	512.63	21.59	390.42	10	14.59	0.61	11.11	2
MO	74,755	58,918	78.8%	788.37	33.21	600.42	4	10.55	0.44	8.03	4
MS	54,392	22,125	40.7%	211.70	8.92	161.23	30	3.89	0.16	2.96	41
MT	41,737	23,923	57.3%	139.67	5.88	106.37	36	3.35	0.14	2.55	47
NC	36,312	41,901	115.4%	165.03	6.95	125.69	34	4.54	0.19	3.46	33
ND	15,212	7,947	52.2%	32.41	1.37	24.69	48	2.13	0.09	1.62	51
NE	26,909	18,435	68.5%	112.81	4.75	85.92	38	4.19	0.18	3.19	38
NH	9,588	5,049	52.7%	57.09	2.40	43.48	44	5.95	0.25	4.53	25
NJ	38,739	40,095	103.5%	402.49	16.95	306.54	14	10.39	0.44	7.91	6
NM	73,564	54,838	74.5%	354.92	14.95	270.31	21	4.82	0.20	3.67	30
NV	20,785	13,413	64.5%	178.26	7.51	135.76	33	8.58	0.36	6.53	13
NY	91,015	67,562	74.2%	398.93	16.80	303.83	16	4.38	0.18	3.34	35
OH	73,868	63,503	86.0%	609.35	25.67	464.08	6	8.25	0.35	6.28	14
OK	14,970	12,312	82.2%	96.47	4.06	73.47	40	6.44	0.27	4.91	20
OR	45,194	37,200	82.3%	215.80	9.09	164.35	29	4.77	0.20	3.64	31
PA	74,670	66,104	88.5%	580.21	24.44	441.89	7	7.77	0.33	5.92	15
RI	3,893	3,555	91.3%	24.64	1.04	18.77	50	6.33	0.27	4.82	21
SC	32,555	30,231	92.9%	140.86	5.93	107.28	35	4.33	0.18	3.30	37
SD	27,042	21,013	77.7%	106.05	4.47	80.77	39	3.92	0.17	2.99	40
TN	59,818	48,121	80.4%	365.48	15.39	278.35	20	6.11	0.26	4.65	22
TX	239,489	181,054	75.6%	2,235.46	94.16	1,702.53	1	9.33	0.39	7.11	9
US	108,827	67,634	62.1%	377.03	15.88	287.14	19	3.46	0.15	2.64	46
UT	32,689	26,005	79.6%	291.71	12.29	222.17	24	8.92	0.38	6.80	11
VA	39,124	32,138	82.1%	350.07	14.74	266.61	22	8.95	0.38	6.81	10
VT	6,602	5,157	78.1%	37.01	1.56	28.19	47	5.61	0.24	4.27	27
WA	138,385	102,204	73.9%	532.71	22.44	405.71	8	3.85	0.16	2.93	42
WI	36,976	33,775	91.3%	385.83	16.25	293.85	18	10.43	0.44	7.95	5
WV	15,962	13,170	82.5%	56.84	2.39	43.29	45	3.56	0.15	2.71	45
WY	20,171	14,613	72.4%	87.38	3.68	66.55	41	4.33	0.18	3.30	36
OT	2,963	2,637	89.0%	45.14	1.90	34.38		15.23	0.64	11.60	
Total	**3,006,919**	**2,197,656**	**73.1%**	**17,150.54**	**722.38**	**13,061.85**		**343.02**	**14.45**	**261.24**	

Figure 13. 2003 State Level TE & RI Program Benefits

State	Total Initiating Interventions	Roadside Inspections				Estimated Totals				Estimates per 1,000 Roadside Inspections			
		Number	% of Total	# with DR/VH	% of Total	Crashes Avoided	Lives Saved	Injuries Avoided	Rank	Crashes Avoided	Lives Saved	Injuries Avoided	Rank
AK	8,473	7,061	83.3%	3,063	36.2%	30.75	1.30	23.42	46	4.35	0.18	3.32	35
AL	28,202	18,445	65.4%	18,777	66.6%	136.90	5.77	104.27	31	7.42	0.31	5.65	18
AR	62,919	45,361	72.1%	21,656	34.4%	161.37	6.80	122.90	29	3.56	0.15	2.71	43
AZ	37,794	18,886	50.0%	19,137	50.6%	391.11	16.47	297.87	7	20.71	0.87	15.77	1
CA	486,322	378,509	77.8%	191,255	39.3%	720.36	30.34	548.63	2	1.90	0.08	1.45	52
CO	68,760	56,560	82.3%	34,056	49.5%	342.00	14.41	260.47	10	6.05	0.25	4.61	27
CT	21,957	14,643	66.7%	14,867	67.7%	186.24	7.84	141.84	26	12.72	0.54	9.69	4
DC	3,499	2,939	84.0%	2,706	77.3%	7.69	0.32	5.86	52	2.62	0.11	1.99	50
DE	4,368	3,108	71.2%	2,151	49.2%	21.71	0.91	16.54	49	6.99	0.29	5.32	20
FL	69,461	46,360	66.7%	28,028	40.4%	288.43	12.15	219.67	15	6.22	0.26	4.74	25
GA	99,961	70,216	70.2%	28,387	28.4%	705.08	29.70	536.99	3	10.04	0.42	7.65	9
HI	5,079	4,121	81.1%	1,938	38.2%	11.88	0.50	9.05	51	2.88	0.12	2.20	49
IA	70,240	54,649	77.8%	40,350	57.4%	166.66	7.02	126.93	28	3.05	0.13	2.32	48
ID	8,709	4,305	49.4%	4,104	47.1%	52.86	2.23	40.26	42	12.28	0.52	9.35	5
IL	87,858	50,126	57.1%	26,343	30.0%	275.81	11.62	210.06	17	5.50	0.23	4.19	28
IN	57,119	24,884	43.6%	24,283	42.5%	244.68	10.31	186.35	21	9.83	0.41	7.49	10
KS	62,125	42,359	68.2%	23,936	38.5%	159.53	6.72	121.50	30	3.77	0.16	2.87	41
KY	97,006	84,027	86.6%	36,168	37.3%	261.21	11.00	198.94	18	3.11	0.13	2.37	47
LA	51,768	28,821	55.7%	19,367	37.4%	135.13	5.69	102.92	32	4.69	0.20	3.57	32
MA	21,241	13,109	61.7%	5,084	23.9%	80.30	3.38	61.16	38	6.13	0.26	4.67	26
MD	95,576	79,098	82.8%	48,299	50.5%	333.17	14.03	253.74	12	4.21	0.18	3.21	38
ME	8,666	5,873	67.8%	3,835	44.3%	39.12	1.65	29.80	44	6.66	0.28	5.07	21
MI	58,473	23,126	39.5%	14,060	24.0%	314.48	13.25	239.51	13	13.60	0.57	10.36	3
MN	35,137	17,849	50.8%	14,896	42.4%	282.99	11.92	215.53	16	15.85	0.67	12.08	2
MO	74,755	45,983	61.5%	30,146	40.3%	506.48	21.33	385.74	4	11.01	0.46	8.39	6
MS	54,392	53,331	98.0%	21,064	38.7%	199.36	8.40	151.83	24	3.74	0.16	2.85	42
MT	41,737	37,328	89.4%	19,514	46.8%	123.67	5.21	94.18	33	3.31	0.14	2.52	45
NC	36,312	26,275	72.4%	31,864	87.8%	119.16	5.02	90.75	34	4.54	0.19	3.45	33
ND	15,212	11,706	77.0%	4,441	29.2%	25.91	1.09	19.73	47	2.21	0.09	1.69	51
NE	26,909	21,540	80.0%	13,066	48.6%	96.44	4.06	73.45	36	4.48	0.19	3.41	34
NH	9,588	7,278	75.9%	2,739	28.6%	38.75	1.63	29.51	45	5.32	0.22	4.05	29
NJ	38,739	22,929	59.2%	24,285	62.7%	242.39	10.21	184.60	22	10.57	0.45	8.05	8
NM	73,564	52,536	71.4%	33,810	46.0%	255.01	10.74	194.22	19	4.85	0.20	3.70	30
NV	20,785	14,436	69.5%	7,064	34.0%	112.23	4.73	85.47	35	7.77	0.33	5.92	17
NY	91,015	76,786	84.4%	53,333	58.6%	292.61	12.32	222.85	14	3.81	0.16	2.90	40
OH	73,868	54,891	74.3%	44,526	60.3%	434.71	18.31	331.08	5	7.92	0.33	6.03	15
OK	14,970	7,489	50.0%	4,831	32.3%	59.07	2.49	44.99	41	7.89	0.33	6.01	16
OR	45,194	34,905	77.2%	26,911	59.5%	167.72	7.06	127.73	27	4.80	0.20	3.66	31
PA	74,670	57,067	76.4%	48,501	65.0%	416.64	17.55	317.32	6	7.30	0.31	5.56	19
RI	3,893	2,506	64.4%	2,168	55.7%	15.85	0.67	12.07	50	6.33	0.27	4.82	23
SC	32,555	14,440	44.4%	12,116	37.2%	90.31	3.80	68.78	37	6.25	0.26	4.76	24
SD	27,042	17,724	65.5%	11,695	43.2%	69.97	2.95	53.29	39	3.95	0.17	3.01	39
TN	59,818	24,164	40.4%	12,467	20.8%	218.80	9.22	166.64	23	9.05	0.38	6.90	12
TX	239,489	229,565	95.9%	171,130	71.5%	2,158.39	90.91	1,643.83	1	9.40	0.40	7.16	11
US	108,827	107,608	98.9%	66,415	61.0%	367.73	15.49	280.06	8	3.42	0.14	2.60	44
UT	32,689	24,799	75.9%	18,115	55.4%	197.55	8.32	150.45	25	7.97	0.34	6.07	14
VA	39,124	28,912	73.9%	21,926	56.0%	244.73	10.31	186.39	20	8.46	0.36	6.45	13
VT	6,602	3,699	56.0%	2,254	34.1%	24.41	1.03	18.59	48	6.60	0.28	5.03	22
WA	138,385	80,325	58.0%	44,144	31.9%	340.31	14.33	259.18	11	4.24	0.18	3.23	37
WI	36,976	32,434	87.7%	29,233	79.1%	355.07	14.96	270.42	9	10.95	0.46	8.34	7
WV	15,962	12,806	80.2%	10,014	62.7%	41.65	1.75	31.72	43	3.25	0.14	2.48	46
WY	20,171	15,171	75.2%	9,613	47.7%	65.25	2.75	49.69	40	4.30	0.18	3.28	36
OT	2,963	2,694	90.9%	2,368	79.9%	37.34	1.57	28.44		13.86	0.58	10.56	
Total	**3,006,919**	**2,215,762**	**73.7%**	**1,406,499**	**46.8%**	**12,666.99**	**533.53**	**9,647.18**		**361.71**	**15.24**	**275.48**	

Figure 14. 2003 State Level Roadside Inspection Program Benefits

State	Total Initiating Interventions	Traffic Enforcements		Estimated Totals				Estimates per 1,000 Traffic Enforcements			
		Number	% of Total	Crashes Avoided	Lives Saved	Injuries Avoided	Rank	Crashes Avoided	Lives Saved	Injuries Avoided	Rank
AK	8,473	1,412	16.7%	13.37	0.56	10.18	44	9.47	0.40	7.21	10
AL	28,202	9,757	34.6%	62.52	2.63	47.61	26	6.41	0.27	4.88	24
AR	62,919	17,558	27.9%	74.95	3.16	57.08	23	4.27	0.18	3.25	39
AZ	37,794	18,908	50.0%	260.60	10.98	198.47	3	13.78	0.58	10.50	1
CA	486,322	107,813	22.2%	282.37	11.89	215.05	1	2.62	0.11	1.99	50
CO	68,760	12,200	17.7%	57.45	2.42	43.75	27	4.71	0.20	3.59	32
CT	21,957	7,314	33.3%	74.69	3.15	56.89	24	10.21	0.43	7.78	7
DC	3,499	560	16.0%	1.94	0.08	1.47	52	3.46	0.15	2.63	45
DE	4,368	1,260	28.8%	8.96	0.38	6.83	48	7.11	0.30	5.42	19
FL	69,461	23,101	33.3%	128.85	5.43	98.13	14	5.58	0.23	4.25	28
GA	99,961	29,745	29.8%	248.67	10.47	189.39	4	8.36	0.35	6.37	14
HI	5,079	958	18.9%	8.23	0.35	6.27	50	8.59	0.36	6.54	13
IA	70,240	15,591	22.2%	42.59	1.79	32.44	32	2.73	0.12	2.08	49
ID	8,709	4,404	50.6%	29.27	1.23	22.29	37	6.65	0.28	5.06	21
IL	87,858	37,732	42.9%	174.54	7.35	132.93	9	4.63	0.19	3.52	34
IN	57,119	32,235	56.4%	147.59	6.22	112.41	12	4.58	0.19	3.49	35
KS	62,125	19,766	31.8%	77.19	3.25	58.79	21	3.91	0.16	2.97	42
KY	97,006	12,979	13.4%	31.52	1.33	24.01	35	2.43	0.10	1.85	51
LA	51,768	22,947	44.3%	93.18	3.92	70.96	20	4.06	0.17	3.09	41
MA	21,241	8,132	38.3%	47.93	2.02	36.50	30	5.89	0.25	4.49	26
MD	95,576	16,478	17.2%	106.64	4.49	81.22	15	6.47	0.27	4.93	23
ME	8,666	2,793	32.2%	18.37	0.77	13.99	39	6.58	0.28	5.01	22
MI	58,473	35,347	60.5%	200.28	8.44	152.53	6	5.67	0.24	4.32	27
MN	35,137	17,288	49.2%	229.63	9.67	174.89	5	13.28	0.56	10.12	2
MO	74,755	28,772	38.5%	281.88	11.87	214.68	2	9.80	0.41	7.46	9
MS	54,392	1,061	2.0%	12.34	0.52	9.40	46	11.63	0.49	8.86	4
MT	41,737	4,409	10.6%	16.00	0.67	12.19	42	3.63	0.15	2.76	44
NC	36,312	10,037	27.6%	45.87	1.93	34.94	31	4.57	0.19	3.48	36
ND	15,212	3,506	23.0%	6.51	0.27	4.96	51	1.86	0.08	1.41	52
NE	26,909	5,369	20.0%	16.37	0.69	12.47	41	3.05	0.13	2.32	47
NH	9,588	2,310	24.1%	18.34	0.77	13.97	40	7.94	0.33	6.05	15
NJ	38,739	15,810	40.8%	160.11	6.74	121.94	11	10.13	0.43	7.71	8
NM	73,564	21,028	28.6%	99.91	4.21	76.09	18	4.75	0.20	3.62	31
NV	20,785	6,349	30.5%	66.03	2.78	50.29	25	10.40	0.44	7.92	5
NY	91,015	14,229	15.6%	106.32	4.48	80.98	16	7.47	0.31	5.69	18
OH	73,868	18,977	25.7%	174.64	7.36	133.00	8	9.20	0.39	7.01	12
OK	14,970	7,481	50.0%	37.39	1.58	28.48	33	5.00	0.21	3.81	29
OR	45,194	10,289	22.8%	48.08	2.03	36.62	29	4.67	0.20	3.56	33
PA	74,670	17,603	23.6%	163.57	6.89	124.57	10	9.29	0.39	7.08	11
RI	3,893	1,387	35.6%	8.79	0.37	6.69	49	6.34	0.27	4.83	25
SC	32,555	18,115	55.6%	50.55	2.13	38.50	28	2.79	0.12	2.13	48
SD	27,042	9,318	34.5%	36.09	1.52	27.48	34	3.87	0.16	2.95	43
TN	59,818	35,654	59.6%	146.68	6.18	111.71	13	4.11	0.17	3.13	40
TX	239,489	9,924	4.1%	77.07	3.25	58.70	22	7.77	0.33	5.91	16
US	108,827	1,219	1.1%	9.30	0.39	7.08	47	7.63	0.32	5.81	17
UT	32,689	7,890	24.1%	94.16	3.97	71.71	19	11.93	0.50	9.09	3
VA	39,124	10,212	26.1%	105.34	4.44	80.23	17	10.32	0.43	7.86	6
VT	6,602	2,903	44.0%	12.60	0.53	9.60	45	4.34	0.18	3.31	38
WA	138,385	58,060	42.0%	192.40	8.10	146.53	7	3.31	0.14	2.52	46
WI	36,976	4,542	12.3%	30.76	1.30	23.43	36	6.77	0.29	5.16	20
WV	15,962	3,156	19.8%	15.19	0.64	11.57	43	4.81	0.20	3.67	30
WY	20,171	5,000	24.8%	22.13	0.93	16.85	38	4.43	0.19	3.37	37
OT	2,963	269	9.1%	7.79	0.33	5.93		28.97	1.22	22.06	
Total	**3,006,919**	**791,157**	**26.3%**	**4,483.55**	**188.85**	**3,414.67**		**362.22**	**15.26**	**275.87**	

Figure 15. 2003 State Level Traffic Enforcement Program Benefits

Intervention Model Technical Documentation

Overview

The Intervention Model measures the effectiveness of the roadside inspection and commercial vehicle traffic enforcement programs in terms of safety. The majority of roadside inspections and traffic enforcements are conducted by state personnel under the MCSAP grant program.[1] Effectiveness, for the purposes of this analysis, is defined as the estimated reduction in motor carrier crashes attributable to the existence and implementation of the aforementioned safety programs. The model is a key element of the FMCSA's Safety Program Performance Measures project.

This section presents a more detailed description of the model than that provided in the section entitled "Intervention Model" on page 1. It also contains mathematical explanations of the algorithms employed in the model.

Intervention Data

Raw intervention data serve as the inputs from which all further determinations flow. The data consist of individual records of roadside inspections and traffic enforcements carried out during a given period. The model creates a crashes-avoided figure for each intervention based on the number and type of violations present.

Roadside Inspections

Roadside inspections are interventions performed by qualified safety inspectors using the North American Standard (NAS) guidelines.[2] The NAS is a vehicle and driver inspection structure established by the FMCSA and the Commercial Vehicle Safety Alliance.

Traffic Enforcements

MCSAP traffic enforcements are a subset of traffic enforcements in general.[3] MCSAP traffic enforcements include only those enforcement stops that lead to an on-the-spot roadside inspection. The enforcement agent, if qualified, performs the subsequent roadside inspection. Otherwise, a safety inspector is called to the scene to conduct it. Since a traffic infraction precipitates the ensuing roadside inspection, 21 moving violations are incorporated into the driver section of the roadside checklist.

1 "The MCSAP is a Federal grant program that provides financial assistance to States to reduce the number and severity of accidents … involving commercial motor vehicles (CMVs). … Investing grant monies in appropriate safety programs will increase the likelihood that safety defects, driver deficiencies, and unsafe motor carrier practices will be detected and corrected before they become contributing factors to accidents." http://www.fmcsa.dot.gov/safetyprogs/mcsap.htm.

2 See http://www.inspector.org/37stepin.htm.

The model classifies an intervention as a traffic enforcement intervention when at least one traffic violation is present in the intervention record. The only exception is when one or more drug and alcohol violations (392.4, 392.4A, 392.5, and 392.5A) are the only traffic enforcement violations present. These interventions are counted as roadside inspection interventions rather than traffic enforcement-initiated interventions.

Intervention Level Impact

As the name implies, the Intervention Model places a great deal of importance on individual interventions. The reason for this is that violation tabulations come from interventions and those tabulations are matched against a Violation Crash Risk Probability Profile, which then serves as a basis for determining the number of crashes avoided for a given intervention. Aggregates developed from the intervention-level crashes avoided numbers eventually form national and state statistics.

Violation Crash Risk Probability Profile

The model assumes that observed deficiencies (OOS and non-OOS violations) can be converted into crash risk probabilities. This assumption is based on the belief that detected defects represent varying degrees of mechanical or judgmental faults and, as a result, some are more likely than others to play contributory roles in causing motor carrier crashes. These differences can be estimated and ranked into discrete risk categories. Thus, the Violation Crash Risk Probability Profile (VCRPP) contains all violation codes, each with an assigned risk category and a corresponding crash probability.

Using Cycla's risk categories and the relative weights assigned to the categories, the Volpe Center analysts sought to account for error margins by opting for two probability sets - a Higher Bound set and a Lower Bound set. The outputs computed from the two sets are used to compute a mean with a range of ± 20 percent. Because crash causation data is still forthcoming, users are reminded to employ caution interpreting the Model's results.

The values in Table 6 and Table 7 indicate the Lower Bound and Higher Bound numbers of violations that would have to be discovered to cause the model to credit one of the programs with an avoided crash. Keep in mind, however, the numbers in the tables are not meant to be definitive. They constitute the best guesses of industry experts interpreting available data. Volpe Center analysts used these figures to test and calibrate the model. As more reliable crash causation statistics become available,

[3] § Sec.350.111 of the Federal Motor Carrier Safety Regulations defines a MCSAP traffic enforcement as follows: “Traffic enforcement means enforcement activities of State or local officials, including stopping CMVs operating on highways, streets, or roads for violations of State or local motor vehicle or traffic laws (e.g., speeding, following too closely, reckless driving, improper lane change). To be eligible for funding through the grant, traffic enforcement must include an appropriate North American Standard Inspection of the CMV or driver or both prior to releasing the driver or CMV for resumption of operations.”

table quantities may have to be revised.[4] These revisions will not affect the overall soundness of the model.

Note that in moving from Risk Category (RC) 1 to RC 2, from RC 2 to RC 3, and so on, each step varies by a factor of ten. This tracks Cycla's variation in designated relative weights between risk categories. Note further that the weight given to traffic enforcement violations is four times that of the roadside inspection counterpart violations. Table 6 and Table 7 illustrate the factor and weighting differences. For example, the tenfold factor variation can be seen when Traffic Enforcement RC1 OOS Violations jump from 30 to 300 when stepping to Traffic Enforcement OOS Violations RC2. Additionally, it takes quadruple the number of Roadside Inspection OOS Violations in RC1 (120) to have the same impact as Traffic Enforcement OOS Violations in RC1 (30), demonstrating the reduced weight given to roadside inspection violations vis-à-vis traffic enforcement violations. Volpe Center analysts used the latest, preliminary data available from ongoing crash causation studies to support this difference. The studies found that driver faults represented by traffic enforcement violations are more likely to lead to motor carrier crashes than are roadside-inspection driver or vehicle faults of an equivalent risk category.[5]

Table 6. Lower Bound of Number of Violations to Avoid One Crash

Risk Category	Roadside Inspection		Traffic Enforcement	
	OOS	Non-OOS	OOS	Non-OOS
1	120	240	30	60
2	1,200	2,400	300	600
3	12,000	24,000	3,000	6,000
4	120,000	240,000	30,000	60,000
5	1,200,000	2,400,000	300,000	600,000

Table 7. Higher Bound of Number of Violations to Avoid One Crash

Risk Category	Roadside Inspection		Traffic Enforcement	
	OOS	Non-OOS	OOS	Non-OOS
1	80	160	20	40
2	800	1,600	200	400
3	8,000	1,600	2,000	4,000
4	80,000	16,000	20,000	40,000
5	800,000	160,000	200,000	400,000

4 A Large Truck Crash Causation Study, supported by FMCSA and NHTSA, is underway at the University of Michigan Transportation Research Institute.

5 Ibid.

Table 8 and Table 9 display the higher bound and lower bound probabilities, respectively. The crash reduction probabilities are the reciprocals of the numbers in Table 6 and Table 7, so it follows that the probabilities also experience a tenfold change between steps. The crash reduction probabilities associated with each violation form the VCRPP.

Table 8. Lower Bound Crash Reduction Probabilities

Risk Category	Roadside Inspection		Traffic Enforcement	
	OOS	Non-OOS	OOS	Non-OOS
1	8.33×10^{-3}	4.167×10^{-3}	0.033	0.0167
2	8.33×10^{-4}	4.167×10^{-4}	3.3×10^{-3}	1.67×10^{-3}
3	8.33×10^{-5}	4.167×10^{-5}	3.3×10^{-4}	1.67×10^{-4}
4	8.33×10^{-6}	4.167×10^{-6}	3.3×10^{-5}	1.67×10^{-5}
5	8.33×10^{-7}	4.167×10^{-7}	3.3×10^{-6}	1.67×10^{-6}

Table 9. Higher Bound Crash Reduction Probabilities

Risk Category	Roadside Inspection		Traffic Enforcement	
	OOS	Non-OOS	OOS	Non-OOS
1	0.0125	6.25×10^{-3}	0.05	0.025
2	1.25×10^{-3}	6.25×10^{-4}	5.0×10^{-3}	2.5×10^{-3}
3	1.25×10^{-4}	6.25×10^{-5}	5.0×10^{-4}	2.5×10^{-4}
4	1.25×10^{-5}	6.25×10^{-6}	5.0×10^{-5}	2.5×10^{-5}
5	1.25×10^{-6}	6.25×10^{-7}	5.0×10^{-6}	2.5×10^{-6}

Applied to Recorded Violations. Because each inspection used in the analysis has one or more violations, the model classifies recorded violations according to their VCRPP ratings. Table 10 and Table 11 display the classification process for two example interventions.

Intervention A is a roadside-initiated intervention, since no traffic enforcement violations are present. It contains roadside RC 1 OOS violations and both OOS and non-OOS RC 2 violations. Using the VCRPP, the violations receive their respective probabilities from the Higher Bound and Lower Bound probability sets.

The VCRPP is also applied to Intervention B. Unlike Intervention A, Intervention B is classified as a traffic enforcement-initiated intervention, because it has at least one traffic enforcement violation. Additionally, several roadside violations were identified during the subsequent roadside inspection.

Table 10. Violations for Intervention A

Violation Number	Violation Description	Violation Type	OOS	Risk Category	Lower Risk Probability	Higher Risk Probability
392.5C	Operating a CMV while fatigued	Roadside	Yes	1	8.33×10^{-3}	0.0125
393.9H	Inoperable head lamps	Roadside	Yes	1	8.33×10^{-3}	0.0125
395.3A1	10 hour rule violation	Roadside	Yes	2	8.33×10^{-4}	1.25×10^{-3}
392.14	Failed to use caution for hazardous condition	Roadside	Yes	2	8.33×10^{-4}	1.25×10^{-3}
393.201B	Bolts securing cab broken	Roadside	Yes	2	8.33×10^{-4}	1.25×10^{-3}
393.9T	Inoperable tail lamp	Roadside	No	2	4.167×10^{-4}	6.25×10^{-4}
393.60C	Use of vision reducing matter on windows	Roadside	No	2	4.167×10^{-4}	6.25×10^{-4}
392.9A3	Driver's view is obstructed	Roadside	No	2	4.167×10^{-4}	6.25×10^{-4}
393.77	Prohibited heaters	Roadside	No	2	4.167×10^{-4}	6.25×10^{-4}

Table 11. Violations for Intervention B

Violation Number	Violation Description	Violation Type	OOS	Risk Category	Lower Risk Probability	Higher Risk Probability
393.48A	Inoperative brakes	Roadside	Yes	1	8.33×10^{-3}	0.0125
393.209D	Inoperative steering system component	Roadside	Yes	1	8.33×10^{-3}	0.0125
393.17B	No deflective side marker	Roadside	No	2	4.167×10^{-4}	6.25×10^{-4}
392.9A	Failure to secure load	Roadside	No	2	4.167×10^{-4}	6.25×10^{-4}
392.5	Driver using or in possession of alcohol	Traffic	Yes	1	0.033	0.05
392.2C	Failure to obey traffic control device	Traffic	Yes	2	3.3×10^{-3}	5.0×10^{-3}
392.2P	Improper passing	Traffic	Yes	2	3.3×10^{-3}	5.0×10^{-3}

Occurrences per Risk Category. After the application of the VCRPP, the model aggregates violations occurring in a particular risk category. Table 12 continues with the example interventions from Table 10 and Table 11 by exhibiting the results of the aggregation.

Table 12. Violation Occurrences per Risk Category†

Inspection	Roadside Inspection				Traffic Enforcement			
	RC 1 Viol.		RC 2 Viol.		RC 1 Viol.		RC 2 Viol.	
	OOS	Non-OOS	OOS	Non-OOS	OOS	Non-OOS	OOS	Non-OOS
A	2	0	3	4	0	0	0	0
B	2	0	0	2	1	0	2	0

†. To avoid needless complexity, the examples have been crafted using risk categories 1 and 2, rather than the entire range of risk categories 1 through 5.

Crashes Avoided per Intervention

To generate an intervention's crashes avoided, the number of violation occurrences per risk category is multiplied by the crash probability associated with that risk category. For instance, if four occurrences of roadside OOS violations in RC 1 were noted on an inspection report, then the model would multiply four by the roadside OOS RC 1 probability from the VCRPP. This would be done for all roadside OOS and non-OOS violations, along with all traffic OOS and non-OOS violations. Summing the products creates an initial crash risk reduction for the inspection's risk category being evaluated.

$$ICRR_{rc} = \sum_{t}\sum_{oos} v_{rc,\,t,\,oos} \cdot P_{rc,\,t,\,oos} \qquad [1]$$

where:

Variable	Description	Values
$ICRR$	Initial Crash Risk Reduction	$0...\infty$
v	Number of Violations	$0...\infty$
P	Crash Risk Probability	Table 10, Table 11
rc	Risk Category	1,2,3,4,5
t	Type of Violation	Roadside, Traffic
oos	Out of Service	Yes, No

Next, all violations recorded for a risk category during an intervention, roadside OOS and non-OOS and, if applicable, traffic OOS and non-OOS, are added together. Multiplying the total by the initial crash risk reduction calculated in Equation [1] produces the final crash risk reduction for a given risk category in a particular intervention. Equation [2] is designed to capture the growth in crash risk arising from the discovery and correction of numerous violations during a single intervention. The logic behind this is that, while each violation carries a certain degree of crash risk in isolation, additional violations occurring in tandem elevate the crash risk beyond the mere combined, additive, risk levels caused by each violation alone. In essence, the Final Crash Risk Reduction per Risk Category equation measures the multiplicative crash risk effect of compound safety defects.

$$CRR_{rc} = \left(\sum_{t}\sum_{oos} v_{t,\,oos}\right) \cdot ICRR_{rc} \qquad [2]$$

where CRR_{rc} is the final calculated crash risk reduction for a given risk category within an intervention. Equation [1] and Equation [2] must be calculated for each of the five risk categories.

When all five risk categories have had their respective crash risk reductions determined, the model calculates the intervention's crashes avoided by adding the five CRR_{rc} numbers as shown in Equation [3]. A cap of 0.75 is placed on the outcome for each intervention, thus ensuring that the model never produces a crashes avoided total greater than one. Volpe Center analysts chose three-quarters of a crash avoided as a cap to maintain a more conservative tendency in the model, given the lack of empirical crash causation data.

$$I_A = \sum_{rc} CRR_{rc} \qquad [3]$$

where I_A is the calculated crashes avoided due to an intervention.

Repeating this process using both Higher Bound and Lower Bound probabilities yields the crashes avoided range for each intervention.

Examples

Intervention A. For Intervention A (see Table 10), a vehicle given a roadside inspection is found to have two out-of-service violations in Risk Category 1, three out-of-service violations in Risk Category 2, and four non-out-of-service violations in Risk Category 2. The calculation of the total crashes avoided of this single inspection, using Higher Bound probabilities, appears below.

Multiplying the crash reduction probability for each risk category by the number of out-of-service violations in that risk category and adding it to the product of the risk reduction probability and the number of non-out-of-service violations gives the initial crash risk reduction as formalized by Equation [1].

Risk Category	Higher Bound Calculation
1	$ICRR_1 = 2 \cdot 0.0125 = 0.025$
2	$ICRR_2 = 3 \cdot 0.00125 + 4 \cdot 0.000625 = 0.00625$

Final crash risk reduction becomes known after multiplying the initial crash risk reduction for each risk category by the number of violations in that risk category. The model supplies total crashes avoided for the intervention by tallying the final crash risk reduction from each risk category as formalized by Equation [2] and Equation [3].

Risk Category	Higher Bound Calculation
1	$CRR_1 = 0.025 \cdot 2 = 0.05$
2	$CRR_2 = 0.00625 \cdot 7 = 0.04375$
Total	$I_A = 0.05 + 0.04375 = 0.09375$

Therefore, Inspection A's range of crashes avoided begins at the Higher Bound result, 0.09375, and would extend to the Lower Bound output.

Intervention B. For Intervention B (see Table 11), a traffic enforcement stop has resulted in both traffic enforcement violations and roadside inspection violations. The intervention involved one traffic enforcement out-of-service violation in Risk Category 1 and two out-of-service violations in Risk Category 2. In addition, the inspection involved two roadside out-of-service violations in Risk Category 1 and two non out-of-service violations in Risk Category 2. Inspection B's computations follow:

Risk Category	Higher Bound Calculation
1	$ICRR_1 = 2 \cdot 0.0125 + 1 \cdot 0.05 = 0.075$
2	$ICRR_2 = 2 \cdot 0.000625 + 2 \cdot 0.005 = 0.01125$

To account for multiple violations, the model makes the following intensification adjustments to calculate the final crash risk reduction for each risk category:

Risk Category	Higher Bound Calculation
1	$CRR_1 = 0.075 \cdot 3 = 0.225$
2	$CRR_2 = 0.01125 \cdot 4 = 0.045$
Total	$I_A = 0.225 + 0.045 = 0.27$

The crashes avoided range for Inspection B starts at 0.27 at the higher bound and extends down to the lower bound.

Program Level Impact

Measuring interventions at the program level is next. It is here, however, that the model follows two divergent paths, one measuring direct effects and the other measuring indirect effects. Direct effects, it should be remembered, are the immediate products of roadside inspections and traffic enforcement stops performed in a given year, while indirect effects are based on behavioral changes caused by program awareness.

Direct Effect Approach

This section outlines the development of direct-effect crashes-avoided estimates. Figure 16 shows the process used to determine the direct effects of the programs. First, there is a primary crashes avoided computation. Afterwards, a roadside allocation credits a portion of traffic enforcement crashes avoided to the roadside inspection program, recognizing the contribution to the traffic enforcement total made by the ensuing roadside inspection.

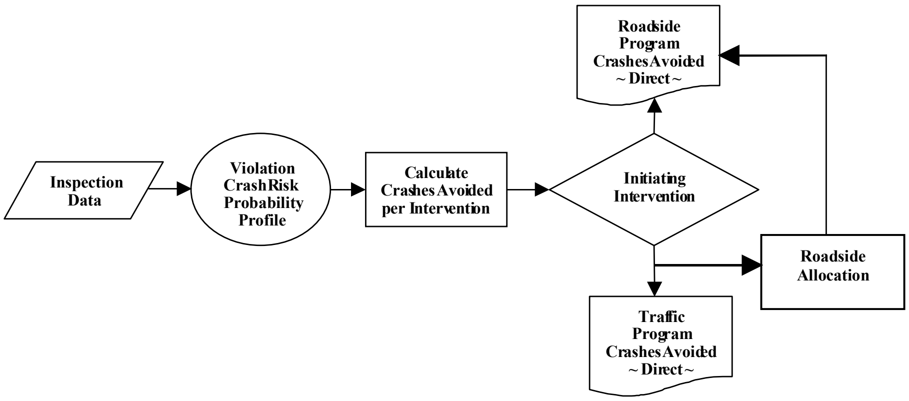


Figure 16. Direct-Effect Approach with Roadside Allowance

Primary Determination. The model initially examines all inspections in a given year in terms of the numbers and types of violations associated with each individual inspection. Based on the VCRPP described above, inspection violations (both OOS and non-OOS) are matched with their respective crash risk reduction probabilities, to produce an estimated range of crashes avoided for that inspection. The model next segregates the complete set of inspections into two groups, depending on whether the initiating intervention was a roadside inspection or a traffic enforcement. Interventions with drug and alcohol violations (392.4, 392.4A, 392.5, and 392.5A) as the only traffic enforcement violations are counted as roadside inspection interventions. The logic behind this is the only way an officer could have identified drug and alcohol violations is by stopping the vehicle, and if the vehicle was not stopped for a moving violation, then it must have been detained as a part of a roadside inspection. Thus these types of interventions are counted as part of the roadside inspection program, but the drug and alcohol violations are assigned the traffic enforcement crash reduction probabilities. Once all of the inspections have been divided among the two programs, the estimated crashes-avoided ranges are summed across all inspections in each program. Two overall estimates of crashes avoided emerge: one for the roadside inspection program and one for the traffic enforcement program.

$$Total_{Roadside} = \sum_{i=1}^{n} I_{j,\,Roadside} \qquad [4]$$

$$Total_{Traffic} = \sum_{i=1}^{n} I_{j,\,Traffic} \qquad [5]$$

Roadside Inspection Allowance. The process, however, does not end with the primary determination. An additional allocation of crashes avoided is necessary. As stated above, when the traffic enforcement action is the initiating event for an inspection, it is appropriate to credit back to the roadside inspection program those crashes avoided due to the correcting of roadside inspection-related violations.

Once the sums for the two groups are computed, these two values are added together to create the denominator for the Roadside Inspection Allowance (*RIA*). The numerator of the *RIA* is merely the estimated crashes avoided for the roadside inspection crashes. This results in the percentage of traffic enforcement crashes that should be allocated back to the roadside inspection program.

$$RIA = \frac{Total_{Roadside}}{Total_{Roadside} + Total_{Traffic}} \quad [6]$$

The final direct effect totals are then:

$$DE_{Roadside} = Total_{Roadside} + Total_{Traffic} \cdot RIA \quad [7]$$

$$DE_{Traffic} = Total_{Traffic} \cdot (1 - RIA) \quad [8]$$

Examples. Continuing with the example interventions, the results of applying Equation [4] through Equation [8] to Intervention A and Intervention B appear below. Intervention A was initiated by a roadside inspection so its total counts toward the roadside inspection program. Intervention B was initiated by a traffic enforcement and thus its total counts toward the traffic enforcement program.

Since Intervention A resulted in 0.09375 crashes avoided and Intervention B resulted in 0.27 crashes avoided, these numbers are summed to arrive at a denominator of 0.36375. The numerator is just the crashes prevented by Intervention A since it is the only intervention with a roadside inspection as the initiating action. Using these numbers the Roadside Inspection Allowance is 25.77%.

$$RIA = \frac{0.09375}{0.09375 + 0.27} = \frac{0.09375}{0.36375} = 0.2577$$

Now that the percentage is determined, the appropriate adjustment to the totals of the roadside inspection and traffic enforcement can be made.

$$DE_{Roadside} = 0.09375 + (0.27 \cdot 0.2577) = 0.163338$$

$$DE_{Traffic} = 0.27 \cdot (1 - 0.2577) = 0.200412$$

Thus, the recalculated higher bound crashes-avoided of the roadside program is 0.163, and the recalculated higher bound crashes-avoided of the traffic program is 0.20.

Indirect-Effect Approach

The fundamental premise of the indirect-effect approach is that once carriers have been exposed to the combination of roadside inspection and traffic enforcement actions, a change in their behavior will be manifested by a reduction in crashes. This section presents a summary of the methods used in the model to arrive at the programs' indirect effects. Figure 17 provides a view of the processes involved in assessing the indirect effects of the model.

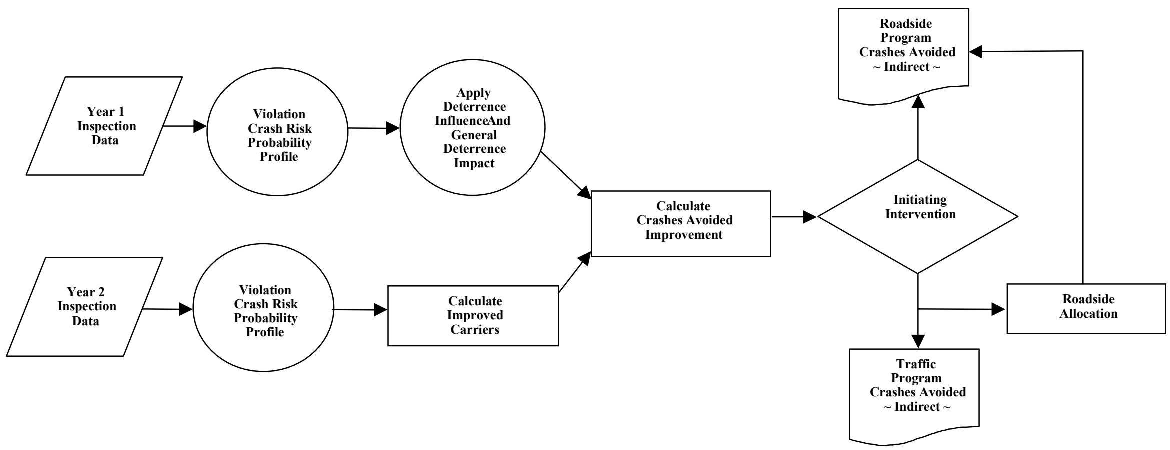


Figure 17. Indirect Effect Approach with Roadside Allocation

Indirect effects require means other than direct measurement to reveal their presence. For that reason, the model uses changes in the number of violations recorded during inspections to identify and evaluate the indirect effects. Specifically, the model's algorithm employs two successive years of inspection data to undertake this process.

To conduct a year-to-year comparison, it is necessary to identify and link the carriers who were inspected with the inspections each received during the two-year span. Only in this way can a cross-year evaluation discern the indirect influence (i.e., behavior modification) that causes a reduction in crashes. In contrast, this inspection-carrier link is not needed in the direct-effect approach.

Modified Approach. As discussed in the executive summary, the method of computing indirect effects was modified so that the results of a program's effectiveness can be computed in the year following the program's execution rather than two years after. This section will discuss the modified approach to computing the indirect effects.

For the years 1998 to 2000, the Intervention Model used the methodology described in the September 2002 report "Intervention Model: Roadside Inspection and Traffic Enforcement Effectiveness Assessment." to compute the indirect program benefits. These benefits are captured in Table 13 and Table 14. Additionally in the tables below, the indirect and direct benefits are measured as a percentage of the total benefits.

For the Roadside Inspection Program the indirect benefits as a percentage of the total appear to be decreasing by roughly one-half a percent per year. For the Traffic Enforcement Program, the trend is not as clear since the percentage increases from 2000 to 2001 before decreasing from 2001 to 2002. These results can be seen in Figure 18.

Table 13. Roadside Inspection Program Benefits 1998 - 2000

	1998		1999		2000	
	Crashes Avoided	% of Total	Crashes Avoided	% of Total	Crashes Avoided	% of Total
Direct	6,995	81.23%	7,455	81.75%	7,723	82.49%
Indirect	1,617	18.77%	469	18.25%	1,640	17.51%
Total	**8,612**		**9,119**		**9,362**	

Table 14. Traffic Enforcement Program Benefits 1998 - 2000

	1998		1999		2000	
	Crashes Avoided	% of Total	Crashes Avoided	% of Total	Crashes Avoided	% of Total
Direct	2,331	83.25%	2,510	83.07%	2,785	84.24%
Indirect	469	16.75%	512	16.93%	521	15.76%
Total	**2,800**		**3,021**		**3,306**	

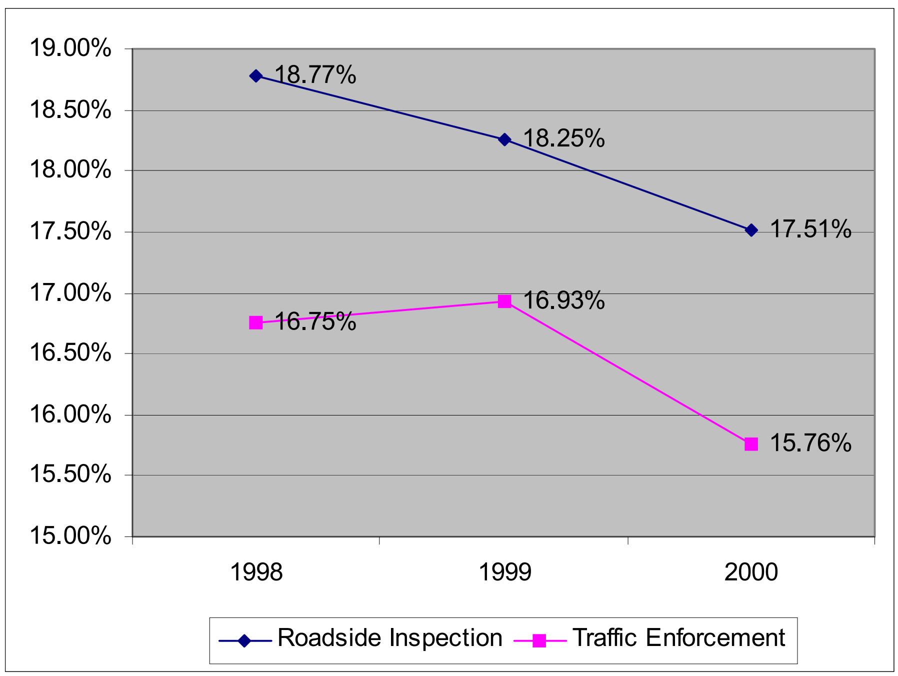


Figure 18. Indirect Benefits as a Percentage of the Total Benefits

As a result of this analysis, it was recommended that the Intervention Model estimate the indirect benefits by using an average for each program rather than waiting for the additional year of data. For each program, an unweighted average of the indirect benefits contribution to the total was computed using the results from 1998 - 2000. The results for each program are shown in Table 15.

Table 15. Indirect Benefits as Percentage of Total

Program	Percentage
Roadside Inspection Program	18.18%
Traffic Enforcement Program	16.48%

The values in Table 15 are not intended to be constants. In fact, they will be continually updated as the second year's worth of data becomes available and the full version of the indirect model can be run.

Since the indirect benefits are measured as a percentage of the total benefits, which are also composed of the indirect benefits, it is necessary to manipulate basic equations in order to express the indirect benefits as a function of the direct benefits.

$$IE_{Roadside} = Pct_{Roadside} \cdot TCA_{Roadside} \quad [9]$$

$$DE_{Roadside} = (1 - Pct_{Roadside}) \cdot TCA_{Roadside} \quad [10]$$

Solving Equation [10] for the Total Crashes Avoided (*TCA*) and substituting that expression into Equation [9] yields the desired result.

$$IE_{Roadside} = Pct_{Roadside} \cdot \frac{DE_{Roadside}}{(1 - Pct_{Roadside})} \quad [11]$$

Similarly for the Traffic Enforcement Program:

$$IE_{Traffic} = Pct_{Traffic} \cdot \frac{DE_{Traffic}}{(1 - Pct_{Traffic})} \quad [12]$$

Examples. Continuing with Intervention A and Intervention B yields the following results for the program level indirect benefits.

$$IE_{Roadside} = 0.1818 \cdot \frac{0.163338}{(1 - 0.1818)} = 0.03629$$

$$IE_{Traffic} = 0.1648 \cdot \frac{0.200412}{(1 - 0.1648)} = 0.03955$$

Program Benefits

Crash severity varies. Some crashes may result in no more than minor property damage, while others may result in bodily harm or loss of life. Of the many gradations possible, two classifications of crashes suffice for calculating program benefits, fatal crashes and injury crashes. Any motor carrier crash that results in at least one fatality is a fatal crash. A fatal crash may also involve injuries, but the fatality governs the crash's classification. Any motor carrier crash that results in at least one injury requiring transport for immediate medical attention but no fatalities, is an injury crash.

Statistics of fatal and injury crashes supply the basis for creating lives saved and injuries avoided figures. This follows NHTSA established practice, which expresses program benefits in terms of lives saved and injuries avoided. Fatal crashes avoided translate to lives saved and injuries avoided, while injury crashes avoided translate to injuries avoided. Figure 19 shows the process used to calculate program benefits.

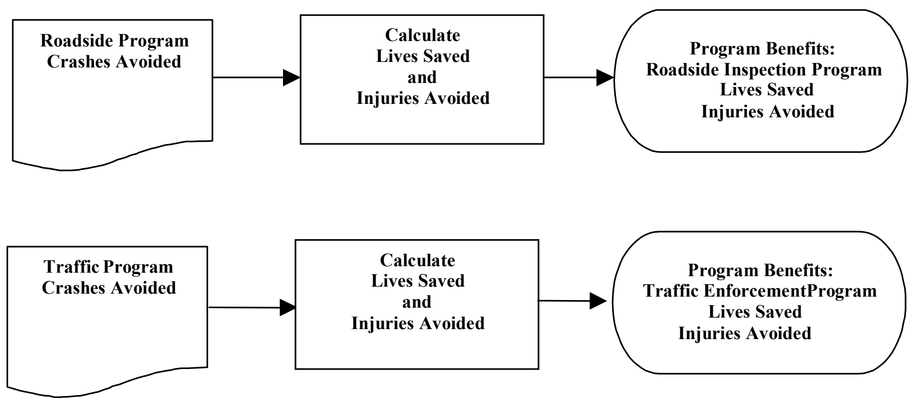


Figure 19. Program Benefits Determination

Obtaining program benefits from estimated crashes-avoided figures requires two prior determinations, the first being a proportional identification of crashes by severity and the second being the average numbers of fatalities and injuries per crash.

Using the state-reported crash data in MCMIS, the shares of fatal, injury, and towaway[6] crashes were determined at a national level for the years 2000 through 2003. These values are shown in Table 16. In order to smooth out yearly fluctuations, the Intervention Model uses a two-year average in partitioning the crashes avoided into fatal and injury crashes. The two-year averages used to estimate the 2001 through 2003 safety benefits are shown in Table 17.

[6] 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.

Table 16. Crash Severity Shares

	2000	2001	2002	2003
% Fatal Crashes	4.4%	4.1%	4.0%	3.3%
% Injury Crashes	48.2%	46.6%	47.7%	47.2%
% Towaway Crashes	47.4%	49.3%	48.3%	49.5%

Table 17. Two Year Average of Crash Severity Shares

	2000 - 01	2001 - 02	2002 - 03
% Fatal Crashes	4.2%	4.0%	3.6%
% Injury Crashes	47.4%	47.1%	47.5%
% Towaway Crashes	48.4%	48.9%	48.9%

In the second step in the determination of program benefits, the expected number of fatalities and injuries per crash type are used to compute the lives saved and injuries avoided. The average number of fatalities per fatal crash was calculated from FARS crash data. 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 in the MCMIS were used to compute the average numbers of injuries in fatal and injury crashes in a given year. These values (see Table 18) are recomputed each year and used in the program benefits calculations. In order to be consistent with the Compliance Review

Table 18. Average Numbers of Fatalities and Injuries by Year

	2000	2001	2002	2003
Fatalities Per Fatal Crash	1.16	1.15	1.17	1.17
Injuries Per Fatal Crash	1.03	1.08	1.13	1.07
Injuries Per Injury Crash	1.55	1.50	1.51	1.52

Effectiveness Model and to smooth yearly fluctuations, a two-year average (see Table 19) is used by the Intervention Model to estimate the lives saved and injuries avoided.

Table 19. Two Year Average of Fatalities and Injuries

	2000 - 01	2001 - 02	2002 - 03
Fatalities Per Fatal Crash	1.16	1.16	1.17
Injuries Per Fatal Crash	1.05	1.10	1.10
Injuries Per Injury Crash	1.53	1.51	1.52

The input to the program benefits portion of the model requires the union of crashes avoided attributable to direct effects and indirect effects. The program benefits calculations use the output of Equation [13] and Equation [14]. The calculations entail the development of estimated totals of crashes by severity as well as the final tally of lives saved and injuries avoided.

$$TCA_{Roadside} = DE_{Roadside} + IE_{Roadside} \quad [13]$$

$$TCA_{Traffic} = DE_{Traffic} + IE_{Traffic} \quad [14]$$

where *TCA* is the Total Crashes Avoided for each of the programs (Roadside Inspection and Traffic Enforcement).

Fatal and Injury Crashes Avoided

The model breaks out program crashes-avoided figures into the numbers of program crashes avoided by severity. The expected number of fatal crashes avoided are computed as follows:

$$FCA_{Roadside} = TCA_{Roadside} \cdot Prob_{Fatal} \quad [15]$$

$$FCA_{Traffic} = Total_{Traffic} \cdot Prob_{Fatal} \quad [16]$$

where *FCA* is the Fatal Crashes Avoided for each of the programs (Roadside Inspection and Traffic Enforcement) and $Prob_{Fatal}$ is the probability of a fatal crash given a crash.

The expected number of injury crashes avoided are computed as follows:

$$ICA_{Roadside} = TCA_{Roadside} \cdot Prob_{Injury} \quad [17]$$

$$ICA_{Traffic} = Total_{Traffic} \cdot Prob_{Injury} \quad [18]$$

where *ICA* is the Injury Crashes Avoided for each of the programs (Roadside Inspection and Traffic Enforcement) and $Prob_{Injury}$ is the probability of a injury crash given a crash.

Lives Saved

To calculate the number of lives saved, the number of fatal crashes avoided is multiplied by the average number of fatalities per fatal crash.

$$LS_{Roadside} = FCA_{Roadside} \cdot Fatals_{FC} \quad [19]$$

$$LS_{Traffic} = FCA_{Traffic} \cdot Fatals_{FC} \quad [20]$$

where *LS* is the Lives Saved for each of the programs and $Fatals_{FC}$ is the average number of fatalities per fatal crash.

Injuries Avoided

To calculate the number of injuries avoided, the number of fatal crashes avoided is multiplied by the average number of injuries per fatal crash, and the number of injury crashes avoided is multiplied by the average number of injuries per injury crash. The two products are then added to obtain the total number of injuries avoided.

$$IA_{Roadside} = FCA_{Roadside} \cdot Injuries_{FC} + ICA_{Roadside} \cdot Injuries_{IC} \quad [21]$$

$$IA_{Traffic} = FCA_{Traffic} \cdot Injuries_{FC} + ICA_{Traffic} \cdot Injuries_{IC} \quad [22]$$

where IA is the Injuries Avoided for each of the programs, $Injuries_{FC}$ is the average number of injuries per fatal crash, and $Injuries_{IC}$ is the average number of injuries per injury crash.

Examples

Continuing with the example interventions, the program benefits are estimated using the 2001 - 2002 averages. The first step is to apply Equation [13] and Equation [14] to determine the total crashes avoided for each program.

$$TCA_{Roadside} = DE_{Roadside} + IE_{Roadside} = 0.16338 + 0.03629 = 0.19963$$

$$TCA_{Traffic} = DE_{Traffic} + IE_{Traffic} = 0.20041 + 0.03955 = 0.23996$$

Now that the total number of crashes avoided has been computed, these crashes can be partitioned into the expected number of injury and fatality accidents according to Equation [15] through Equation [18].

Fatal Crashes Avoided.

$$FCA_{Roadside} = TCA_{Roadside} \cdot Prob_{Fatal} = 0.19963 \cdot 0.04 = 7.99 \times 10^{-3}$$

$$FCA_{Traffic} = Total_{Traffic} \cdot Prob_{Fatal} = 0.23996 \cdot 0.04 = 9.60 \times 10^{-3}$$

Injury Crashes Avoided.

$$ICA_{Roadside} = TCA_{Roadside} \cdot Prob_{Injury} = 0.19963 \cdot 0.471 = 9.40 \times 10^{-2}$$

$$ICA_{Traffic} = Total_{Traffic} \cdot Prob_{Injury} = 0.19963 \cdot 0.471 = 0.113$$

The second step in the computation of the overall program benefits is to apply Equation [19] through Equation [22] to determine the number of lives saved and the number of injuries avoided.

Lives Saved.

$$LS_{Roadside} = FCA_{Roadside} \cdot Fatals_{FC} = 7.99 \times 10^{-3} \cdot 1.16 = 9.26 \times 10^{-3}$$

$$LS_{Traffic} = FCA_{Traffic} \cdot Fatals_{FC} = 9.60 \times 10^{-3} \cdot 1.16 = 1.11 \times 10^{-2}$$

Injuries Avoided.

$$IA_{Roadside} = 7.99 \times 10^{-3} \cdot 1.10 + 9.40 \times 10^{-2} \cdot 1.51 = 0.15076$$

$$IA_{Traffic} = 9.60 \times 10^{-3} \cdot 1.10 + 0.113 \cdot 1.51 = 0.18122$$

Table 20 summarizes the program benefits from the two example interventions.

Table 20. Example Program Benefits

	Crashes Avoided	Lives Saved	Injuries Avoided
Roadside Inspection	0.19963	0.00926	0.15076
Traffic Enforcement	0.23969	0.01113	0.18122
Intervention Model Total	**0.43959**	**0.02040**	**0.33198**

Violations

Roadside Inspection Violations

Violation is the potential single, immediate factor leading to a crash or injuries/fatalities from a given crash.

Risk Category 1

Table 21. Roadside Inspection Category 1 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	0.0125	6.25×10^{-3}
Lower Bound	8.33×10^{-3}	4.167×10^{-3}
Mean	1.04×10^{-3}	5.208×10^{-3}

Table 22. Roadside Inspection Category 1 Violations

Violation Code	Violation Type	Source	Description
392.3	Driver	Cycla	Operating a CMV while ill/fatigued
392.5C2	Driver	Cycla	Violation OOS order pursuant to 392.5(a)/(b)
393.207B	Equipment	Cycla	Adjacent axle locking pin missing/disengaged
393.209D	Equipment	Cycla	Steering system components worn/welded/missing
393.42	Equipment	Cycla	No brakes as required
393.42A	Equipment	Volpe	No brakes on all wheels as required
393.42B	Equipment	Volpe	No/defective front wheel brakes as required
393.48A	Equipment	Cycla	Inoperative/defective brakes
393.70B2	Equipment	Cycla	Defective fifth wheel locking mechanism
393.70C	Equipment	Cycla	Defective coupling devices for full trailer
393.71	Equipment	Cycla	Improper coupling driveaway/towaway operation
393.75A	Equipment	Cycla	Flat tire or fabric exposed
393.75A1	Equipment	Cycla	Tire-ply or belt material exposed
393.75A2	Equipment	Cycla	Tire-tread and/or sidewall separation
393.75A3	Equipment	Cycla	Tire-flat and/or audible air leak
393.75A4	Equipment	Cycla	Tire-cut exposing ply and/or belt material
393.9H	Equipment	Cycla	Inoperable head lamps
396.9C	Driver	Volpe	Operating OOS vehicle

Table 22. Roadside Inspection Category 1 Violations

Violation Code	Violation Type	Source	Description
396.9C2	Driver	Cycla	Operating OOS vehicle
398.4	Driver	Cycla	Driving migrant workers
398.5	Equipment	Cycla	Parts/access-migrant workers

Risk Category 2

Violation is the potential single, eventual factor leading to a crash or injuries/fatalities from a given crash.

Table 23. Roadside Inspection Category 2 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	1.25×10^{-3}	6.25×10^{-4}
Lower Bound	8.33×10^{-4}	4.167×10^{-4}
Mean	1.04×10^{-4}	5.208×10^{-4}

Table 24. Roadside Inspection Category 2 Violations

Violation Code	Violation Type	Source	Description
383.23A	Driver	Volpe	Operating a CMV without a valid CDL
383.23A2	Driver	Cycla	Operating a CMV without a CDL
383.23A2C1	Driver	Volpe	Operating on learner's permit w/o CDL holder
383.23C	Driver	Volpe	Operating on learner's permit w/o CDL holder
383.23C1	Driver	Cycla	Operating on learner's permit w/o CDL holder
383.51A	Driver	Cycla	Driving a CMV (CDL) while disqualified
391.11	Driver	Volpe	All other driver violations
391.11B4	Driver	Volpe	Operating commercial vehicle w/o corrective lenses
391.11B5	Driver	Volpe	Not licensed for type vehicle being operated
391.11B6	Driver	Cycla	Operating CMV w/o corrective lenses
391.11B7	Driver	Cycla	No or invalid driver's license CMV
391.15	Driver	Volpe	Driver disqualified
391.15A	Driver	Cycla	Driving a CMV while disqualified
392.14	Driver	Cycla	Failed to use caution for hazardous condition
392.33	Equipment	Cycla	Operating CMV with lamps/reflectors obscured
392.6	Driver	Volpe	All other driver violations
392.71A	Driver	Cycla	Using or equipping a CMV with radar detector
392.8	Driver	Cycla	Failing to inspect/use emergency equipment

Table 24. Roadside Inspection Category 2 Violations

Violation Code	Violation Type	Source	Description
392.9	Driver or Equipment	Volpe	Driver load secure
392.9A	Driver	Volpe	Failing to secure load
392.9A1	Driver	Cycla	Failing to secure cargo/393.100-393.106
392.9A2	Driver	Cycla	Failing to secure vehicle equipment
392.9A3	Equipment	Cycla	Driver's view/movement is obstructed
392.9AAR	Driver	Volpe	
392.9AAS	Driver	Volpe	
393.100	Equipment	Volpe	No or improper load securement
393.100A	Equipment	Cycla	No or improper load securement
393.100B	Equipment	Volpe	No or improper load securement
393.100C	Equipment	Volpe	No or improper load securement
393.100E	Equipment	Cycla	Improper securement of intermodal containers
393.102	Equipment	Cycla	Improper securement system (tiedown assemblies)
393.102A	Equipment	Cycla	Improper securement system (tiedown assemblies)
393.102A1	Equipment	Volpe	Improper securement system (tiedown assemblies)
393.102B	Equipment	Cycla	Improper securement system (tiedown assemblies)
393.104	Equipment	Volpe	Improper blocking and/or bracing
393.104A	Equipment	Cycla	Improper blocking and/or bracing-longitudinal
393.104B	Equipment	Cycla	Improper blocking and/or bracing-lateral
393.104F3	Equipment	Volpe	Improper blocking and/or bracing (tiedown)
393.104F4	Equipment	Volpe	Improper blocking and/or bracing (tiedown)
393.11	Equipment	Cycla	No/defective lighting devices/ref/projected
393.11B	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11B1	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11B2	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11B3	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11C	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11C1	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11C2	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11LR	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11N	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11RT	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11S	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11TL	Equipment	Volpe	No/defective lighting devices/ref/projected

Table 24. Roadside Inspection Category 2 Violations

Violation Code	Violation Type	Source	Description
393.11TT	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11TU	Equipment	Volpe	No/defective lighting devices/ref/projected
393.11UR	Equipment	Volpe	No/defective lighting devices/ref/projected
393.116	Equipment	Volpe	Improperly secured logs
393.120	Equipment	Volpe	Improperly secured metal coils
393.126	Equipment	Volpe	Improperly secured intermodal container
393.128	Equipment	Volpe	Improperly secured light vehicle
393.13A	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13B	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13C1	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13C2	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13C3	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13D1	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13D2	Equipment	Volpe	No/defective lighting devices/ref/projected
393.13D3	Equipment	Volpe	No/defective lighting devices/ref/projected
393.130	Equipment	Volpe	Improperly secured heavy vehicle
393.134	Equipment	Volpe	Improperly secured roll-on/roll-off or hook lift containers
393.134B3	Equipment	Volpe	Improperly secured roll-on/roll-off or hook lift containers
393.17	Equipment	Cycla	No/defective lamp/reflector-towaway operation
393.17A	Equipment	Cycla	No/defective lamps-towing unit-towaway operation
393.17B	Equipment	Cycla	No/defective side marker
393.19	Equipment	Cycla	No/defective turn/hazard lamp as required
393.201	Equipment	Volpe	All frame violations
393.201A	Equipment	Cycla	Frame cracked/broken/bent/loose
393.201B	Equipment	Cycla	Bolts securing cab broken/loose/missing
393.203B	Equipment	Cycla	Cab/body improperly secured to frame
393.205	Equipment	Volpe	Wheel violations (general)
393.205A	Equipment	Cycla	Wheel/rim cracked or broken
393.205B	Equipment	Cycla	Stud/bolt holes elongated on wheels
393.205C	Equipment	Cycla	Wheel fasteners loose and/or missing
393.207	Equipment	Volpe	All suspension violations
393.207A	Equipment	Cycla	Axle positioning parts defective/missing
393.207C	Equipment	Cycla	Leaf spring assembly defective/missing
393.207D	Equipment	Cycla	Coil spring cracked and/or broken
393.207E	Equipment	Cycla	Torsion bar cracked and/or broken

Table 24. Roadside Inspection Category 2 Violations

Violation Code	Violation Type	Source	Description
393.209	Equipment	Volpe	All steering violations
393.209A	Equipment	Cycla	Steering wheel not secured/broken
393.209B	Equipment	Cycla	Excessive steering wheel lash
393.209C	Equipment	Cycla	Loose steering column
393.24B	Equipment	Cycla	Non-compliance with head lamp requirements
393.25B	Equipment	Cycla	Lamps are not visible as required
393.25E	Equipment	Volpe	Lamp not steady burning
393.25F	Equipment	Cycla	Stop lamp violations
393.26	Equipment	Volpe	Requirements for reflectors
393.40	Equipment	Cycla	Inadequate brake system on a CMV
393.47	Equipment	Cycla	Inadequate brake lining for safe stopping
393.55A	Equipment	Volpe	Brakes, all others
393.55C1	Equipment	Volpe	Brakes, all others
393.55C2	Equipment	Volpe	Brakes, all others
393.60C	Equipment	Cycla	Use of vision reducing matter on windows
393.61A	Equipment	Cycla	Inadequate or missing truck side windows
393.65C	Equipment	Cycla	Improper securement of fuel tank
393.67	Equipment	Cycla	Fuel tank requirement violations
393.70B	Equipment	Cycla	Defective/improper fifth wheel assemblies
393.71H	Equipment	Cycla	Towbar requirement violations
393.75F4	Equipment	Volpe	Flat Tire
393.77	Equipment	Cycla	Defective and/or prohibited heaters
393.80	Equipment	Cycla	No or defective rear-vision mirror
393.9	Equipment	Cycla	Inoperable lamp (other than head/tail)
393.95G	Equipment	Volpe	HM-restricted emergency warning device
393.9T	Equipment	Cycla	Inoperable tail lamp
395.13D	Driver	Cycla	Driving after being declared out-of-service
395.1I1	Driver	Cycla	15,20,70/80 hours of service violations (ak)
395.1I2	Driver	Cycla	Adverse driving conditions violations (ak)
395.3A1	Driver	Cycla	10 hour rule violation
395.3A2	Driver	Cycla	15 hour rule violation
395.3B	Driver	Cycla	60/70 hour rule violation
395.3E	Driver	Volpe	15/20 hour rule viol (alaska)
395.3E1	Driver	Volpe	15 hour rule (alaska)
395.3E2	Driver	Volpe	20 hour rule (alaska)

Table 24. Roadside Inspection Category 2 Violations

Violation Code	Violation Type	Source	Description
395.3E3	Driver	Volpe	70 hour rule (alaska)
395.8	Driver	Volpe	Log violation (general/form and manner)
395.8A	Driver	Cycla	No drivers record of duty status
395.8E	Driver	Cycla	False report of drivers record of duty status
395.8K2	Driver	Cycla	Driver failing to retain previous 7 days logs
395.8K3	Driver	Volpe	Failed to retain 7 previous days
396.7	Driver	Volpe	Unsafe operations forbidden
398.3B	Driver	Cycla	Driver qualified-migrant workers
398.6	Driver	Cycla	Violation of hours of service reg-migrant

Risk Category 3

Violation is the potential contributing factor leading to a crash or injuries/fatalities from a given crash.

Table 25. Roadside Inspection Category 3 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	1.25×10^{-4}	6.25×10^{-5}
Lower Bound	8.33×10^{-5}	4.167×10^{-5}
Mean	1.04×10^{-5}	5.208×10^{-5}

Table 26. Roadside Inspection Category 3 Violations

Violation Code	Violation Type	Source	Description
383.21A	Driver	Cycla	Operating a CMV with more than 1 driver’s license
383.23C2	Driver	Cycla	Operator on learner's permit w/o valid driver’s license
383.91A	Driver	Cycla	Operating a CMV with improper CDL group
383.93B1	Driver	Cycla	No double/triple trailer endorsement on CDL
383.93B2	Driver	Cycla	No passenger vehicle endorsement on CDL
383.93B3	Driver	Cycla	No tank vehicle endorsement on CDL
383.93B4	Driver	Cycla	No hazardous materials endorsement on CDL
383.95A	Driver	Cycla	Violating airbrake restriction
391.11B1	Driver	Cycla	Interstate driver under 21 years of age
391.11B2	Driver	Cycla	Non-english speaking driver
391.41	Driver	Volpe	No medical certificate
391.41A	Driver	Cycla	No medical certificate on driver's possession
391.45	Driver	Volpe	Expired medical exam

Table 26. Roadside Inspection Category 3 Violations

Violation Code	Violation Type	Source	Description
391.45B	Driver	Cycla	Expired medical examiner's certificate
391.45B1	Driver	Volpe	Expired medical examiner's certificate
391.49	Driver	Volpe	No medical waiver
391.49A	Driver	Volpe	No valid medical waiver in possession
391.49J	Driver	Cycla	No valid medical waiver in driver's possession
392.10A1	Driver	Cycla	Failing to stop at railroad crossing-bus
392.10A2	Driver	Cycla	Failing to stop at railroad crossing-chlorine
392.10A3	Driver	Cycla	Failing to stop at railroad crossing-placard
392.10A4	Driver	Cycla	Failing to stop at railroad crossing-HM cargo
392.12	Driver	Volpe	Failing to stop at drawbridge-bus
392.15	Driver	Volpe	Failing or improper use of turn signal
392.15A	Driver	Cycla	Failing or improper use of turn signal
392.15B	Driver	Cycla	Failed to signal direction from parked position
392.15C	Driver	Cycla	Failing to signal a lane change
392.16	Driver	Cycla	Failing to use seat belt while operating CMV
392.52	Driver	Volpe	Improper bus fueling
392.61	Driver	Volpe	Unauthorized driver
392.62	Driver	Volpe	Bus driver distracted
392.63	Driver	Volpe	Pushing/towing a loaded bus
392.7	Driver	Cycla	No pretrip inspection
393.201C	Equipment	Cycla	Frame rail flange improperly bent/cut/notched
393.201E	Equipment	Cycla	Prohibited holes drilled in frame rail flange
393.203A	Equipment	Cycla	Cab door missing/broken
393.203C	Equipment	Cycla	Hood not securely fastened
393.203D	Equipment	Cycla	Cab seats not securely mounted
393.203E	Equipment	Cycla	Cab front bumper missing/unsecured/protrude
393.207F	Equipment	Cycla	Air suspension pressure loss
393.209E	Equipment	Cycla	Power steering violations
393.41	Equipment	Cycla	No or defective parking brake system on CMV
393.43	Equipment	Cycla	No/improper breakaway or emergency braking
393.43A	Equipment	Cycla	No/improper tractor protection valve
393.43D	Equipment	Cycla	No or defective automatic trailer brake
393.44	Equipment	Cycla	No/defective bus front brake line protection
393.45	Equipment	Cycla	Brake tubing aid hose adequacy
393.45A4	Equipment	Cycla	Brake hose/tubing chaffing and/or kinking

Table 26. Roadside Inspection Category 3 Violations

Violation Code	Violation Type	Source	Description
393.45A5	Equipment	Cycla	Brake hose/tubing contacting exhaust system
393.46	Equipment	Cycla	Brake hose/tube connection
393.46B	Equipment	Cycla	Brake connections with leaks/constrictions
393.50	Equipment	Cycla	Inadequate reservoir for air/vacuum brakes
393.50A	Equipment	Cycla	Failing to have sufficient air/vacuum reserve
393.50B	Equipment	Cycla	Failing to equip vehicle-prevent res air/vac leak
393.50C	Equipment	Cycla	No means to ensure operable check valve
393.51	Equipment	Cycla	No or defective brake warning device
393.53A	Equipment	Volpe	Brakes, all others
393.53B	Equipment	Volpe	Brakes, all others
393.53C	Equipment	Volpe	Brakes, all others
393.55B	Equipment	Volpe	Brakes, all others
393.55D1	Equipment	Volpe	Brakes, all others
393.55D2	Equipment	Volpe	Brakes, all others
393.55D3	Equipment	Volpe	Brakes, all others
393.55E	Equipment	Volpe	Brakes, all others
393.60	Equipment	Volpe	Windshield condition
393.60D	Equipment	Volpe	Windshield
393.61B	Equipment	Cycla	Buses-window escape inoperative/obstructed
393.61B1	Equipment	Volpe	Bus windows
393.61B2	Equipment	Cycla	No or defective bus emergency exits
393.61C	Equipment	Cycla	Buses-push out window requirements violation
393.61C1	Equipment	Volpe	Bus pushout window requirements violations
393.62	Equipment	Cycla	Window obstructed which would hinder escape
393.65	Equipment	Volpe	Fuel system requirements
393.65B	Equipment	Cycla	Improper location of fuel system
393.65F	Equipment	Cycla	Improper fuel line protection
393.67C7	Equipment	Cycla	Fuel tank fill pipe cap missing
393.67C8	Equipment	Cycla	Improper fuel tank safety vent
393.70	Equipment	Volpe	Fifth wheel
393.70A	Equipment	Cycla	Defective coupling device-improper tracking
393.70D	Equipment	Cycla	No/improper safety chains/cables for full trailer
393.71H10	Equipment	Cycla	No/improper safety chains/cables for towbar
393.75	Equipment	Volpe	Tires/tubes (general)
393.75B	Equipment	Cycla	Tire-front tread depth less than 4/32 of inch

Table 26. Roadside Inspection Category 3 Violations

Violation Code	Violation Type	Source	Description
393.75C	Equipment	Cycla	Tire-other tread depth less than 2/32 of inch
393.75D	Equipment	Cycla	Tire-bus regrooved/recap on front wheel
393.75E	Equipment	Cycla	Tire-regrooved on front of truck/truck-tractor
393.75F	Equipment	Cycla	Tire-load weight rating/under inflated
393.75F1	Equipment	Volpe	Weight carried exceeds tire load limit
393.75F2	Equipment	Volpe	Tire - under-inflated
393.77B11	Equipment	Volpe	Defective and/or prohibited heaters
393.77B5	Equipment	Volpe	All other vehicle defects
393.78	Equipment	Cycla	Windshield wipers inoperative/defective
393.79	Equipment	Cycla	Defroster inoperative
393.83A	Equipment	Cycla	Exhaust system location
393.83B	Equipment	Cycla	Exhaust discharge fuel tank/filler tube
393.83C	Equipment	Cycla	Improper exhaust-bus (gasoline)
393.83D	Equipment	Cycla	Improper exhaust-bus (diesel)
393.83E	Equipment	Cycla	Improper exhaust discharge (not rear of cab)
393.83F	Equipment	Cycla	Improper exhaust system repair (patch/wrap)
393.83G	Equipment	Cycla	Exhaust leak under truck cab and/or sleeper
393.83H	Equipment	Cycla	Exhaust system not securely fastened
393.86	Equipment	Cycla	No or improper rearend protection
393.86A1	Equipment	Volpe	All other vehicle defects
393.86A2	Equipment	Volpe	All other vehicle defects
393.86A3	Equipment	Volpe	All other vehicle defects
393.86A4	Equipment	Volpe	All other vehicle defects
393.86A5	Equipment	Volpe	All other vehicle defects
393.86B1	Equipment	Volpe	All other vehicle defects
393.87	Equipment	Cycla	No flag on projecting load
393.88	Equipment	Cycla	Improperly located tv receiver
393.89	Equipment	Cycla	Bus driveshaft not properly protected
393.93	Equipment	Volpe	Vehicle equipped seat belts
393.93A	Equipment	Cycla	Bus-not equipped with seat belt
393.93B	Equipment	Cycla	Truck not equipped with seat belt
393.95F	Equipment	Cycla	Emergency warning devices not as required
396.3A1B	Equipment	Cycla	Brakes (general)
396.3A1BA	Equipment	Cycla	Brake-out of adjustment
396.3A1BC	Equipment	Cycla	Brake-air compressor violation

Table 26. Roadside Inspection Category 3 Violations

Violation Code	Violation Type	Source	Description
396.3A1BD	Equipment	Cycla	Brake-defective brake drum
396.3A1BH	Equipment	Volpe	Brake-hose/tube damaged and/or leaking
396.3A1BL	Equipment	Cycla	Brake-reserve system pressure loss
396.3A1T	Equipment	Cycla	Tires (general)
396.5	Equipment	Volpe	Excessive oil leaks
396.5B	Equipment	Volpe	Oil and/or grease leak
397.1B	Driver	Volpe	Driver/carrier must obey part 397
397.67	Driver	Volpe	HM vehicle routing violation (non ram)
398.3B8	Driver	Cycla	No doctor's certificate in possession

Risk Category 4

Violation is the unlikely potential contributing factor leading to a crash or injuries/fatalities from a given crash.

Table 27. Roadside Inspection Category 4 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	1.25×10^{-5}	6.25×10^{-6}
Lower Bound	8.33×10^{-6}	4.167×10^{-6}
Mean	1.04×10^{-6}	5.208×10^{-6}

Table 28. Roadside Inspection Category 4 Violations

Violation Code	Violation Type	Source	Description
107.620B	Driver	Volpe	No copy of us dot HM registration number
139.01	Driver	Volpe	Operating w/o proper motor carrier authority
139.06	Driver	Volpe	Operator w/o proper insurance or other securities
386.83C	Driver	Volpe	Failure to pay civil penalties
387.403A	Driver	Volpe	Freight forwarder-no evidence of insurance
392.9B	Driver	Cycla	Hearing aid not worn while operating a CMV
392.9C	Equipment	Volpe	Buses-emergency exits inoperative/obstructed
392.9C1	Driver	Volpe	Bus-standee forward of line
392.9C3	Driver	Volpe	Bus-improper storage of baggage or freight
393.106	Equipment	Volpe	No/improper front end structure/headerboard
393.106A	Equipment	Cycla	No/improper front end structure/headerboard
393.20	Equipment	Cycla	No/improper mounting of clearance lamps
393.201D	Equipment	Cycla	Frame accessories not bolted/riveted securely

Table 28. Roadside Inspection Category 4 Violations

Violation Code	Violation Type	Source	Description
393.28	Equipment	Cycla	Improper or no wiring protection as required
393.30	Equipment	Cycla	Improper battery installation
393.32	Equipment	Cycla	Improper electrical connections
393.33	Equipment	Cycla	Improper wiring installations
393.48B1	Equipment	Cycla	Defective brake limiting device
393.60B	Equipment	Cycla	Damaged or discolored windshield
393.63	Equipment	Cycla	No or inadequate bus escape window markings
393.81	Equipment	Cycla	Horn inoperative
393.84	Equipment	Cycla	Inadequate floor condition
393.91	Equipment	Cycla	Bus-improper aisle seats
393.92	Equipment	Cycla	Bus-no/improper emergency door marking
393.95A	Equipment	Cycla	No/discharged/unsecured fire extinguisher
393.106B	Equipment	Volpe	Improper securement of cargo
393.106D	Equipment	Volpe	Improper securement devices
393.110	Equipment	Volpe	Minimum number of tiedowns not used
393.112	Equipment	Volpe	Non-adjustable tiedowns used
393.114	Equipment	Volpe	Securement system violation (front end structure)
395.15C	Equipment	Volpe	On-board recording device info not available
395.15G	Equipment	Cycla	On-board recording device info not available
395.15F	Equipment	Volpe	On-board recording device info not available
395.15I5	Equipment	Volpe	On-board recording device info not available
396.1	Driver	Volpe	All other driver violations
396.3A	Equipment	Volpe	Vehicle maintenance (general)
396.3A1	Equipment	Cycla	Inspection/repair and maintenance
398.7	Equipment	Cycla	Inspect/maintenance me-migrant workers

Violation has little or no connection to crash or prevention of injuries/fatalities. **Risk Category 5**

Table 29. Roadside Inspection Category 5 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	1.25×10^{-6}	6.25×10^{-7}
Lower Bound	8.33×10^{-7}	4.167×10^{-7}
Mean	1.04×10^{-7}	5.208×10^{-7}

Table 30. Roadside Inspection Category 5 Violations

Violation Code	Violation Type	Source	Description
139.02C4B	Driver	Volpe	Operating beyond geographical restrictions
387.301A	Driver	Volpe	No evidence of public liability and property damage insurance
387.301B	Driver	Volpe	No evidence of cargo insurance
387.303B4	Driver	Volpe	No copy of certificate of registration
387.307	Driver	Volpe	Prop brkr-no evidence of bond or trust fund agreement
387.31F	Driver	Cycla	No proof of financial responsibility-foreign passenger
387.403B	Driver	Volpe	Freight forwarder-no evidence of public liability & property damage insurance
387.7F	Driver	Cycla	No proof of financial responsibility-foreign
390.21	Driver	Volpe	No dot # marking and/or name/city/state
390.21A	Equipment	Cycla	No dot # marking and/or name/city/state
390.21B	Equipment	Volpe	All other equipment defects
390.21C	Equipment	Volpe	All other equipment defects
390.21E	Equipment	Volpe	All other equipment defects
390.35	Driver	Volpe	All other equipment defects
391.43E	Driver	Cycla	Improper medical exam form
391.43F	Driver	Volpe	Improper medical certificate
391.43G	Driver	Cycla	Improper medical examiner's certificate
392.15D	Driver	Cycla	Using turn signal to indicate disabled vehicle
392.15E	Driver	Cycla	Using turn signal as a “do pass”
392.30	Equipment	Volpe	Use lamps as required
392.32	Equipment	Volpe	Dim headlights
392.60	Driver	Volpe	Unauthorized passenger on board CMV
392.60A	Driver	Cycla	Unauthorized passenger on board CMV
393.203	Equipment	Volpe	Cab/body parts requirements violations
393.76	Equipment	Cycla	Sleeper berth requirement violations
393.82	Equipment	Cycla	Speedometer inoperative
393.90	Equipment	Cycla	Bus-no or obscure standee line
393.95C	Equipment	Cycla	Spare fuses not as required
395.8F1	Driver	Cycla	Drivers record of duty status not current
396.11	Driver	Cycla	Driver vehicle inspection report
396.11A	Driver	Volpe	Driver vehicle inspection report
396.13A	Driver	Volpe	Driver inspection
396.13C	Driver	Cycla	No reviewing driver's signature
396.17C	Equipment	Cycla	Operating a CMV without periodic inspection

Table 30. Roadside Inspection Category 5 Violations

Violation Code	Violation Type	Source	Description
396.21	Equipment	Volpe	Periodic inspection
396.9D2	Equipment	Volpe	All other vehicle defects
396.9D3	Equipment	Volpe	All other vehicle defects
399.207	Equipment	Cycla	Vehicle access requirements violations
399.211	Equipment	Cycla	Inadequate maintenance of driver access

Traffic Enforcement Violations

Risk Category 1

Violation is the potential single, immediate factor leading to a crash or injuries/fatalities from a given crash.

Table 31. Traffic Enforcement Category 1 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	0.05	0.025
Lower Bound	0.033	0.0167
Mean	0.0415	0.02085

Table 32. Traffic Enforcement Category 1 Violations

Violation Code	Violation Type	Source	Description
392.22A	Driver	Cycla	Failing to use hazard warning flashers
392.2D	Driver	Cycla	Local law/other driver violations
392.2R	Driver	Cycla	Local law/reckless driving
392.2Y	Driver	Cycla	Local laws/failure to yield right of way
392.4	Driver	Volpe	Driver uses or is in possession of drugs
392.4A	Driver	Cycla	Driver uses or is in possession of drugs
392.5	Driver	Volpe	Driver uses or is in possession of alcohol
392.5A	Driver	Cycla	Poss/use/under influence alcohol-4hr prior duty

Risk Category 2

Violation is the potential single, eventual factor leading to a crash or injuries/fatalities from a given crash.

Table 33. Traffic Enforcement Category 2 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	3.3×10^{-3}	1.67×10^{-3}
Lower Bound	5.0×10^{-3}	2.5×10^{-3}
Mean	4.15×10^{-3}	2.085×10^{-3}

Table 34. Traffic Enforcement Category 2 Violations

Violation Code	Violation Type	Source	Description
392.2	Driver	Volpe	Local laws (general)
392.22B	Driver	Cycla	Failing/improper placement of warning devices
392.2C	Driver	Cycla	Local laws/failure to obey traffic control device
392.2H	Driver	Cycla	Local laws/failure to obey traffic control device
392.2FC	Driver	Cycla	Local law/following too close
392.2LC	Driver	Cycla	Local law/improper lane change
392.2OT	Driver	Cycla	Local law/other moving violation
392.2P	Driver	Cycla	Local law/improper passing
392.2S	Driver	Cycla	Local law/speeding
392.2T	Driver	Cycla	Local laws/improper turns
392.2V	Driver	Volpe	Local law/other vehicle defects

Risk Category 3

Violation is the potential contributing factor leading to a crash or injuries/fatalities from a given crash.

Table 35. Traffic Enforcement Category 3 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	3.3×10^{-4}	1.67×10^{-4}
Lower Bound	5.0×10^{-4}	2.5×10^{-4}
Mean	4.15×10^{-4}	2.085×10^{-4}

Table 36. Traffic Enforcement Category 3 Violations

Violation Code	Violation Type	Source	Description
392.21	Driver	Volpe	Stopped vehicle interfering with traffic
392.2W	Driver	Cycla	Local laws/size and weight

Risk Category 4

Violation is the unlikely potential contributing factor leading to a crash or injuries/fatalities from a given crash.

Table 37. Traffic Enforcement Category 4 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	3.3×10^{-5}	1.67×10^{-5}
Lower Bound	5.0×10^{-5}	2.5×10^{-5}
Mean	4.15×10^{-5}	2.085×10^{-5}

Table 38. Traffic Enforcement Category 4 Violations

Violation Code	Violation Type	Source	Description
392.20	Driver	Cycla	Failing to properly secure parked vehicle

Risk Category 5

Violation has little or no connection to crash or prevention of injuries/fatalities.

Table 39. Traffic Enforcement Category 5 Crash Reduction Probabilities

	OOS	Non-OOS
Higher Bound	3.3×10^{-6}	1.67×10^{-6}
Lower Bound	5.0×10^{-6}	2.5×10^{-6}
Mean	4.15×10^{-6}	2.085×10^{-6}

Table 40. Traffic Enforcement Category 5 Violations

Violation Code	Violation Type	Source	Description