CRASH WEIGHTING ANALYSIS

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# ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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</thead>
<tbody>
<tr>
<td>AIC</td>
<td>Akaike Information Criterion</td>
</tr>
<tr>
<td>ATRI</td>
<td>American Transportation Research Institute</td>
</tr>
<tr>
<td>BASIC</td>
<td>Behavior Analysis and Safety Improvement Category</td>
</tr>
<tr>
<td>BIC</td>
<td>Bayesian Information Criterion</td>
</tr>
<tr>
<td>CIR</td>
<td>Crash Investigation Record</td>
</tr>
<tr>
<td>CMV</td>
<td>Commercial Motor Vehicle</td>
</tr>
<tr>
<td>CSA</td>
<td>Compliance, Safety, Accountability</td>
</tr>
<tr>
<td>CSMS</td>
<td>Carrier Safety Measurement System</td>
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<tr>
<td>FARS</td>
<td>Fatality Analysis Reporting System</td>
</tr>
<tr>
<td>FMCSA</td>
<td>Federal Motor Carrier Safety Administration</td>
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<tr>
<td>GES</td>
<td>General Estimates System</td>
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<tr>
<td>HM</td>
<td>Hazardous Materials</td>
</tr>
<tr>
<td>HOS</td>
<td>Hours-of-Service</td>
</tr>
<tr>
<td>LTCCS</td>
<td>Large Truck Crash Causation Study</td>
</tr>
<tr>
<td>MCMIS</td>
<td>Motor Carrier Management Information System</td>
</tr>
<tr>
<td>NASS</td>
<td>National Automotive Sampling System</td>
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<tr>
<td>NHTSA</td>
<td>National Highway Traffic Safety Administration</td>
</tr>
<tr>
<td>NMVCCS</td>
<td>National Motor Vehicle Crash Causation Survey</td>
</tr>
<tr>
<td>NSC</td>
<td>National Safety Code [Canada]</td>
</tr>
<tr>
<td>OOS</td>
<td>Out-of-Service</td>
</tr>
<tr>
<td>PAR</td>
<td>Police Accident Report</td>
</tr>
<tr>
<td>PU</td>
<td>Power Unit</td>
</tr>
<tr>
<td>SMS</td>
<td>Safety Measurement System</td>
</tr>
<tr>
<td>TIFA</td>
<td>Trucks Involved in Fatal Accidents</td>
</tr>
<tr>
<td>UMTRI</td>
<td>University of Michigan Transportation Research Institute</td>
</tr>
<tr>
<td>VMT</td>
<td>Vehicle Miles Traveled</td>
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</tbody>
</table>
EXECUTIVE SUMMARY

EX 1 INTRODUCTION

The Federal Motor Carrier Safety Administration (FMCSA) is dedicated to reducing crashes, injuries, and fatalities involving large trucks and buses. The Compliance, Safety, Accountability (CSA) program is FMCSA’s enforcement model that allows the Agency and State Partners to address motor carrier safety problems before crashes occur. The foundation of CSA is the Safety Measurement System (SMS), which quantifies the on-road safety performance of motor carriers to prioritize enforcement resources.

The SMS uses State-reported crash and inspection data to assess motor carriers’ crash risk and prioritize them for safety interventions. The Crash Indicator is one of the seven Behavior Analysis and Safety Improvement Categories (BASICs) that the SMS uses to evaluate safety performance. The Crash Indicator uses all crash records involving commercial motor vehicles (CMVs) that are submitted by the States through the Agency’s Motor Carrier Management Information System (MCMIS). In submitting these crash records, States may use data from Police Accident Reports (PARs) that were prepared by State or local law enforcement officials; FMCSA does not receive PARs or any other information pertaining to a motor carrier’s role in a crash from the States. Crash Indicator measures and percentiles are not available to the public: this information is available only to motor carriers and enforcement personnel with access to the SMS.

A variety of studies have looked at the SMS BASICs and their relationship to future crash risk. Starting with the independent analysis during the test phase of CSA conducted by the University of Michigan Transportation Research Institute (UMTRI) and continuing with studies conducted by the FMCSA, it is clear that there is a strong relationship between several of the BASICs, especially the Crash Indicator, and future crash involvement:

- The 2011 UMTRI evaluation of the effectiveness of the CSA field test found that the SMS is a significant improvement over its predecessor, SafeStat, in identifying unsafe motor carriers. In particular, the evaluation found that five of the seven BASICs employed during the test demonstrated a strong relationship to crash risk.\(^2\)

- The FMCSA analysis shows that nearly 40 percent of recently active motor carriers\(^3\) have sufficient data to be assessed by the SMS; these carriers own or operate 80 percent of vehicles and are involved in over 90 percent of all crashes involving a CMV.\(^4\)

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1 49 CFR Part 390.5 defines the types of crashes that States must report (recordable crashes) as occurrences involving a commercial motor vehicle operating on a highway in interstate or intrastate commerce that result in (1) a fatality; (2) bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident; or (3) one or more motor vehicles incurring disabling damage as a result of the accident, requiring the motor vehicle(s) to be transported away from the scene by a tow truck or other motor vehicle.

2 University of Michigan Transportation Research Institute (UMTRI), Evaluation of the CSA 2010 Operational Model Test, August 2011.

3 Recently active carriers are those with an inspection, crash, investigation, safety audit, Unified Carrier Registration payment, registration, or insurance update within the last three years.
The FMCSA’s SMS Effectiveness Test (ET) shows that motor carriers prioritized for interventions in six of the BASICs have higher future crash rates than the national average; in particular, those carriers above the threshold in the Crash Indicator have a future crash rate that is 85 percent higher than the national average.\(^5\)

While this research demonstrates the relationship between crashes and future crash risk, some stakeholders have expressed concern that the Crash Indicator may not identify the highest risk motor carriers for intervention because it looks at all crashes without regard to the role of the carrier in the crash. In response to stakeholder interest and as part of the Agency’s commitment to continuous improvement, this Crash Weighting Analysis informs decision-making about the feasibility of using a motor carrier’s role in crashes as an indicator of future crash risk. The analysis focused only on the three broad questions below addressing the procedural issues surrounding a crash weighting program and the feasibility of implementing such a program; it did not focus on any other implications of the program. The Agency will seek comments on this study and the other implications of a crash weighting program through a Federal Register notice. The three analysis questions are not addressed sequentially but each as separate analyses designed to inform Agency decisions.

- Do PARs provide sufficient, consistent, and reliable information to support crash weighting determinations?
- Would a crash weighting determination process offer an even stronger predictor of crash risk than overall crash involvement, and how would crash weighting be implemented in the SMS?
- Depending upon the analysis results for the questions above, how might FMCSA manage the process for making crash weighting determinations, including public input to the process?

**EX 2 STUDY APPROACH**

To address these questions, FMCSA defined crash weighting as the following two-step process: (1) review a sample of PARs to determine the critical reason for the crash events and the motor carriers’ roles; and (2) use the critical reason determinations (defined below) as a basis for weighting the crashes in the SMS using various approaches. Based on this approach, FMCSA identified a process and associated costs for a national crash weighting program.

PARs are used by law enforcement across the United States to document the circumstances surrounding a crash. This study focused on crashes involving a fatality, an injury, or a vehicle towed from the scene. There is no one single standard format for a PAR or for the many pieces of information that a police officer records in a PAR—including all of the vehicles involved in the crash, the names of drivers and companies if CMVs are involved, the weather and road conditions, etc.

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conditions, a written description of the events leading to the crash, and a diagram to illustrate what happened and where. The format and content of PARs vary among the States and often even within a State.

The FMCSA does not receive PARs from the States, but only a partial set of the information recorded on the PAR that may be included in the State-reported crash record. Thus, to create a database for the purposes of this analysis, FMCSA obtained 10,892 PARs from two national data sets: the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) and the National Motor Vehicle Crash Causation Survey (NMVCCS).

Depending upon State procedures, most PARs do not indicate the reason for a crash; therefore, the FMCSA employed a review process based on the process developed for FMCSA’s Large Truck Crash Causation Study (LTCCS), particularly the methodology for assigning the “critical event” and the “critical reason” for the critical event. This methodology focuses on pre-crash events, such as vehicle and driver actions/movements, driver condition, and the environment at the crash scene, to identify the circumstances leading to the crash. The critical event and critical reason are defined as follows:

- **Critical Event**: The event that immediately led to the crash and that put the vehicle or vehicles on a course that made the crash unavoidable. In this study, the PAR reviewers assigned the critical event to the vehicle or other party, such as a pedestrian, responsible for the action or inaction that made the crash inevitable.

- **Critical Reason**: The immediate reason for the critical event or the failure leading to the critical event. The critical reason was identified to describe the role of the driver or vehicle involved in the crash event. For example, if a CMV driver decides to drive too fast for the roadway type, the CMV driver would be assigned the critical reason.

The FMCSA reviewed the PARs and determined the critical event and critical reason to identify a motor carrier’s role in a crash and assign a crash weighting for analysis purposes. The sections below present an overview of the results of analyses conducted to provide insight into the three questions guiding the study. In order to derive the most robust analysis of each question, the Agency used several crash data sources, including PARs, the NMVCCS, and the MCMIS. Each section of the report identifies the source of the data used for the particular analysis.

**EX 3 DO PARS PROVIDE SUFFICIENT, CONSISTENT, AND RELIABLE INFORMATION TO SUPPORT CRASH WEIGHTING DETERMINATIONS?**

One of the key questions for this study is whether FMCSA could make reliable crash weighting determinations based solely on PARs, since the PAR is often perceived as the most common and timely record of a crash. This analysis reviewed PAR sufficiency for determining a motor carrier’s role in a crash, compared a sample of PARs with other data sets to assess the reliability

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6 A State uploads CMV accident reports in accordance with current FMCSA policy guidelines.
7 The FMCSA obtained 10,505 PARs representing fatal crashes in the FARS from 2008-2010 and 387 PARs for recordable crashes (fatality, injury, or tow-away) from the 2005-2007 NMVCCS.
of the information on the PARs, and assessed the feasibility of identifying (coding) the motor carrier’s role for particular types of crash events without reviewing the PAR.

EX 3.1 Sufficiency of PARs to Support Crash Weighting Determinations

This analysis assessed the sufficiency of PARs for determining a motor carrier’s role in a crash. The analysis assumed that the information on PARs was accurate.

EX 3.1.1 Approach

The PAR reviewers first examined the 10,892 PARs to identify those that met the study criteria: at least one vehicle was a CMV; the CMV was regulated by FMCSA; and the crash met the severity criteria for a recordable crash (i.e., fatality, bodily injury, or tow-away). They reviewed those PARs thoroughly, including any narratives, diagrams, or supplemental material, and coded each with one of five critical reason choices: (1) truck/bus driver; (2) truck/bus vehicle; (3) environment; (4) not assigned to this truck/bus driver/vehicle; and (5) unable to assign critical reason.

EX 3.1.2 Analysis Results

Of the 10,892 PARs:

- Ninety-one percent (9,884) met the criteria to be reviewed for a critical reason determination.

- Nine percent (1,008) could not be reviewed because it could not be determined from the PAR that the study criteria were met (a CMV was involved, the CMV was regulated by FMCSA, and the crash was recordable). These PARs were often incomplete or contained illegible or redacted information.

Table EX 1 summarizes the results of the PAR review process. These results show the critical reason outcomes for the CMVs involved in the 9,884 crash events for which the PAR met the criteria to be reviewed for a critical reason determination.

<table>
<thead>
<tr>
<th>Critical Reason Outcomes</th>
<th>Attribute to Motor Carrier?</th>
<th># CMVs Involved in Crash Events</th>
<th>% CMVs Involved in Crash Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck/Bus Driver</td>
<td>Yes</td>
<td>3,622</td>
<td>33.7%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Yes</td>
<td>234</td>
<td>2.2%</td>
</tr>
<tr>
<td>Environment</td>
<td>Unknown</td>
<td>52</td>
<td>0.5%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle</td>
<td>No</td>
<td>6,537</td>
<td>60.8%</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>Unknown</td>
<td>304</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

The five critical reason outcomes shown in Table EX 1 above formed the basis for assigning crash weighting determinations in the second part of this study. (See Section 4.) The “Truck/Bus Driver” and “Truck/Bus Vehicle” outcomes determined that the reason for the crash could be attributed to the motor carrier. The “Not Assigned to This Driver/Vehicle” outcome determined
that the crash could not be attributed to the motor carrier. The “Environment” and “Unable to Assign Critical Reason” outcomes determined that the crash could not be attributed to either the motor carrier or the other vehicle(s). The crashes were “weighted” by assigning a value, for analysis purposes, based on the role of the motor carrier in the crash (attributed or not attributed to the carrier).

EX 3.2 Reliability of PARs

The purpose of this analysis was to assess whether the critical reason determinations based solely on reviewing the PARs could be considered reliable. It was limited to the following:

- Comparing data from specific fields on the PAR with related fields in the matching FARS record. Because the FARS does not identify the critical reason for a crash, the comparison of data fields was thought to provide insight into the overall reliability of the PAR and thus the resulting critical reason determination.

- Comparing the critical reasons assigned by the PAR reviewers with those assigned in matching records from the NMVCCS, which employs the same critical event/critical reason methodology used by the LTCCS.

EX 3.2.1 Comparison of PARs with FARS

Approach

After linking PARs to records in the FARS, FMCSA compared five data fields on each PAR with the same data fields in the matched FARS record to look for the same outcomes:

- Driver contributing factors
- First harmful event
- Traffic-way flow
- Weather condition
- Roadway surface condition

Analysis Results

Results of the PARs-FARS comparison indicated varying levels of agreement on the data for the fields examined, as shown in Table EX 2.
Table EX 2. Results of PARs–FARS Comparison

<table>
<thead>
<tr>
<th>Data Field</th>
<th>PARs/FARS Match</th>
<th>PARs/FARS Non-Match</th>
<th>Missing PAR Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Contributing Factors</td>
<td>12.6%</td>
<td>5.3%</td>
<td>82.0%</td>
</tr>
<tr>
<td>First Harmful Event</td>
<td>46.9%</td>
<td>5.6%</td>
<td>47.5%</td>
</tr>
<tr>
<td>Traffic-Way Flow</td>
<td>52.4%</td>
<td>14.9%</td>
<td>32.8%</td>
</tr>
<tr>
<td>Weather Condition</td>
<td>95.7%</td>
<td>3.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Roadway Surface Condition</td>
<td>96.7%</td>
<td>2.3%</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

EX 3.2.2 Comparison of PARs with NMVCCS

Approach

The FMCSA received 387 PARs used for the 2005-2007 NMVCCS. There were 277 CMVs from these PARs that could be linked to a corresponding NMVCCS vehicle record. The Agency compared the critical reason assignments for these CMVs to identify any discrepancies.

Analysis Results

The comparison of critical reason assignments shows that:

- Ninety percent (249) of CMVs had the same critical reason determinations in the two data sources.
- Ten percent (28) were coded differently.

EX 3.3 Feasibility of Coding Crash Events without a PAR Review

The FMCSA assessed the practicality of coding crashes for two types of crash events using information available in the MCMIS as an approach to crash weighting that would not require reviewing an actual PAR:

- Single-vehicle crashes deemed to be “attributable” to the motor carrier.9
- Both single- and multiple-vehicle crashes with associated post-crash inspection records indicating a pre-crash out-of-service (OOS) condition on the CMV involved.10

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9 This study considered a single-vehicle crash to be attributable to the CMV when the event code description did not indicate a collision with a pedestrian, a motor vehicle in transport, an animal, work zone maintenance equipment, other/unknown movable object, or "other."
10 The study used State, date, vehicle, and carrier information to match PAR crash records to MCMIS crash records. It considered MCMIS inspection records to be associated with a pre-crash OOS condition when the "post-accident indicator" field equaled "yes" and the "OOS total" value was greater than zero.
EX 3.3.1 Approach

For the two categories of crashes listed above, FMCSA identified the crashes from 2008-2010 coded by the PAR reviewers that were linked with records in the MCMIS. This produced a linked set of 671 records for single-vehicle crashes and 767 records for crashes associated with a pre-crash OOS violation.

It was hypothesized that the reviewers would assign a critical reason that would attribute to the motor carrier for any single-vehicle crash or crash with a pre-crash OOS condition. The assumption for pre-crash OOS conditions was that the CMV driver or vehicle should not have been on the road and should thus be assigned the critical reason. To test the feasibility of such an approach, PAR reviewers assigned the critical reason for such crashes independently, without referring to the MCMIS data.

EX 3.3.2 Analysis Results

Results of the analysis are as follows:

- For 94 percent of the 671 single-vehicle crashes identified, the PAR reviewers assigned a critical reason attributed to the motor carrier. Of the remaining 6 percent, 3 percent were coded “unable to assign critical reason” because the PAR lacked sufficient information to make a determination, 2 percent were assigned to another vehicle, and 1 percent were assigned to the environment. For the 2 percent assigned to another vehicle, the PAR indicated that another vehicle was involved, while the MCMIS record did not.

- For the 767 crashes with an accompanying OOS condition, PAR reviewers assigned a critical reason attributed to the motor carrier for fewer than half (43 percent) of the records. This is likely because they used only the PAR and did not have access to post-crash inspection results indicating a pre-crash driver or vehicle OOS condition.

EX 4 WOULD A CRASH WEIGHTING DETERMINATION PROCESS OFFER AN EVEN STRONGER PREDICTOR OF CRASH RISK THAN OVERALL CRASH INVOLVEMENT?

This portion of the crash weighting analysis assumed PAR sufficiency and reliability and looked at whether a crash weighting methodology in the SMS Crash Indicator would provide a sharper view of the highest risk motor carriers. Crash weights were derived based on the critical reason assignments for the 10,892 PARs that were reviewed and single-vehicle attributable crashes identified in the MCMIS. The Agency employed various statistical and analytical approaches to assess crash weighting benefits, in particular the SMS ET Methodology.

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11 As stated above, the study questions addressing PAR sufficiency, PAR reliability, and crash weighting benefits were not addressed sequentially but as separate analyses designed to inform Agency decisions. Thus, this portion of the analysis did not consider the sufficiency or reliability of the PARs used in the study.
EX 4.1 Overview of Methodology

The FMCSA used the SMS ET to assess the safety benefits of implementing various approaches to crash weighting as part of the Crash Indicator. The Crash Indicator currently relies on crash involvement and does not include any weighting based on a motor carrier’s role in a crash. The SMS ET quantifies how effectively FMCSA uses its resources to target high-risk motor carriers for interventions; it compares the crash rate of carriers above the Intervention Threshold to the national average. For this analysis, the test used crash data from 2009-2010 to define Crash Indicator percentiles, then tracked the future (January 2011 to June 2012) crash rate of motor carriers above the Intervention Threshold.

The Agency applied two approaches for modifying crash weights:

- Applying higher severity weights for two types of crashes—crashes for which PAR reviewers assigned a critical reason attributed to the motor carrier and single-vehicle attributable crashes—and applying lower weights for crashes that were reviewed, but not attributed to the motor carrier.
- Removing crashes that were reviewed but not attributed to the motor carrier.

The FMCSA then compared these crash weighting approaches with the current Crash Indicator. The analysis was performed using both all crashes and fatal crashes alone.

EX 4.2 Crash Weighting Using All Crashes

The data set used for this analysis consisted of fatal crashes from the PAR data set obtained from the FARS that were coded for a critical reason using the PAR, single-vehicle attributable crashes identified in the MCMIS, and all other crashes in the MCMIS for the required time period without a crash weighting determination. The first two types of crashes accounted for less than 20 percent of the crashes used in the analysis, or approximately 25,000 crashes over the 2-year period.12

EX 4.2.1 Approach

The FMCSA ran the SMS ET for the modified Crash Indicator, applying the crash weighting approaches described above. The Agency then compared the results with those for the current Crash Indicator.

EX 4.2.2 Analysis Results

The analysis results showed that modifying the Crash Indicator by changing the crash weights based on a motor carrier’s role in a crash does not appear to improve its ability to predict future crash rates when all crashes are considered. If effectiveness were improved, the average crash rate for carriers above the Intervention Threshold would be higher for the modified Crash

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12 For the analysis years, 2009-2010, the data available for analysis included 1,995 crashes coded to the truck/bus driver or vehicle; 3,613 coded “not assigned to this driver/vehicle”; and 34,385 single-vehicle attributable crashes.
Indicator than for the current approach; however, the analysis results showed that these average crash rates were nearly identical.\(^{13}\)

**EX 4.3 Crash Weighting Using Fatal Crashes Alone**

This data set consisted of fatal crashes from the PAR data set obtained from the FARS that were coded for a critical reason based on the PAR and all other fatal crashes in the MCMIS for the required time period. Fatal crashes that were coded for the critical reason accounted for more than 75 percent of fatal crashes used in the analysis; however, all fatal crashes account for 3 percent of the crashes in the MCMIS.

**EX 4.3.1 Approach**

The FMCSA modified the Crash Indicator to include only fatal crashes. The Agency then applied crash weighting and compared the SMS ET results with those for the unweighted Crash Indicator.

**EX 4.3.2 Analysis Results**

When using fatal crashes alone in the Crash Indicator, weighting crashes by removing those not attributed to the motor carrier appears to improve the ability of the SMS to predict future crash rates by 1.8 percent to 5.0 percent. However, this analysis was limited to approximately 4,500 fatal crashes over the 2-year period,\(^{14}\) or less than 3 percent of total crashes.

**EX 5 HOW MIGHT FMCSA MANAGE THE PROCESS FOR MAKING CRASH WEIGHTING DETERMINATIONS?**

This analysis examined how a crash weighting process might be structured and the estimated resources required. In particular, such a process requires a method for uniformly acquiring the final PARs for all or a subset of crashes, since the States do not currently provide PARs to FMCSA; a process and system for uniform analysis; and a method for receiving and analyzing public input. To estimate the associated costs and other resources, FMCSA identified a potential process for a national crash weighting program based on that used for this analysis.

**EX 5.1 Crash Weighting Determination Process**

**EX 5.1.1 Approach**

The Agency expanded the PAR review process employed for this analysis to include the acceptance of public input.

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\(^{13}\) Applying the two crash weighting approaches resulted in a change in the average crash rate of -1.3 percent to 0.7 percent compared to the current Crash Indicator.

\(^{14}\) Fatal crashes used in the SMS are fewer than all fatal crashes over the 2-year period; this is due to motor carrier screens designed to remove carriers from the analysis with potential data anomalies that could skew the results.
EX 5.1.2 Analysis Results

A potential process for crash weighting determinations would include five steps:

- Establish agreements with the States and obtain PARs in either hard copy or electronic format.
- Develop a system to support the collection and storage of crash weighting determinations.
- Implement the PAR review process.
- Publish the results of the PAR reviews in the Federal Register.
- Establish a procedure for accepting public input should the results of a PAR review be appealed.

EX 5.2 Implementation Costs

EX 5.2.1 Approach

The FMCSA estimated the costs associated with the five-step process described above. The estimate was based on information collected throughout the study and included both start-up and annual costs. To determine the costs associated with the acceptance of public input, the Agency considered as a proxy the current process for approval of applications for operating authority.  

EX 5.2.2 Analysis Results

Estimated costs for a crash weighting determination process are as follows:

- The start-up costs to establish agreements with each State, obtain the PARs, and develop information technology systems are estimated at $1.1 million.
- Coding a single PAR (including labor and overhead costs for both the initial review and a quality control review) requires on average 19 minutes and costs $26.50, based on the process used for this analysis.
- Annual costs for a PAR review process depend on both the number of crashes reviewed and the number of appeals; estimated annual costs, including PAR reviews and appeals, range from $3.9 million to $11.2 million.  

15 Because FMCSA receives relatively few appeals for the granting of operating authority, the cost estimate for crash weighting appeals may be low.

16 Estimates assume $26.50 per PAR for initial review and quality control and $106 for re-review of a PAR and any additional materials following an appeal. The annual cost to obtain the PARs from the States is assumed to be $500,000 and annual operation and maintenance costs are estimated at $350,000.
which a post-crash inspection identified a pre-crash OOS condition to reviewing all recordable crashes.

EX 5.3 Timeframes

One concern is the timeliness of the review and weighting of any crashes. The above analysis assumes that the reviews are completed on crashes used in the SMS, which uses a 24-month time period. It is possible that the timeframe for the entire process—including the submittal of the PAR by law enforcement, its receipt by FMCSA, analysis to make a crash weighting determination, possible appeal of the analysis results, and final disposition of the appeal—could exceed the 24-month analysis period used by the SMS.

EX 6 CONCLUSIONS

The following are conclusions resulting from the analyses described above. Although these conclusions will inform FMCSA decision-making regarding crash weighting, they are not definitive and additional analysis may be needed to address the study questions.

EX 6.1 Do PARs provide sufficient, consistent, and reliable information to support crash weighting determinations?

- Although 91 percent of PARs met the criteria to be reviewed for a critical reason determination, the information on the PAR may not be reliable. For a large number of PARs, a low match rate between fields on the PAR and similar fields in the FARS was identified. This could be due to the additional information and analysis used in creating FARS records, which was not available for this study. These results suggest that PARs may not provide sufficient information to support crash weighting determinations.

- For 9 percent of PARs, the reviewers could not determine that a CMV was involved, that a CMV was regulated by FMCSA, or that the crash was recordable. These PARs were often incomplete or contained illegible or redacted information.

- Coding crash events based solely on MCMIS data for either single-vehicle attributable crashes or crashes with a post-crash inspection with a pre-crash OOS condition was not always consistent with coding results based on a PAR review.

EX 6.2 Would a crash weighting determination process offer an even stronger predictor of crash risk than overall crash involvement?

- Modifying the SMS Crash Indicator to include crash weighting improves its ability to predict future crash rates when fatal crashes alone are used. However, fatal crashes represent less than 3 percent of all crashes in the MCMIS.

- Analysis using all crashes shows that incorporating crash weighting determinations does not consistently improve the Crash Indicator when the various weighting approaches are applied.
EX 6.3 How might FMCSA manage the process for making crash weighting determinations?

- The FMCSA would need to establish a process with the States to receive and manage PAR data.

- The range of costs for implementing a system for accepting and analyzing public input is conservatively estimated to be four times that of the initial PAR review. Annual costs could range from $3.9 million to $11.2 million, depending on the number of PARs reviewed, the number of appeals, and the process established by the Agency.

- The timeframe for the entire process—including the submittal of the PAR by law enforcement, its receipt by FMCSA, analysis to make a crash weighting determination, possible appeal of the analysis results, and final disposition of the appeal—could exceed the 2-year analysis period used by the SMS.
1 INTRODUCTION

The Federal Motor Carrier Safety Administration (FMCSA) is dedicated to reducing crashes, injuries, and fatalities involving large trucks and buses. The Compliance, Safety, Accountability (CSA) program is FMCSA’s enforcement model that allows the Agency and State Partners to address motor carrier safety problems before crashes occur. The foundation of CSA is the Safety Measurement System (SMS), which quantifies the on-road safety performance of motor carriers to prioritize enforcement resources.

1.1 BACKGROUND

The SMS uses State-reported crash and inspection data to assess motor carriers’ crash risk and prioritize them for safety interventions. The Crash Indicator is one of seven Behavior Analysis and Safety Improvement Categories (BASICs) that the SMS uses to evaluate safety performance:

- **Unsafe Driving**: Operation of commercial motor vehicles (CMVs) in a dangerous or careless manner.
- **Hours-of-Service (HOS) Compliance**: Operation of CMVs by drivers who are ill, fatigued, or in noncompliance with the HOS regulations.
- **Driver Fitness**: Operation of CMVs by drivers who are unfit to operate due to a lack of training, experience, or medical qualifications.
- **Controlled Substances and Alcohol**: Operation of CMVs by drivers who are impaired due to alcohol, illegal drugs, or misuse of prescription or over-the-counter medications.
- **Vehicle Maintenance**: Failure to properly maintain a CMV and/or to properly prevent shifting loads.
- **Hazardous Materials (HM) Compliance**: Unsafe handling of HM on a CMV.
- **Crash Indicator**: Histories or patterns of high crash involvement, including frequency and severity, based on information from State-reported crashes.

The Crash Indicator uses all crash records involving CMVs that are submitted by the States through the Agency’s Motor Carrier Management Information System (MCMIS). In submitting these crash records, States may use data from Police Accident Reports (PARs) that were prepared by State or local law enforcement officials; FMCSA does not receive PARs or any other information pertaining to a motor carrier’s role in a crash from the States. Crash Indicator

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17 49 CFR Part 390.5 defines the types of crashes that States must report (recordable crashes) as occurrences involving a commercial motor vehicle operating on a highway in interstate or intrastate commerce that result in (1) a fatality; (2) bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident; or (3) one or more motor vehicles incurring disabling damage as a result of the accident, requiring the motor vehicle(s) to be transported away from the scene by a tow truck or other motor vehicle.
measures and percentiles are not available to the public: this information is available only to motor carriers and enforcement personnel with access to the SMS.

A variety of studies have looked at the SMS BASICs and their relationship to future crash risk. Starting with the independent analysis during the test phase of CSA conducted by the University of Michigan Transportation Research Institute (UMTRI) and continuing with studies conducted by the FMCSA, it is clear that there is a strong relationship between several of the BASICs, especially the Crash Indicator, and future crash involvement:

- The 2011 UMTRI evaluation of the effectiveness of the CSA field test found that the SMS is a significant improvement over its predecessor, SafeStat, in identifying unsafe motor carriers. In particular, the evaluation found that five of the seven BASICs employed during the test demonstrated a strong relationship to crash risk.\(^\text{18}\)

- The FMCSA analysis shows that nearly 40 percent of recently active motor carriers\(^\text{19}\) have sufficient data to be assessed by the SMS; these carriers own or operate 80 percent of vehicles and are involved in over 90 percent of all crashes involving a CMV.\(^\text{20}\)

- The FMCSA’s SMS Effectiveness Test (ET) shows that motor carriers prioritized for interventions in six of the BASICs have higher future crash rates than the national average; in particular, those carriers above the threshold in the Crash Indicator have a future crash rate that is 85 percent higher than the national average.\(^\text{21}\)

While this research demonstrates the relationship between crashes and future crash risk, some stakeholders have expressed concern that the Crash Indicator may not identify the highest risk motor carriers for interventions because it looks at all crashes without regard to the role of the carrier in the crash. In response to stakeholder interest and as part of the Agency’s commitment to continuous improvement, this Crash Weighting Analysis informs decision-making about the feasibility of using a motor carrier’s role in crashes as an indicator of future crash risk. The analysis focused only on the three broad questions below addressing the procedural issues surrounding a crash weighting program and the feasibility of implementing such a program; it did not focus on any other implications of the program. The Agency will seek comments on this study and the other implications of a crash weighting program through a Federal Register notice. The three analysis questions are not addressed sequentially but each as separate analyses designed to inform Agency decisions.

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\(^{19}\) Recently active carriers are those with an inspection, crash, investigation, safety audit, Unified Carrier Registration payment, registration, or insurance update within the last three years.
- Do PARs provide sufficient, consistent, and reliable information to support crash weighting determinations?

- Would a crash weighting determination process offer an even stronger predictor of crash risk than overall crash involvement, and how would crash weighting be implemented in the SMS?

- Depending upon the analysis results for the questions above, how might FMCSA manage the process for making crash weighting determinations, including public input to the process?

1.2 STUDY APPROACH

To address these questions, FMCSA defined crash weighting as the following two-step process: (1) review a sample of PARs to determine the critical reason for the crash events and the motor carriers’ roles; and (2) use the critical reason determinations (defined below) as a basis for weighting the crashes in the SMS using various approaches. Based on this approach, FMCSA identified a process and associated costs for a national crash weighting program.

PARs are used by law enforcement across the United States to document the circumstances surrounding a crash. This study focused on crashes involving a fatality, an injury, or a vehicle towed from the scene. There is no one single standard format for a PAR or for the many pieces of information that a police officer records in a PAR—including all of the vehicles involved in the crash, the names of drivers and companies if CMVs are involved, the weather and road conditions, a written description of the events leading to the crash, and a diagram to illustrate what happened and where. The format and content of PARs vary among the States and often even within a State.

The FMCSA does not receive PARs from the States, but only a partial set of the information recorded on the PAR that may be included in the State-reported crash record. Thus, to create a database for the purposes of this analysis, FMCSA obtained 10,892 PARs from two national data sets: the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) and the National Motor Vehicle Crash Causation Survey (NMVCCS).

Depending upon State procedures, most PARs do not indicate the reason for a crash; therefore, the FMCSA employed a review process based on the process developed for FMCSA’s Large Truck Crash Causation Study (LTCCS), particularly the methodology for assigning the “critical event” and the “critical reason” for the critical event. This methodology focuses on pre-crash events, such as vehicle and driver actions/movements, driver condition, and the environment at the crash scene, to identify the circumstances leading to the crash. The critical event and critical reason are defined as follows:

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22 A State uploads CMV accident reports in accordance with current FMCSA policy guidelines.
23 The FMCSA obtained 10,505 PARs representing fatal crashes in the FARS from 2008-2010 and 387 PARs for recordable crashes (fatality, injury, or tow-away) from the 2005-2007 NMVCCS.
• **Critical Event:** The event that immediately led to the crash and that put the vehicle or vehicles on a course that made the crash unavoidable. In this study, the PAR reviewers assigned the critical event to the vehicle or other party, such as a pedestrian, responsible for the action or inaction that made the crash inevitable.

• **Critical Reason:** The immediate reason for the critical event or the failure leading to the critical event. The critical reason was identified to describe the role of the driver or vehicle involved in the crash event. For example, if a CMV driver decides to drive too fast for the roadway type, the CMV driver would be assigned the critical reason.

The FMCSA reviewed the PARs and determined the critical event and critical reason to identify a motor carrier’s role in a crash and assign a crash weighting for analysis purposes.

1.3 **CONTENTS**

The sections below present an overview of the results of analyses conducted to provide insight into the three questions guiding the study. In order to derive the most robust analysis of each question, the Agency used several crash data sources, including PARs, the NMVCCS, and the MCMIS. Each section of the report identifies the source of the data used for the particular analysis.

• **Section 2:** Review of previous studies addressing the sufficiency, completeness, and reliability of PARs, the effectiveness of predicting future crashes based on prior crashes, and related efforts to identify high-crash-risk motor carriers and drivers.

• **Section 3:** Analysis approach and results for the assessment of PAR sufficiency and reliability, including a description of the data sets analyzed, the process used to review the PARs, and the results of the review process (Study Question 1).

• **Section 4:** Analysis approach and results for the assessment of crash weighting safety benefits, including alternative approaches for implementing crash weighting in the SMS (Study Question 2).

• **Section 5:** Estimated costs associated with implementing a crash weighting determination process and discussion of other implementation issues (Study Question 3).

• **Section 6:** Conclusions from this *Crash Weighting Analysis*.

• **Appendix A:** Police Accident Report Coding Guidelines.

• **Appendix B:** Examples of PARs used in this analysis.

• **Appendix C:** Additional methodological details and analysis results for the assessment of crash weighting benefits.

• **Appendix D:** Additional details related to the calculation of the Crash Indicator.
• **Appendix E**: Summary of comments from the peer review of this study and FMCSA’s response.
As part of this Crash Weighting Analysis, the Federal Motor Carrier Safety Administration (FMCSA) identified and reviewed previous studies whose methodologies, results, or conclusions might support the Agency’s crash weighting research. In particular, this review focused on three areas:

- Studies assessing the accuracy of information contained in Police Accident Reports (PARs) and the consistency of PARs among States and other reporting agencies.

- Research addressing the benefits of weighting crashes based on the motor carrier’s role in the crash, including the effectiveness or validity of predicting future crashes based on prior crashes and of crash prediction models, with or without crash weighting.

- Other efforts to identify high-crash-risk drivers or motor carriers based on factors that include prior crashes and responsibility for those crashes.

### 2.1 PAR ACCURACY AND CONSISTENCY

Law enforcement officials use PARs to document the circumstances surrounding a crash event. Police officers record many pieces of information in this report, including all of the vehicles involved in the crash; the names of drivers and, if commercial motor vehicles (CMVs) are involved, the names of companies; weather and road conditions; a written description of the events that led to the crash; and a diagram to illustrate what happened and where.

The documents and studies reviewed for this analysis contain important information about the accuracy and consistency of PARs. In particular, a 2009 FMCSA study assessed the feasibility of accurately and consistently determining a motor carrier’s role in a crash event using only the PAR. For this study, the test was whether the CMV involved in a crash could be coded with the critical reason for the crash event. The test included PARs for 1,221 fatal, injury, and property-damage-only large truck and bus crashes that were part of either the Large Truck Crash Causation Study (LTCCS) or the National Highway Traffic Safety Administration’s General Estimates System (GES). The study employed two different validation processes:

- For crashes from the LTCCS, the study compared the critical reason determination made by reviewers using only the PAR with the critical reason identified in the LTCCS.

- For crashes from the GES, the study compared the critical reason determination of two different reviewers who used only the PAR.

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26 The critical crash event is the action or event that immediately led to the crash and that made the crash inevitable. FMCSA's study uses the critical crash reason coding methodology developed for the LTCCS. The critical crash reason is the immediate reason for the critical crash event or the failure leading to the critical event.
Between the two data sets, the study documented a 93 percent agreement on the critical reason.27

Other studies reviewed for this analysis concluded the following:

- Police officers do not always complete a PAR, especially for minor crashes, and are most likely to do so for crashes involving fatalities or injuries.28

- When comparing the PAR and other sources of information about a crash (such as the emergency department report or ambulance report) with an in-depth crash investigation record, the PAR is the most accurate data source.29 However, for all information sources, there is only fair to moderate agreement with the crash investigation record.

- Because CMV crashes are complex, police officers may not be able to document the crash event sufficiently. Thus, when using crash data, analysts should examine carefully the driver statements and the facts that officers collect at the crash scene to identify discrepancies.30

The studies discussed above provide insight as to how to analyze information on PARs to determine the critical reason; however, this research is limited due to small and restricted sample sizes; failure to examine whether the PAR accurately depicts the circumstances that led to the crash; inability to identify an outside data source or methodology for validating and coding PARs across all States; and failure to address a process for coding PARs to identify a motor carrier’s role, including quality control issues.

2.2 PREDICTING FUTURE CRASHES BASED ON PRIOR CRASHES

The FMCSA reviewed research relevant to identifying the benefits of weighting crashes based on the motor carrier’s role. These studies highlighted the many factors that contribute to a crash and found that, for drivers, past crash involvement is a good predictor of future crashes. Specifically:

- A number of CMV driver behaviors are statistically significant predictors of future crashes, especially failure to use or improper use of signals, involvement in a prior crash, and improper passing.31

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27 In a July 2, 2013 letter to the FMCSA Administrator, members of the Motor Carrier Safety Advisory Committee (MCSAC) wrote that, because of the methodology employed, this analysis failed to demonstrate the viability of relying on PARs to determine a motor carrier’s role in a crash.
Past crashes, driver and vehicle violations, and driver demographics are all significantly related to the likelihood of future crashes. In particular, CMV driver crash involvement significantly increases the chance of a future crash.\(^{32}\)

A model developed to predict future “at-fault” crashes for all Kentucky drivers found that prior at-fault crashes, driver’s license suspensions, and citations are strongly associated with driver responsibility for a subsequent crash.\(^{33}\)

For Ontario truck and car drivers, crash involvement is a strong predictor of future crashes.\(^{34}\)

Among older drivers in Québec, prior crashes are a better predictor of crash risk than prior convictions for such violations as speeding, failure to stop at a traffic signal or stop sign, or failure to wear a safety belt.\(^{35}\)

Among the limitations of these various studies are a short timeframe of analysis, geographic restrictions, focus only on drivers rather than motor carriers, focus on a limited driver population, and focus not on CMV drivers. Most significantly, none of the studies examined the benefits of assessing crash risk based on motor carriers’ and drivers’ roles in crashes rather than on overall crash involvement.

2.3 IDENTIFYING HIGH-CRASH-RISK MOTOR CARRIERS AND DRIVERS

For this part of the review, FMCSA consulted a number of sources, including insurance companies and Canadian officials, to identify various approaches to classifying “risky” motor carriers and drivers and determining their roles in crashes. Insurance companies were unwilling to share information about how they assign fault and identify high-risk drivers; therefore, the study focused on Canada’s approach to evaluating motor carrier crash involvement. In summary:

- Canada regulates the motor carrier industry based on the National Safety Code (NSC), which is similar to the Federal Motor Carrier Safety Regulations; however, there is no national oversight of the NSC, and each province implements the code independently.

- All provinces evaluate motor carrier crash involvement using some form of crash weighting, although the “weighted” crashes remain on the carriers’ and drivers’ records.

- There is no national policy or standardized metric for determining crash weighting; the specific approach varies among the Canadian provinces.

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• Ontario assigns points for crashes based on severity and “impropriety”; if a crash involves no impropriety on the part of the CMV or driver, zero points are assigned; however, all crashes remain on carrier and driver records for five years.

2.4 OBSERVATIONS
The FMCSA’s review of previous studies provides insight into methodologies and approaches relevant to an assessment of crash weighting. In particular:

• While analysis has shown that critical reason determinations based solely on the PAR are consistent 93 percent of the time, other studies suggest that PARs may have shortcomings in the extent to which they thoroughly depict the circumstances of a crash.

• Research shows that particular driver behaviors, including crash involvement, are highly predictive of future crashes.

• All Canadian provinces use some method of crash weighting; however, the weighted crashes remain on motor carriers’ and drivers’ records for five years.

• Previous analyses do not address the practicability, effectiveness, or safety benefits of weighting crashes based on a motor carrier’s role in the crash.
3 DO PARS PROVIDE SUFFICIENT, CONSISTENT, AND RELIABLE INFORMATION TO SUPPORT CRASH WEIGHTING DETERMINATIONS?

One of the key questions for this study is whether the Federal Motor Carrier Safety Administration (FMCSA) could make crash weighting determinations based solely on Police Accident Reports (PARs), since the PAR is often perceived as the most common and timely record of a crash. FMCSA addressed this question by:

- Reviewing PAR sufficiency for determining a motor carrier’s role in a crash.
- Comparing a sample of PARs with other data sets to assess the reliability of the information on the PARs.
- Assessing the feasibility of identifying (coding) the motor carrier’s role for particular types of crash events, such as some single-vehicle crashes, without reviewing the PAR.

3.1 SUFFICIENCY OF PARS TO SUPPORT CRASH WEIGHTING DETERMINATIONS

This analysis assessed the sufficiency of PARs for determining a motor carrier’s role in a crash. The analysis assumed that the information on the PARs was accurate.

3.1.1 Approach

The analysis of PAR sufficiency included:

- Obtaining a sample of PARs.
- Reviewing and collecting data from the PARs in an online data collection tool and coding the involved motor carriers’ roles in the crashes recorded.
- Analyzing the results of the PAR reviews.

3.1.1.1 Obtaining the PARs

As discussed in Section 1.2, FMCSA reviewed and collected data from 10,892 PARs from two national data sets:

- **Fatality Analysis Reporting System (FARS):** The FARS contains data on fatal crashes within the 50 States, the District of Columbia, and Puerto Rico. Collected by FARS analysts in each of the States, the data is gathered from the original PAR and the State’s own source documents and then coded on standard FARS forms. FARS analysts are trained to understand and translate data from their State PAR to FARS data elements using State documents such as vehicle registration files, driver licensing files, highway department data, vital statistics, death certificates, coroner/medical examiner reports, hospital medical reports, and emergency medical service reports. Each crash in the FARS has more than 125 different coded data elements that characterize the crash, the vehicles,
and the people involved. The specific data elements may be modified slightly each year to conform to changing user needs, vehicle characteristics, and highway safety emphasis areas.

- **National Motor Vehicle Crash Causation Survey (NMVCCS):** The NMVCCS uses recordable crashes from NHTSA’s National Automotive Sampling System, which is based on a nationally representative sample of police-reported motor vehicle crashes resulting in property damage, injury, or death. Like the FARS analysts, the NMVCCS analysts are well trained to interpret and research crash facts using supplemental data sources beyond the PAR. The NMVCCS database includes more than 600 data elements related to the drivers, vehicles, roadways, and environment. In particular, the NMVCCS includes photographs, schematic diagrams, vehicle information, data from event data recorders, and other information collected during an in-depth study of each PAR. The NMVCCS also assesses the critical reason and critical event related to the crash.

Table 1 shows the number of PARs received from each data set and source.

<table>
<thead>
<tr>
<th>Data Set/Source</th>
<th>Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>FARS 2008-2010</td>
<td>10,505</td>
</tr>
<tr>
<td>NMVCCS 2005-2007</td>
<td>387</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,892</strong></td>
</tr>
</tbody>
</table>

### 3.1.1.2 Reviewing and Collecting PAR Data

FMCSA employed a PAR review process based on that developed for the Agency’s Large Truck Crash Causation Study (LTCCS). Central to this process was the LTCCS critical event/critical reason methodology. (See Section 1.2 for definitions of the critical event and critical reason.)

The PAR reviewers had previous experience with the critical event/critical reason methodology and with interpreting and understanding the nuances of crash reporting. Reviewers also had experience with earlier studies, such as the LTCCS, that involved the processing of large volumes of PARs to identify unique crash variables. As additional guidance for the PAR reviewers, FMCSA developed guidelines addressing the types of information to be reviewed on a PAR; the various crash scenarios covering most single- and multi-vehicle events; and the collection of information from the PAR in an online tool. (See Appendix A.)

### 3.1.1.2.1 Data Collection Tool

FMCSA developed an online tool to support a uniform method for collecting data from and analyzing the PARs. The PAR reviewers entered information into the online tool from specific sections of the PAR as completed by the police officer. Based on this information, the reviewers coded the critical reason and the justification for the critical reason; all other data elements were entered directly from the PAR without interpretation. The PAR reviewers did not interpret information found elsewhere on the PAR if it differed from the specified field.
Table 2 shows the information that was collected from the PAR and entered into the data collection tool. The PAR reviewers collected information for each data element shown in Table 2, unless it was not available on the PAR. Several of these data elements were used to match the information on the PAR to a corresponding record in the FARS database, the NMVCCS, or the Motor Carrier Management Information System (MCMIS).

**Table 2. PAR Data Captured by Collection Tool**

<table>
<thead>
<tr>
<th>Type of Data</th>
<th>Reason for Including</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System-Generated Information</strong></td>
<td></td>
</tr>
<tr>
<td>1 Record ID #</td>
<td>Database record number</td>
</tr>
<tr>
<td>2 Date of review</td>
<td>Identifies when review was conducted</td>
</tr>
<tr>
<td>3 Start time of review</td>
<td>Used to calculate time to enter record</td>
</tr>
<tr>
<td>4 End time of review</td>
<td>Used to calculate time to enter record</td>
</tr>
<tr>
<td>5 User ID</td>
<td>Identifies who conducted review</td>
</tr>
<tr>
<td><strong>Crash Information on the PAR</strong></td>
<td></td>
</tr>
<tr>
<td>6 Scanned PAR file name</td>
<td>Used to match database record to a PAR</td>
</tr>
<tr>
<td>7 Reporting State</td>
<td>Used to match PAR to records in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>8 PAR number</td>
<td>Identifies State report number</td>
</tr>
<tr>
<td>9 Record source</td>
<td>Identifies source of record</td>
</tr>
<tr>
<td>10 Report/case # from the source</td>
<td>Used to match PAR to records in FARS</td>
</tr>
<tr>
<td>11 Crash date</td>
<td>Used to match PAR to records in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>12 Crash time (as appears on PAR)</td>
<td>Used to match PAR to records in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>13 Crash severity</td>
<td>Used to categorize records by severity</td>
</tr>
<tr>
<td>14 Total # of vehicles involved in crash event</td>
<td>Used to identify single- versus multi-vehicle crashes</td>
</tr>
<tr>
<td>15 # of CMVs involved in crash event</td>
<td>Used to identify CMV involvement</td>
</tr>
<tr>
<td>16 Weather condition</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>17 Roadway surface condition</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>18 Traffic-way type</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>19 First harmful event in the crash event</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td><strong>Vehicle and Carrier Information &amp; Critical Reason Results</strong></td>
<td></td>
</tr>
<tr>
<td>20 Vehicle # involved in crash</td>
<td>Used to match PAR to records in MCMIS/FARS</td>
</tr>
<tr>
<td>21 Vehicle type</td>
<td>Used to verify vehicle type in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>22 Vehicle license plate #</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>23 Vehicle license plate State</td>
<td>Used to match PAR to records in MCMIS/FARS</td>
</tr>
<tr>
<td>24 Initial impact area on the vehicle*</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>25 Driver contributing factors</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>26 Carrier U.S. DOT #</td>
<td>Used to match PAR to records in MCMIS/FARS</td>
</tr>
<tr>
<td>27 Carrier MC #</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>28 Carrier name</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>29 Street address</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>Type of Data</td>
<td>Reason for Including</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>30 City</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>31 State</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>32 Zip code</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>33 Critical reason (required)</td>
<td>Used to capture critical reason determination and compare to NMVCCS</td>
</tr>
<tr>
<td>34 Critical reason justification (required)</td>
<td>Identifies a justification for critical reason determination</td>
</tr>
<tr>
<td>35 Justification description</td>
<td>Captures text explanation for “other” critical reason justifications</td>
</tr>
</tbody>
</table>

* Dropped from study because of difficulties with coding.

### 3.1.1.2.2 PAR Review

The PAR reviewers examined thoroughly all documentation provided in a PAR to understand the driver, vehicle, and other factors influencing the crash event and assign a critical reason. Reviewers faced a number of challenges, including:

- **PAR Quality**: Because the PARs were provided in hard-copy format, they varied greatly in terms of quality, legibility, and completeness. Many were handwritten and, in some cases, had been edited, marked on, or redacted. This compounded the legibility problems associated with reviewing scanned copies. (See Appendix B for an example.)

- **Lack of Consistency across States**: Each State had a unique format for the PAR. (See Appendix B.)

- **Changes within a State**: Because crashes are reported at the local, county, and State levels, a State could have multiple versions of the same PAR; moreover, States often made changes to the format of their PARs, sometimes annually.

Although States’ PARs had unique layouts and somewhat different data elements, the large majority contained the information necessary to determine the critical event and critical reason. Such information included details about the parties involved in the crash, the numbers and types of vehicles, the general weather and roadway characteristics, and a detailed description and diagram of the crash event. In addition, some PARs had supplemental forms, such as witness statements, photographs of the crash scene, driver logbooks, or commercial driver/vehicle inspection reports.

Shown in Figure 1, the process that the PAR reviewers followed comprised four steps:

- **Step 1. Review PAR for Relevancy and Completeness**: The PAR reviewers first checked each PAR to ensure that it met the following study criteria:
  - At least one of the vehicles was a CMV (a large truck or bus or a light vehicle placarded for hazardous materials (HM)).
  - The CMV was regulated by FMCSA.
The crash event met the severity criteria for a recordable crash (fatal, bodily injury, or tow-away). If a reviewer could not determine from the PAR that these criteria were met, he or she created a record for that crash but did not complete a full review; the number of CMVs was entered as “0” and the review process ended.

- **Step 2. Review Crash and Vehicle Information**: The PAR reviewers examined the remaining PARs to understand the nature of the crash events, including the basic crash information (crash date and time, crash severity, number of vehicles involved, number of CMVs, weather and road surface condition, traffic-way type, first harmful event); vehicle information (configuration, cargo body type, weight, class, HM information, license plate number and State, motor carrier information); driver information (driver condition, driver action immediately prior to the crash, alcohol test results, citations, license class, endorsements, restrictions, or license status); and the crash diagram and narrative description. Reviewers crosschecked the data in the driver and vehicle sections to ensure that the PAR contained sufficient information to determine the critical event/critical reason; if the PAR did not contain enough information, the reviewer assigned the critical reason as “unable to assign critical reason.”

- **Step 3. Determine the Critical Event and Critical Reason**: After thoroughly reviewing the information on the PAR, reviewers determined the vehicle(s) (or other party) that committed the critical event and assigned a critical reason to each CMV involved in the crash. (Reviewers did not assign a critical reason to the non-CMVs.) There were five critical reason choices: (1) truck/bus driver; (2) truck/bus vehicle; (3) environment; (4) not assigned to this truck/bus driver/vehicle; and (5) unable to assign critical reason. Reviewers also selected from among a number of critical reason justifications.

- **Step 4. Enter Crash and Vehicle Information into the Data Collection Tool**: Reviewers entered relevant data from the PAR, as well as the critical reason and critical reason justification, into the data collection tool. (See Figure 2.) Reviewers entered information for each CMV involved in the crash. No information was recorded for the non-CMVs. (In addition, reviewers did not record driver identifying information due to privacy issues.)

---

36 The review process did not involve looking up vehicle identification numbers to decode the vehicle type or tracking down missing pages or other information from the PAR that may have contained the CMV information.
Figure 1. PAR Review Process
Figure 2. Data Collection Tool Screenshot

3.1.2 Analysis Results

Table 3 shows the number of PARs, the number that met the criteria to be reviewed for a critical reason determination, and the number not reviewed, for the FARS and NMVCCS data sets.

<table>
<thead>
<tr>
<th>Critical Reason Coding</th>
<th>FARS</th>
<th>NMVCCS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
</tr>
<tr>
<td>Reviewed for Critical Reason</td>
<td>9,574</td>
<td>91%</td>
<td>310</td>
</tr>
<tr>
<td>Not Reviewed for Critical Reason</td>
<td>931</td>
<td>9%</td>
<td>77</td>
</tr>
<tr>
<td>Total</td>
<td>10,505</td>
<td>100%</td>
<td>387</td>
</tr>
</tbody>
</table>

As shown in Table 3, approximately 91 percent (9,884) of PARs met the criteria to be reviewed for a critical reason determination. For the remaining 9 percent (1,008) of PARs, the reviewers could not determine from the PAR that a CMV was involved, the CMV was regulated by FMCSA, and the crash was recordable. These PARs were often incomplete or contained illegible or redacted information.
Table 4 shows the number of CMVs involved in the crashes reported on the PARs.

<table>
<thead>
<tr>
<th># CMVs per PAR</th>
<th># PARs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9,196</td>
</tr>
<tr>
<td>2</td>
<td>587</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Could Not Determine CMV Involvement</td>
<td>1,008</td>
</tr>
</tbody>
</table>

Total CMVs: 10,749  Total PARs: 10,892

The table shows that the number of CMVs involved in the crash events ranged widely, from 1 to 13. The large majority of crashes (85 percent) involved a single CMV. PARs categorized as “Could Not Determine CMV Involvement” lacked sufficient information to determine that a CMV was involved. Although the PARs used in this study were assumed to have had at least one CMV involved in the crash, the information presented on the PAR alone proved insufficient to confirm that a CMV was involved.

### 3.1.2.1 Critical Reason Determinations

For each CMV involved in a crash, the PAR reviewers evaluated the crash event and assigned one of five critical reasons: (1) truck/bus driver; (2) truck/bus vehicle; (3) environment; (4) not assigned to this truck/bus driver/vehicle; or (5) unable to assign critical reason. (Reviewers considered all non-CMVs involved in a crash, but only to the extent that their role pertained to determining the CMV’s responsibility.)

Table 5 summarizes the results of the PAR review process. These results show the critical reason outcomes for the CMVs involved in the 9,884 crash events for which the PAR met the criteria to be reviewed for a critical reason determination.

---

37 Of the 10,749 CMVs, 10,711 were trucks, 36 were buses, and 2 were light vehicles placarded for HM.
Table 5. PAR Coding Results: CMV Critical Reason Outcomes

<table>
<thead>
<tr>
<th>Critical Reason Outcomes</th>
<th>Attribute to Motor Carrier?</th>
<th># CMVs Involved in Crash Events</th>
<th>% CMVs Involved in Crash Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck/Bus Driver</td>
<td>Yes</td>
<td>3,622</td>
<td>33.7%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Yes</td>
<td>234</td>
<td>2.2%</td>
</tr>
<tr>
<td>Environment</td>
<td>Unknown</td>
<td>52</td>
<td>0.5%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle</td>
<td>No</td>
<td>6,537</td>
<td>60.8%</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>Unknown</td>
<td>304</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

The five critical reason outcomes shown in Table 5 formed the basis for assigning crash weighting determinations in the second part of this study. (See Section 4.) The “Truck/Bus Driver” and “Truck/Bus Vehicle” outcomes determined that the reason for the crash could be attributed to the motor carrier. The “Not Assigned to This Driver/Vehicle” outcome determined that the crash could not be attributed to the motor carrier. The “Environment” and “Unable to Assign Critical Reason” outcomes determined that the crash could not be attributed to either the motor carrier or the other vehicle(s). The crashes were “weighted” by assigning a value, for analysis purposes, based on the role of the motor carrier in the crash (attributed or not attributed to the carrier).

In addition to assigning a critical reason, PAR reviewers selected a critical reason justification associated with the driver’s or vehicle’s actions to explain how the critical reason was determined. Table 6 shows the breakout of critical reasons and their justifications for all CMVs.

Table 6. Critical Reasons Associated with Justification Descriptions

<table>
<thead>
<tr>
<th>Critical Reason</th>
<th>Critical Reason Justification Description</th>
<th>#CMVs</th>
<th>%CMVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category - Recognition Error/Poor Judgment</td>
<td></td>
<td>3,622</td>
<td>33.70%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver was following too close for conditions.</td>
<td>120</td>
<td>1.12%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver was going too fast for conditions.</td>
<td>400</td>
<td>3.72%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver was going too slowly for traffic stream.</td>
<td>11</td>
<td>0.10%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver exhibited aggressive driving behavior.</td>
<td>11</td>
<td>0.10%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus struck the rear of a vehicle.</td>
<td>310</td>
<td>2.88%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver was aware of dangerous atmospheric conditions.</td>
<td>5</td>
<td>0.05%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver was aware of ongoing highway conditions.</td>
<td>8</td>
<td>0.07%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>41</td>
<td>0.38%</td>
</tr>
<tr>
<td>Category - Intersection/Crossing Path</td>
<td></td>
<td>244</td>
<td>2.27%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver turned across path of another vehicle at a junction without a traffic control device present.</td>
<td>108</td>
<td>1.00%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver turned across path at a junction in violation of a traffic control device.</td>
<td>60</td>
<td>0.56%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver performed a wide turn from a portion of wrong lane.</td>
<td>31</td>
<td>0.29%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver performed a wide turn and struck object on road.</td>
<td>1</td>
<td>0.01%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>44</td>
<td>0.41%</td>
</tr>
<tr>
<td>Category - Decision Error</td>
<td></td>
<td>688</td>
<td>6.40%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver misjudged gap or other’s speed.</td>
<td>96</td>
<td>0.89%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver had false assumption of other’s actions.</td>
<td>50</td>
<td>0.47%</td>
</tr>
<tr>
<td>Critical Reason</td>
<td>Critical Reason Justification Description</td>
<td>#CMVs</td>
<td>%CMVs</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus was disabled as a result of a driver action that caused the vehicle to stop operating.</td>
<td>9</td>
<td>0.08%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver did not obey a traffic control device.</td>
<td>194</td>
<td>1.80%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver executed an inadequate evasive action.</td>
<td>175</td>
<td>1.63%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver executed an illegal maneuver.</td>
<td>58</td>
<td>0.54%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>106</td>
<td>0.99%</td>
</tr>
<tr>
<td><strong>Category - Mechanical Failure</strong></td>
<td></td>
<td>30</td>
<td>0.28%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus lost control as a result of mechanical failure.</td>
<td>8</td>
<td>0.07%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver actions caused the cargo shift/loss.</td>
<td>13</td>
<td>0.12%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>9</td>
<td>0.08%</td>
</tr>
<tr>
<td><strong>Category - Erratic Actions/Unsafe Driving</strong></td>
<td></td>
<td>1,008</td>
<td>9.38%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver failed to drive safely due to physical condition.</td>
<td>100</td>
<td>0.93%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver failed to drive safely due to distraction or inattention.</td>
<td>131</td>
<td>1.22%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver failed to drive safely due to inadequate surveillance.</td>
<td>285</td>
<td>2.65%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver failed to drive safely by exercising poor directional control or overcompensating.</td>
<td>467</td>
<td>4.34%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus swung or jackknifed resulting in a crash (if no extenuating circumstances).</td>
<td>5</td>
<td>0.05%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>20</td>
<td>0.19%</td>
</tr>
<tr>
<td><strong>Category - Lane Change</strong></td>
<td></td>
<td>385</td>
<td>3.58%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus encroached into a lane occupied by another motor vehicle.</td>
<td>110</td>
<td>1.02%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus traveled over the lane line or off the road.</td>
<td>272</td>
<td>2.53%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>3</td>
<td>0.03%</td>
</tr>
<tr>
<td><strong>Category – Other</strong></td>
<td></td>
<td>361</td>
<td>3.36%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus struck pedestrian— pedestrian's actions were NOT deliberate.</td>
<td>159</td>
<td>1.48%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Truck/bus struck animal—driver had time for evasive action.</td>
<td>2</td>
<td>0.02%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Driver actions or inactions led to crash.</td>
<td>159</td>
<td>1.48%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>Other.</td>
<td>41</td>
<td>0.38%</td>
</tr>
<tr>
<td><strong>Critical Reason: Truck/Bus Vehicle</strong></td>
<td></td>
<td>234</td>
<td>2.18%</td>
</tr>
<tr>
<td><strong>Category - Vehicle Issue</strong></td>
<td></td>
<td>234</td>
<td>2.18%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Truck/bus was disabled in travel lane and was struck by other vehicle.</td>
<td>32</td>
<td>0.30%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Truck/bus failure or degraded vehicle component(s) led to the crash.</td>
<td>128</td>
<td>1.19%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Truck/bus cargo shift/loss caused loss of control leading to a crash.</td>
<td>15</td>
<td>0.14%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Truck/bus disabled as a result of a mechanical breakdown.</td>
<td>28</td>
<td>0.26%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>Other.</td>
<td>31</td>
<td>0.29%</td>
</tr>
<tr>
<td><strong>Critical Reason: Environment</strong></td>
<td></td>
<td>52</td>
<td>0.48%</td>
</tr>
<tr>
<td><strong>Category – Road</strong></td>
<td></td>
<td>18</td>
<td>0.17%</td>
</tr>
<tr>
<td>Environment</td>
<td>Unanticipated roadway issue.</td>
<td>10</td>
<td>0.09%</td>
</tr>
<tr>
<td>Environment</td>
<td>Traffic control signs/signals: missing; erroneous; defective; inadequate.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Critical Reason</td>
<td>Critical Reason Justification Description</td>
<td>#CMVs</td>
<td>%CMVs</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Environment</td>
<td>Road issue/defect (e.g., low bridge without appropriate signage; sudden roadway deterioration; etc.).</td>
<td>1</td>
<td>0.01%</td>
</tr>
<tr>
<td>Environment</td>
<td>Truck/bus driver's view was obstructed by roadway design/signage or by other vehicles.</td>
<td>2</td>
<td>0.02%</td>
</tr>
<tr>
<td>Environment</td>
<td>Truck/bus cargo shift/loss caused by unanticipated roadway issue.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Environment</td>
<td>Truck/bus struck animal—driver had no time for evasive action.</td>
<td>4</td>
<td>0.04%</td>
</tr>
<tr>
<td>Environment</td>
<td>Other</td>
<td>1</td>
<td>0.01%</td>
</tr>
</tbody>
</table>

### Category – Weather

<table>
<thead>
<tr>
<th>Critical Reason</th>
<th>Critical Reason Justification Description</th>
<th>#CMVs</th>
<th>%CMVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Unanticipated environmental condition.</td>
<td>31</td>
<td>0.29%</td>
</tr>
<tr>
<td>Environment</td>
<td>Truck/bus swung or jackknifed caused by sudden unanticipated environmental condition.</td>
<td>2</td>
<td>0.02%</td>
</tr>
<tr>
<td>Environment</td>
<td>Truck/bus cargo shift/loss caused by unanticipated environmental condition.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Environment</td>
<td>Truck/bus disabled as a result of an unseen or sudden weather event.</td>
<td>1</td>
<td>0.01%</td>
</tr>
<tr>
<td>Environment</td>
<td>Other</td>
<td>0</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

### Category - Other Vehicle Reason

<table>
<thead>
<tr>
<th>Critical Reason: Not Assigned to This Driver/Vehicle</th>
<th>#CMVs</th>
<th>%CMVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus had the right of way.</td>
<td>385</td>
<td>3.58%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus stopped safely before being struck.</td>
<td>17</td>
<td>0.16%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus is the lead vehicle and was stopped at traffic light and struck in rear.</td>
<td>6</td>
<td>0.06%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus is lead vehicle, stopped in traffic, struck in rear and pushed into another vehicle or object.</td>
<td>3</td>
<td>0.03%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus performed a wide turn from correct lane and struck vehicle making an illegal maneuver.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus turned in compliance with a traffic control.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus encroached into another lane/off road to avoid crash.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus struck pedestrian/non-motorist. Pedestrian/non-motorist actions were deliberate.</td>
<td>53</td>
<td>0.49%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus mechanical problem found, but is not responsible for crash.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Truck/bus disabled as a result of previous crash.</td>
<td>6</td>
<td>0.06%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Critical event not coded to truck/bus driver/vehicle.</td>
<td>6,049</td>
<td>56.28%</td>
</tr>
<tr>
<td>Not Assigned to This Driver/Vehicle Other.</td>
<td>18</td>
<td>0.17%</td>
</tr>
</tbody>
</table>

### Critical Reason: Unable to Assign Critical Reason

<table>
<thead>
<tr>
<th>Critical Reason: Unable to Assign Critical Reason</th>
<th>#CMVs</th>
<th>%CMVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR not legible.</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Critical Reason</td>
<td>Critical Reason Justification Description</td>
<td>#CMVs</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>PAR not complete (includes missing pages, supplemental forms).</td>
<td>144</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>PAR information not consistent.</td>
<td>1</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>Not enough/sufficient information to make a determination.</td>
<td>155</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>Other.</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>10,749</td>
</tr>
</tbody>
</table>

Approximately 61 percent of the CMVs were not assigned the critical reason for the crash. For about 34 percent of CMVs, the critical reason was an action or inaction on the part of the truck or bus driver, and for 2 percent it was a CMV-related vehicle issue. Other critical reasons included the environment, such as weather or roadway conditions (less than 1 percent), and “unable to assign,” due to incomplete, inconsistent, or insufficient information (about 3 percent).

Among the CMVs assigned the critical reason (either to the driver or the vehicle), the leading justification was erratic driver actions or unsafe driving (approximately 26 percent of CMVs), followed by driver recognition error or poor judgment (23 percent), driver decision error (18 percent), lane change (10 percent), other (9 percent), intersection/crossing path errors (6 percent), and vehicle issues (6 percent).

### 3.1.2.2 Quality Control of Coding Process

Throughout the PAR coding, the results in the data collection tool were checked against the original PAR for (1) proper interpretation of the data; (2) correct data entry; and (3) understanding of the critical reason methodology. Observations and feedback were provided to the PAR reviewers and, if necessary, the record in the online tool was corrected.

In addition, a quality control check was performed for about 6 percent, or 673, of the coded PARs. The PARs were selected by sampling approximately the same percentage of records completed by each PAR reviewer within a specific timeframe. The quality control check supported approximately 92 percent of the critical reason determinations made by the PAR reviewers. Table 7 shows the explanations for the 8 percent that were not upheld by the quality control process.
Table 7. Results of PAR Coding Quality Control

<table>
<thead>
<tr>
<th>Explanation for Different Critical Reason Determination</th>
<th>Number of Vehicle Records</th>
<th>Percent of Vehicle Records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reviewer Assigned Critical Reason to Non-CMV; Quality Control Assigned to CMV</td>
<td>8</td>
<td>13%</td>
</tr>
<tr>
<td>Reviewer Assigned Critical Reason to CMV; Quality Control Assigned to Non-CMV</td>
<td>16</td>
<td>25%</td>
</tr>
<tr>
<td>Quality Control Assigned Critical Reason to Environment; Reviewer Did Not</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Quality Control Determined There Was Not Enough Information to Identify CMV or That PAR Was Illegible; Reviewer Assigned Critical Reason to CMV or Non-CMV</td>
<td>37</td>
<td>59%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>63</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The majority of differences (59 percent) were due to insufficient information on the PAR as to the involvement of a CMV in the crash; typically, these PARs were unclear or unreadable or did not have a clearly defined motor carrier section to distinguish a vehicle as a CMV. The remaining differences were due to assigning the critical reason to a different driver or vehicle or to the environment.

3.2 RELIABILITY OF PARS

The purpose of this analysis was to assess whether the critical reason determinations based solely on reviewing the PARs could be considered reliable. It was limited to the following:

- Comparing data from specific fields on the PAR with related fields in the matching FARS record. Because the FARS does not identify the critical reason for a crash, the comparison of data fields was thought to provide insight into the overall reliability of the PAR and thus the resulting critical reason determination.

- Comparing the critical reasons assigned by the PAR reviewers with those assigned in matching records from the NMVCCS, which employs the same critical event/critical reason methodology used by the LTCCS. (This analysis used the methodology employed for FMCSA’s 2009 crash weighting study, which was based on but differs somewhat from the LTCCS approach.)

3.2.1 Comparison of PARs with FARS

3.2.1.1 Approach

This analysis involved the following:

- Linking the PARs to records in the FARS.

- Comparing data fields on the PARs with related fields in the matched FARS records.
3.2.1.1 Linking PARs to Records in FARS

There were two criteria for including a PAR from the initial PAR data set in the analysis: (1) the record source was the FARS; and (2) the crash event involved one or more CMVs. The linking process comprised two-steps:

- **Step 1:** Link the PARs to the FARS at the crash level using the year, case number, and State (resulted in a record match for 8,021 PARs).

- **Step 2:** Link the CMVs from these matched PARs to the CMVs in the corresponding FARS records using the license plate, State, and U.S. DOT Number (yielded 8,813 CMVs matched to FARS records).

3.2.1.1.2 Comparison of Data Fields

After linking PARs to records in the FARS, FMCSA compared five data fields on each PAR with the same data fields in the matched FARS record to look for the same outcomes:

- **Driver Contributing Factors:** The police officer’s assessment of driver factors that contributed to the crash event. Up to four factors may be recorded.

- **First Harmful Event:** The first injury- or damage-producing event of the crash (e.g., rollover, collision with pedestrian).

- **Traffic-Way Flow:** The traffic-way type on which the crash event occurred (e.g., not physically divided, one-way).

- **Weather Condition:** The weather condition at the time of the crash event (e.g., clear, rain, snow).

- **Roadway Surface Condition:** The condition of the roadway surface at the time of the crash (e.g., dry, wet).

The records “matched” if the codes for these fields were completed and were the same. Since up to four driver contributing factors can be found per driver in either the PAR or the FARS record, a match was identified if one out of the four were the same.

3.2.1.2 Analysis Results

Results of the PARs-FARS comparison indicated varying levels of agreement on the data for the fields examined, as shown in Table 8.
Table 8. Results of PARs-FARS Comparison

<table>
<thead>
<tr>
<th>Data Field</th>
<th>PARs/FARS Match</th>
<th>PARs/FARS Non-Match</th>
<th>Missing PAR Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Contributing Factors</td>
<td>12.6%</td>
<td>5.3%</td>
<td>82.0%</td>
</tr>
<tr>
<td>First Harmful Event</td>
<td>46.9%</td>
<td>5.6%</td>
<td>47.5%</td>
</tr>
<tr>
<td>Traffic-Way Flow</td>
<td>52.4%</td>
<td>14.9%</td>
<td>32.8%</td>
</tr>
<tr>
<td>Weather Condition</td>
<td>95.7%</td>
<td>3.2%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Roadway Surface Condition</td>
<td>96.7%</td>
<td>2.3%</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

*All fields are counted at the crash level except the driver contributing factors field, which is counted at the vehicle level.

**The FARS has up to four driver contributing factors. All were recorded in the data collection tool if shown on the PAR.

Roadway surface condition and weather condition matched for more than 95 percent of records. Traffic-way flow matched for more than 50 percent; the main reason for the lower match rate for this field is that FARS analysts derive this information from other State documents. Driver contributing factors and first harmful event had match rates of less than 50 percent, primarily because this information was either missing from the PAR or was interpreted by the FARS analyst from information found in other places on the PAR. Further explanation for the low matching percentages includes:

- The PAR reviewers had only the PAR to review and did not have additional documentation. Reviewers were trained to copy information from specific fields on the PAR without interpreting information found elsewhere.

- In addition to a specific field on the PAR, the FARS analysts may derive data from different fields on the PAR, from a combination of fields, or from other information, such as the crash narrative; moreover, a FARS analyst may override a coded field on a PAR if there is conflicting information elsewhere. In general, when the FARS data is derived from a source other than the field being matched, the comparison between the PAR and the FARS record is likely to result as a “non-match.”

- FARS analysts make use of additional resources pertaining to a crash, such as information on vehicles and drivers (from State vehicle registration and driver license files); traffic-way flow type (from State highway departments); or other information related to the crash (such as photographs, witness statements, or other documentation).

This suggests that the PAR alone may not provide sufficient information to support crash weighting determinations.
3.2.2 Comparison of PARs with NMVCCS

3.2.2.1 Approach

This analysis involved:

- Linking the PARs to records in the NMVCCS.
- Comparing the critical reason determinations.

3.2.2.1.1 Linking PARs to NMVCCS

The FMCSA received 387 PARs from the 2005-2007 NMVCCS. Of these PARs, 310 could be coded for a critical reason. (See Table 4.) These 310 coded crashes involved 321 CMVs (vehicle records).

For this analysis, FMCSA attempted to link the information for the 321 PAR vehicle records with the NMVCCS vehicle records. The records “matched” if the State and crash date for both were the same. The process resulted in a linked data set of 277 CMVs.

3.2.2.1.2 Comparing Critical Reason Determinations

FMCSA compared the critical reason assignments for the 277 CMVs to identify any discrepancies.

3.2.2.2 Analysis Results

Table 9 shows the results of the PAR-NMVCCS critical reason comparisons. Ninety percent (249) of the CMVs had the same critical reason determinations in the two data sources. Ten percent (28) were coded differently.

<table>
<thead>
<tr>
<th>Table 9. Comparison of Coded PAR and NMVCCS Critical Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NMVCCS Critical Reason</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
</tr>
<tr>
<td>Environment</td>
</tr>
<tr>
<td>Not Assigned to This Truck/Bus</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
Likely reasons for the 28 non-matches include the following:

- The NMVCCS conducted additional analysis of the crash events that was not part of the PAR review process. For this study, the PAR reviewers relied solely on the information in the PAR to assign the critical reason.

- Differences in the critical reason methodologies may account for a number of the discrepancies. For example, this study assigned the critical reason to the truck/bus driver in 11 cases, while the NMVCCS assigned the critical reason to a different vehicle or entity.  

### 3.3 FEASIBILITY OF CODING OF CRASH EVENTS WITHOUT A PAR REVIEW

The FMCSA assessed the practicality of coding crashes for two types of crash events using information available in the MCMIS as an approach to crash weighting that would not require reviewing an actual PAR:

- Single-vehicle crashes deemed to be “attributable” to the motor carrier.

- Both single- and multiple-vehicle crashes with associated post-crash inspection records indicating a pre-crash out-of-service (OOS) condition on the CMV involved.

### 3.3.1 Approach

For the two categories of crashes listed above, FMCSA identified the crashes from 2008-2010 coded by the PAR reviewers that were linked with records in the MCMIS. Because there is no direct link between a PAR and the MCMIS crash record, two different linking processes were used to create the data sets used for this analysis:

- Linking to a MCMIS crash record based on the State, crash date, vehicle license plate number, and vehicle license plate State.

- Linking to a FARS record using the FARS case number, State, and date, and then to the MCMIS using the FARS/MCMIS matching tool.

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38 Specific circumstances in which this study may have assigned the critical reason to the CMV but the NMVCCS would not have include (1) right-of-way (non-CMV was responsible for the critical event but had the right-of-way); (2) disabled CMV (truck or bus became disabled in the travel lane due to a driver error or vehicle problem); (3) cargo spillage (on-road cargo spillage led to the crash); or (4) multiple CMVs (more than one CMV contributed to the crash event).

39 This study considered a single-vehicle crash to be attributable to the CMV when the event code description did not indicate a collision with a pedestrian, a motor vehicle in transport, an animal, work zone maintenance equipment, other/unknown movable object, or "other."

40 The study used state, date, vehicle, and carrier information to match PAR crash records to MCMIS crash records. It considered MCMIS inspection records to be associated with a pre-crash OOS condition when the "post-accident indicator" field equaled "yes" and the "OOS total" value was greater than zero.

41 The FARS/MCMIS matching tool defines a "matched record" between the two databases as a crash that involved at least one fatality, involved a large truck or bus, and contains the same information in several key fields (e.g., State, date, time, county, U.S. DOT Number, etc.). The methodology has more than 40 unique matching
The results of these two processes produced a linked set of 671 records for single-vehicle crashes and 767 records for crashes associated with a pre-crash OOS violation.

It was hypothesized that the reviewers would assign a critical reason that would attribute to the motor carrier for any single-vehicle crash or crash with a pre-crash OOS condition. The assumption for pre-crash OOS conditions was that the CMV driver or vehicle should not have been on the road and should thus be assigned the critical reason. To test the feasibility of such an approach, PAR reviewers assigned the critical reason for such crashes independently, without referring to the MCMIS data.

3.3.2 Analysis Results

3.3.2.1 Single-Vehicle Crash Analysis

Table 10 shows the critical reason determinations for the 671 single-vehicle crashes identified.

<table>
<thead>
<tr>
<th>Critical Reason Determination</th>
<th>Number Assigned</th>
<th>Percent Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned to CMV</td>
<td>630</td>
<td>93.9%</td>
</tr>
<tr>
<td>Not Assigned to CMV</td>
<td>41</td>
<td>6.1%</td>
</tr>
<tr>
<td>Environment</td>
<td>6</td>
<td>0.9%</td>
</tr>
<tr>
<td>Not Assigned to Truck/Bus Driver or Vehicle</td>
<td>14</td>
<td>2.1%</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>21</td>
<td>3.1%</td>
</tr>
<tr>
<td>Total</td>
<td>671</td>
<td>100%</td>
</tr>
</tbody>
</table>

For 94 percent of the 671 single-vehicle crashes identified, the PAR reviewers assigned a critical reason attributed to the motor carrier. Of the remaining 6 percent, 3 percent were coded “unable to assign critical reason” because the PAR lacked sufficient information to make a determination, 2 percent were assigned to another vehicle, and 1 percent were assigned to the environment. For the 2 percent assigned to another vehicle, the PAR indicated that another vehicle was involved, while the MCMIS record did not.

3.3.2.1 Post-Crash Inspection with OOS Violation Analysis

Table 11 shows the critical reason determinations for the 767 crashes associated with a pre-crash OOS condition.42

42 Of these OOS violations, 39 percent were brake violations, 36 percent were other vehicle violations, 19 percent Hours-of-Service were violations, and 6 percent were other driver violations.
Table 11. Critical Reason Determinations for CMVs with Accompanying OOS Conditions

<table>
<thead>
<tr>
<th>Critical Reason Determination</th>
<th>Number Assigned</th>
<th>Percent Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned to CMV</td>
<td>327</td>
<td>42.6%</td>
</tr>
<tr>
<td>Truck/Bus Driver</td>
<td>293</td>
<td>38.2%</td>
</tr>
<tr>
<td>Truck/Bus Vehicle</td>
<td>34</td>
<td>4.4%</td>
</tr>
<tr>
<td><strong>Not Assigned to CMV</strong></td>
<td><strong>440</strong></td>
<td><strong>57.4%</strong></td>
</tr>
<tr>
<td>Environment</td>
<td>1</td>
<td>0.1%</td>
</tr>
<tr>
<td>Not Assigned to Truck/Bus Driver or Vehicle</td>
<td>426</td>
<td>55.5%</td>
</tr>
<tr>
<td>Unable to Assign Critical Reason</td>
<td>13</td>
<td>1.7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>767</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

For the 767 crashes with an accompanying OOS condition, PAR reviewers assigned a critical reason attributed to the motor carrier for fewer than half (43 percent) of the records. This is likely because they used only the PAR and did not have access to post-crash inspection results indicating a pre-crash driver or vehicle OOS condition.

### 3.4 OBSERVATIONS

The following observations are based on FMCSA’s analysis of the sufficiency, reliability, and feasibility of using PARs to make crash weighting determinations:

- The results of the quality control process, comparison of data on the PARs with that in the FARS, and comparison of critical reason determinations with the NMVCCS suggest that the PAR alone may not be sufficient for a crash weighting determination.

- PAR reviewers may need to take additional time to derive data for blank, missing, or incomplete fields from other data sources, including the MCMIS, to make the most accurate critical reason determinations. This would increase the length and complexity of the PAR review process.

- Some PARs did not clearly identify CMVs or allocate sufficient space or have fields for motor carrier identification information, such as carrier name, U.S. DOT Number, or MC Number; for this reason, additional information may be necessary to identify the motor carrier involved in a crash.

- Because the majority of PARs used for this analysis were limited to fatal crashes, the results may not be applicable to a broader range of crash events.
4 WOULD A CRASH WEIGHTING DETERMINATION PROCESS OFFER AN EVEN STRONGER PREDICTOR OF CRASH RISK THAN OVERALL CRASH INVOLVEMENT?

This portion of the crash weighting analysis assumed the sufficiency and reliability of Police Accident Reports (PARs) and looked at whether a crash weighting methodology in the Safety Measurement System (SMS) Crash Indicator would provide a sharper view of the highest risk motor carriers. The Federal Motor Carrier Safety Administration (FMCSA) defined crash weighting as a two-step process: (1) review a sample of PARs to determine the critical reason for the crash events and the motor carriers’ roles; and (2) use the critical reason determinations as a basis for weighting the crashes in the SMS. Crash weights were derived based on the critical reason assignments for the 10,892 PARs that were reviewed and single-vehicle attributable crashes identified in the Motor Carrier Management Information System (MCMIS). (See Section 3 for details on the critical reason determination process and the identification of single-vehicle attributable crashes.)

The FMCSA employed various statistical and analytical approaches to assess crash weighting benefits, in particular the SMS Effectiveness Test (ET) Methodology. The SMS ET quantifies how effectively FMCSA uses its resources to target high-risk motor carriers for interventions; it compares the crash rate of carriers above the Intervention Threshold to the national average. (A discussion of the methodology and results for the other statistical tests performed is in Appendix C.)

4.1 OVERVIEW OF METHODOLOGY

The FMCSA used the SMS ET to assess the safety benefits of implementing various approaches to crash weighting as part of the Crash Indicator.

4.1.1 Crash Indicator Calculation

As discussed in Section 1, the Crash Indicator currently relies on crash involvement and does not include any weighting based on a motor carrier’s role in a crash.

The Crash Indicator is calculated as the sum of severity- and time-weighted crashes, divided by a motor carrier’s average Power Units (PUs) multiplied by a Utilization Factor that accounts for some difference in Vehicle Miles Traveled (VMT) between carriers, as follows:

\[ \text{Crash Indicator Measure} = \frac{\text{Total of time and severity weighted applicable crashes}}{\text{Average PUs} \times \text{Utilization Factor}} \]

43 As stated above, the study questions addressing PAR sufficiency, PAR reliability, and crash weighting benefits were not addressed sequentially but as separate analyses designed to inform Agency decisions. Thus, this portion of the analysis did not consider the sufficiency or reliability of the PARs used in the study.

In this equation, the terms are defined as follows:

- **Applicable Crash.** A State-reported crash during the past 24 months that meets the recordable crash standard (results in at least one fatality, at least one injury where the injured person is taken to a medical facility for immediate medical attention, or at least one vehicle towed from the scene as a result of disabling damage caused by the crash).

- **Crash Severity Weight.** Places more weight on crashes with more severe consequences. For example, a crash involving an injury or fatality is weighted more heavily than a crash where only a tow-away occurred. A hazardous materials (HM) release also increases the weight of a crash.

- **Time Weight.** Assigned to each applicable crash based on the time elapsed since the crash occurred. This time-weighting places more emphasis on recent crashes relative to older crashes.

- **Time- and Severity-Weighted Crash.** A crash’s severity weight multiplied by its time weight.

- **Average PUs.** Calculated using (1) the motor carrier’s current total PUs; (2) the total PUs the carrier had six months ago; and (3) the total PUs the carrier had 18 months ago.

- **Utilization Factor.** A multiplier that adjusts the average PU values in terms of VMT per average PU where VMT data in the past 24 months are available from either (1) Form MCS-150 (filled out by the motor carrier); or (2) Form MCS-151 (filled out by law enforcement as part of an investigation).

After a measure is calculated, the SMS places a motor carrier in a safety event group based on the carrier’s number of crashes and industry segment. There are two industry segments:

- **Combination Segment.** Combination trucks/motor coach buses constitute 70 percent or more of the total PUs.

- **Straight Segment.** Straight trucks/other vehicles constitute more than 30 percent of the total PUs.

The SMS then determines a percentile from 0 to 100, with 100 indicating the worst performance, by comparing the motor carrier’s Crash Indicator measure to those of other carriers in the safety event group and segment.\(^{45}\) If the carrier’s percentile exceeds the threshold, the carrier becomes a candidate for an intervention.\(^{46}\) (Additional details on the Crash Indicator calculation are presented in Appendix D.)

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\(^{46}\) The Intervention Threshold used in this analysis for the Crash Indicator is the general freight threshold of 65 percent.
4.1.2 SMS ET

The SMS ET compares the crash rate of carriers above the Intervention Threshold to the national average. The SMS is “effective” if the crash rate for above-threshold carriers is higher than the national average crash rate. For this analysis, the test used crash data from 2009-2010 to define Crash Indicator percentiles, then tracked the future (January 2011 to June 2012) crash rate of motor carriers above the Intervention Threshold, as shown in Figure 3. (See Appendix C for additional details on the SMS ET Methodology.)

![Figure 3. SMS Effectiveness Test Timeline](image)

4.1.3 Crash Weighting Approaches

The FMCSA applied two approaches for modifying crash weights in the Crash Indicator:

- **Removing “Not Assigned Crashes.”** “Not assigned crashes” included 3,613 vehicles involved in fatal crashes from the FARS data set with a critical reason not attributed to the motor carrier (critical reason “not assigned to this driver/vehicle”) as a result of the PAR reviews discussed above in Section 3.

- **Increasing the Weight of “Assigned Crashes” and Reducing the Weight of “Not Assigned Crashes.”** “Assigned crashes” included (1) 1,995 vehicles involved in fatal crashes from the FARS data set with a critical reason attributed to the motor carrier (critical reason of “truck/bus driver” or “truck/bus vehicle”)\(^{47}\); and (2) 34,385 single-vehicle crashes from the MCMIS considered to be attributable to the CMV.\(^{48}\) (See Section 3.)

---

\(^{47}\) All crashes in this analysis with a critical reason assigned were fatal crashes, which means that crash severity may be a confounding factor in analysis conducted on the full set of crashes.

\(^{48}\) The crashes that were not coded had no PAR available to confirm the attribution to the CMV; this assignment is based solely on the number of vehicles and first harmful event recorded in the MCMIS crash database. The set of single-vehicle attributable crashes was not chosen to be representative of all attributable crashes and may have biases, such as toward particular geographic areas or carrier operation types.
The Agency then compared these crash weighting approaches with the current Crash Indicator, or “baseline” (SMS Version 3.0), using the SMS ET to assess future crash rates of motor carriers above the Intervention Threshold. The analysis was performed using both all crashes and fatal crashes alone.

### 4.1.4 Motor Carrier Data Set

The FMCSA applied a number of screens to ensure there were no large changes in data relevant to the analysis and that motor carriers continued to operate in the “future crash” period. The following screens were used:

- Carrier must have been under FMCSA jurisdiction in December 2010.50
- Carrier must have been domiciled in the United States.
- Carrier must have had a crash in the pre-period (2009 or 2010).
- Carrier must have had a crash or inspection in the post-period (January 2011 to June 2012).
- Carrier must have had positive average PUs in both the pre- and post-periods.51
- Carrier’s average number of PUs from the pre-period to the post-period is within three standard deviations of the mean.
- Carrier must have had a reasonable crash-to-PU ratio in the pre-period.52

Applying these screens on motor carriers with a Crash Indicator percentile resulted in a data set of 12,640 carriers for the all-crash analysis and 1,912 carriers for the fatal crash analysis. Table 12 shows the resulting size distribution of the motor carriers included in the analysis.

---

49 Additional weighting approaches were tested, but not included in the body of this report, because the results did not differ substantially from those reported below. Appendix B contains descriptions of these other weighting approaches.

50 Active interstate or intrastate hazardous materials carriers.

51 Derived by adding the motor carrier's current PUs, PUs 6 months ago, and PUs 18 months ago, and dividing by 3. Positive average PUs imply that the motor carrier had at least one PU during those three time periods.

Table 12. Motor Carrier Size Distribution

<table>
<thead>
<tr>
<th>Motor Carrier Size Group (Average PUs)</th>
<th>All-Crash Analysis Carriers</th>
<th>Fatal Crash Analysis Carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Carriers</td>
<td>PUs</td>
</tr>
<tr>
<td>Carriers with 5 or fewer PUs</td>
<td>1,279</td>
<td>3,796</td>
</tr>
<tr>
<td>Carriers with more than 5 and up to 15 PUs</td>
<td>2,521</td>
<td>25,269</td>
</tr>
<tr>
<td>Carriers with more than 16 and up to 50 PUs</td>
<td>4,324</td>
<td>126,610</td>
</tr>
<tr>
<td>Carriers with more than 51 and up to 500 PUs</td>
<td>4,002</td>
<td>554,848</td>
</tr>
<tr>
<td>Carriers with more than 500 PUs</td>
<td>514</td>
<td>971,940</td>
</tr>
<tr>
<td>Total</td>
<td>12,640</td>
<td>1,682,464</td>
</tr>
</tbody>
</table>

4.2 CRASH WEIGHTING USING ALL CRASHES

The data set used for this analysis consisted of (1) fatal crashes from the PAR data set obtained from the FARS that were coded for a critical reason using the PAR; (2) single-vehicle attributable crashes identified in the MCMIS; and (3) all other crashes in the MCMIS for the required time period without a crash weighting determination. The first two types of crashes accounted for less than 20 percent of the crashes used in the analysis, or approximately 25,000 crashes over the 2-year period.53

4.2.1 Approach

The approach for this analysis included:

- Modifying the Crash Indicator by applying crash weights.
- Running the SMS ET for the modified and baseline Crash Indicator and comparing the results.

4.2.1.1 Modified Crash Indicator Using All Crashes

The FMCSA modified the Crash Indicator severity weights for “assigned crashes” (those for which the critical reason was attributed to the motor carrier or single-vehicle attributable crashes) and “not assigned crashes” (those that were reviewed but not attributed to the carrier involved). Table 13 compares the current severity weights with the modified approach.

---

53 For the analysis years, 2009-2010, the data available for analysis included 1,995 crashes coded to the truck/bus driver or vehicle; 3,613 coded “not assigned to this driver/vehicle”; and 34,385 single-vehicle attributable crashes.
Table 13. Modified Crash Indicator Weighting Approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>Crash Type</th>
<th>Crash Severity Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Weight</td>
<td>Involves Tow-Away but No Injury or Fatality</td>
<td>1</td>
</tr>
<tr>
<td>Original Weight</td>
<td>Involves Injury or Fatality</td>
<td>2</td>
</tr>
<tr>
<td>Original Weight</td>
<td>Involves an HM Release Severity Weight + 1</td>
<td></td>
</tr>
<tr>
<td>Modified Weight</td>
<td>Assigned Crash</td>
<td>+ Additional Weight</td>
</tr>
<tr>
<td>Modified Weight</td>
<td>Not Assigned Crash</td>
<td>- Weight or Do Not Count</td>
</tr>
</tbody>
</table>

The Agency applied the following methods for modifying the Crash Indicator, as described above: (1) removing “not assigned crashes”; and (2) applying higher severity weights for “assigned crashes” and lower weights for “not assigned crashes.” Table 14 shows these two crash weighting approaches.

Table 14. Crash Severity Weight Approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>Weight for Assigned Crashes</th>
<th>Weight for Not Assigned Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Crash Indicator</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Remove Not Assigned Crashes</td>
<td>+ 1</td>
<td>Not Included</td>
</tr>
<tr>
<td>Add Weight for Assigned Crashes/Remove Weight for Not Assigned Crashes</td>
<td>+ 3</td>
<td>- 0.5</td>
</tr>
</tbody>
</table>

4.2.1.2 SMS ET Run Using All Crashes

The FMCSA ran the SMS ET for the modified Crash Indicator and compared the results with the current Crash Indicator.

4.2.2 Analysis Results

Table 15 shows the future crash rate and the percent improvement for the two crash weighting methods compared to the current Crash Indicator when using all crashes.\(^\text{54}\)

---

\(^{54}\) As explained in the SMS Methodology, the Crash Indicator splits carriers into two segments according to the carrier’s fleet mix (based on the ratio of straight and combination vehicles) to ensure that carriers with fundamentally different types of vehicles and operations are not compared with each other.
Table 15. SMS Effectiveness Test Results Using Crash Weighting for All Crashes

<table>
<thead>
<tr>
<th>Crash Weighting Model</th>
<th>Straight # of Carriers Above Threshold</th>
<th>Straight Crash Rate per 100 Adjusted PUs</th>
<th>Straight % Increase from Baseline</th>
<th>Combination # of Carriers Above Threshold</th>
<th>Combination Crash Rate per 100 Adjusted PUs</th>
<th>Combination % Increase from Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1,501</td>
<td>2.99</td>
<td>0%</td>
<td>3,026</td>
<td>7.02</td>
<td>0%</td>
</tr>
<tr>
<td>Remove Not Assigned Crashes</td>
<td>1,469</td>
<td>2.95</td>
<td>-1.3%</td>
<td>2,967</td>
<td>7.01</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Add Weight for Assigned Crashes/Reduce Weight for Not Assigned Crashes</td>
<td>1,514</td>
<td>3.01</td>
<td>0.7%</td>
<td>3,022</td>
<td>6.99</td>
<td>-0.4%</td>
</tr>
</tbody>
</table>

Changing the weights of “assigned” and “not assigned crashes” in the Crash Indicator does not appear to improve its ability to predict future crash rates when all crashes are considered. If effectiveness were improved, the average crash rate for carriers above the Intervention Threshold would be higher for the modified Crash Indicator than for the current approach; however, the analysis results show that these average crash rates are nearly identical.

The FMCSA also compared the set of carriers that would be above the Intervention Threshold in a modified Crash Indicator versus the baseline, or the “churn rate.” A higher churn rate suggests that the applied weighting approach prioritizes a different set of carriers than the current approach, while a lower churn rate means that fewer carriers would change prioritization status. Whether or not the changes represent an improvement depends on the characteristics (crash and violation rates) of the carriers identified. The Agency found the following:

The approach that adds weight to “assigned crashes” and reduces weight for “not assigned crashes” has a churn rate of 4.2 percent for the straight segment and 4.5 percent for the combination segment. (This means, for example, that 4.2 percent of the straight segment carriers over the threshold in the baseline Crash Indicator are under the threshold in the weighted Crash Indicator.)

- The approach that removes “not assigned crashes” has a churn rate of 1.2 percent for the straight segment and 2.3 percent for the combination segment.

4.3 CRASH WEIGHTING USING FATAL CRASHES ALONE

This data set consisted of (1) fatal crashes from the PAR data set obtained from the FARS that were coded for a critical reason using the PAR; and (2) all other fatal crashes in the MCMIS for

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55 Adjusted PUs = average PUs × Utilization Factor.
56 Weight changes from baseline are described in Table 13 and Table 14.
57 Again, other weighting approaches were tested but results were not included, because they did not differ substantially from the analysis results shown here. See Appendix D.
the required time period. Fatal crashes that were coded for the critical reason accounted for more than 75 percent of fatal crashes used in the analysis; however, all fatal crashes account for 3 percent of the crashes in the MCMIS.

4.3.1 Approach
The analysis approach included:

- Modifying the Crash Indicator to use fatal crashes alone and applying crash weights.
- Running the SMS ET for the modified and baseline Crash Indicator and comparing the results.

4.3.1.1 Modified Crash Indicator Using Fatal Crashes
The FMCSA modified the Crash Indicator to include only fatal crashes since the number of “assigned” and “not assigned crashes” is small relative to the total number of crashes in the SMS. Prior to modifying the Crash Indicator, the Agency adjusted the SMS data sufficiency requirements to account for the smaller number of crashes, from at least two crashes to at least two crashes where one is a fatal crash. FMCSA also adjusted the Crash Indicator safety event groups, as shown in Table 16.

<table>
<thead>
<tr>
<th>Industry Segment</th>
<th>Safety Event Group</th>
<th># Fatal Crashes</th>
<th># Carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination</td>
<td>1</td>
<td>1*</td>
<td>220</td>
</tr>
<tr>
<td>Combination</td>
<td>2</td>
<td>2</td>
<td>63</td>
</tr>
<tr>
<td>Combination</td>
<td>3</td>
<td>3</td>
<td>619</td>
</tr>
<tr>
<td>Combination</td>
<td>4</td>
<td>4+</td>
<td>125</td>
</tr>
<tr>
<td>Straight</td>
<td>1</td>
<td>1*</td>
<td>34</td>
</tr>
<tr>
<td>Straight</td>
<td>2</td>
<td>2+</td>
<td>75</td>
</tr>
</tbody>
</table>

*1 fatal crash but 2 or more total crashes

4.3.1.2 SMS ET Run Using Fatal Crashes
The FMCSA ran the SMS ET for the fatal-only Crash Indicator with crash weights and compared the results with the unweighted fatal-only Crash Indicator.

4.3.2 Analysis Results
Table 17 compares the SMS ET results for the two methods of crash weighting with those for the current Crash Indicator using fatal crashes alone.

58 Combination trucks/motorcoach buses constitute 70 percent or more of the carrier’s total PUs.
59 Straight trucks/other vehicles constitute more than 30 percent of the carrier's total PUs.
### Table 17. SMS Effectiveness Test Results Using Crash Weighting for Fatal Crashes

<table>
<thead>
<tr>
<th>Crash Weighting Model</th>
<th>Straight # of Carriers</th>
<th>Straight Crash Rate per 100 Adjusted Pus</th>
<th>Straight % Increase from Baseline</th>
<th>Combination # of Carriers</th>
<th>Combination Crash Rate per 100 Adjusted Pus</th>
<th>Combination % Increase from Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>106</td>
<td>3.41</td>
<td>0%</td>
<td>309</td>
<td>6.66</td>
<td>0%</td>
</tr>
<tr>
<td>Remove Not Assigned Crashes</td>
<td>57</td>
<td>3.58</td>
<td>5.0%</td>
<td>164</td>
<td>6.78</td>
<td>1.8%</td>
</tr>
<tr>
<td>Add Weight for Assigned Crashes/ Reduce Weight for Not Assigned Crashes</td>
<td>108</td>
<td>3.40</td>
<td>-0.3%</td>
<td>318</td>
<td>6.72</td>
<td>0.9%</td>
</tr>
</tbody>
</table>

When using fatal crashes alone in the Crash Indicator, weighting crashes by removing those not attributed to the motor carrier (“not assigned crashes”) appears to improve the ability of the SMS to predict future crashes by 1.8 percent (for the combination segment) to 5.0 percent (for the straight segment); however, this analysis was limited to approximately 4,500 fatal crashes over the 2-year period, or less than 3 percent of total crashes. Moreover:

- The number of carriers in the fatal-only analysis is about 10 times lower than that for all crashes, as shown in Table 15. Therefore, the differences in future crash rates might simply be a result of the greater variability presented by a smaller sample size.

- Removing crashes not attributed to the motor carrier decreased the total number of carriers above the threshold by approximately 50 percent.

Regarding the churn rate for the fatal-only models:

- The model that adds weight to “assigned crashes” and reduces weight for “not assigned crashes” has a churn rate of 6.5 percent for the straight segment and 8.5 percent for the combination segment. (For example, 6.2 percent of the straight segment carriers over the threshold in the baseline fatal Crash Indicator are under the threshold in the weighted fatal Crash Indicator.)

- The model that removes “not assigned crashes” has a higher churn rate, at 8.8 percent for the straight segment and 14.6 percent for the combination segment; thus, more carriers would have changes in their Crash Indicator percentiles with this model.

### 4.4 OBSERVATIONS

Limitations in the data used restrict the applicability of the results presented above. In particular:

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60 Only 415 carriers were over the threshold for this analysis, compared to 4,527 for the all-crash analysis and about 40,000 used in the standard SMS ET.

61 The SMS ET was not designed to provide sensitivity for such comparative analyses.
• Smaller carriers are underrepresented, since they are less likely to be involved in fatal crashes; conversely, larger carriers are overrepresented, because they are more likely to be involved in such crashes due to exposure.

• Given the limited data available, analysis on a different set of future crashes—such as fatal or single-vehicle “assigned crashes” that were coded for a critical reason or another crash data set—was not deemed feasible.

• The SMS ET can be used only to assess the future crash rates of motor carriers, not drivers; moreover, data sufficiency requirements (two or more crashes) restrict the number of carriers and crashes that can be included.

• Because the SMS ET requires a total of 42 months of data, there was not enough coded crash data available to perform analysis for future assigned coded crash rates.

• For the fatal-only SMS ET results to apply more broadly to all crashes, one must assume that fatal crashes are representative of all other types of crashes.
5 HOW MIGHT FMCSA MANAGE THE PROCESS FOR MAKING CRASH WEIGHTING DETERMINATIONS?

This analysis examined how a crash weighting process might be structured and the estimated resources required. In particular, such a process requires a method for uniformly acquiring the final Police Accident Reports (PARs) for all or a subset of crashes, since the States do not currently provide PARs to the Federal Motor Carrier Safety Administration (FMCSA); a process and system for uniform analysis; and a method for receiving and analyzing public input. To estimate the associated costs and other resources, FMCSA identified a potential process for a national crash weighting program based on that used for this analysis.

5.1 CRASH WEIGHTING DETERMINATION PROCESS

5.1.1 Approach

In identifying a process for a national crash weighting program, the Agency:

- outlined a potential process for reviewing and coding PARs based on the process employed for this analysis.
- expanded the process to include the acceptance of public input.

5.1.2 Analysis Results

A potential process for crash weighting determinations would include five steps:

- **Step 1.** Establish agreements with the States and obtain PARs in either hard copy or electronic format. As this study shows, obtaining and handling physical PARs can be problematic. The majority of PARs used in this study were hard copies that required scanning prior to the review process; a number of these PARs were illegible or otherwise difficult to interpret. Moreover, because of privacy concerns, all PARs had to be stored in a secure location with access control. Challenges associated with accessing electronic PARs include incompatible security controls and differences among the States’ electronic versions.

- **Step 2.** Develop a system to support the collection and storage of crash weighting determinations. Considerations would include how the PAR would be linked to the Motor Carrier Management Information System (MCMIS) record, since no direct link currently exists, and how the crash weighting determinations would be stored within the MCMIS.

- **Step 3.** Implement the PAR review process.

- **Step 4.** Publish the results of the PAR reviews in the Federal Register.

- **Step 5.** Establish a procedure for accepting public input should the results of a PAR review be appealed. Such a process could involve an appeal committee established to re-review the PAR and any additional materials provided.
5.2 IMPLEMENTATION COSTS

5.2.1 Approach

The FMCSA estimated the costs associated with the five-step process described above. The estimate was based on information collected throughout the study and included both start-up and annual costs. To determine the costs associated with the acceptance of public input, the Agency considered as a proxy the current process for approval of applications for operating authority.\(^{62}\)

The FMCSA:

- Estimated the start-up costs for establishing agreements with the States and supporting systems (Steps 1 and 2).

- Estimated costs for PAR review and quality control, based on the total number of hours, and associated costs, required to review and code PARs for this study (Step 3).

- Estimated costs for a PAR appeal process (Step 5) considering the current appeals process for the approval of operating authority applications.

- Estimated total annual costs based upon all of the above.

5.2.2 Analysis Results

5.2.2.1 Start-Up Costs

To establish a process for crash weighting determinations, FMCSA must reach agreements with the States to obtain their PARs and establish the necessary systems for PAR collection and storage. Based on efforts to obtain PARs for this study, FMCSA estimated 40 hours to establish an agreement with each State. (States are reluctant to provide PARs because of privacy concerns and the uncertainty of how the crash weighting process may interact with the State judicial process.) The aggregated costs for all “52 States” (the 50 States, District of Columbia, and territories) are shown in Table 18. The table also shows the approximate cost to establish information technology systems to support the process.

<table>
<thead>
<tr>
<th>Task/Step</th>
<th>Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtain and Store PARs</td>
<td>$610,000.00</td>
</tr>
<tr>
<td>System/Process Set-Up</td>
<td>$500,000.00</td>
</tr>
<tr>
<td>Total</td>
<td>$1,110,000.00</td>
</tr>
</tbody>
</table>

*Assumes $200 per hour for legal support and $95 per hour for administrative support.

The $1.1 million start-up cost shown above is a fixed cost and is not included as an annual operating expense.

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\(^{62}\) Because FMCSA receives relatively few appeals for the granting of operating authority, the cost estimate for crash weighting appeals may be low.
5.2.2.2 Costs of Initial PAR Review

The coding of PARs involves thoroughly reviewing all elements relevant to the crash, determining the critical event and critical reason, and quality control of the coding results. As shown in Table 19, this required approximately 19 minutes and $26.50 per PAR for this analysis.63

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Time per PAR</th>
<th>Cost per PAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review PAR</td>
<td>15.6 minutes</td>
<td>$21.09</td>
</tr>
<tr>
<td>Quality Control (sample of PARs reviewed)</td>
<td>3.0 minutes</td>
<td>$5.37</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18.6 minutes</strong></td>
<td><strong>$26.46</strong></td>
</tr>
</tbody>
</table>

*Includes labor and overhead costs.

The FMCSA assumed that the time and costs shown in Table 19 are representative of those for a nationally implemented crash weighting process.

5.2.2.3 Costs of PAR Review Appeal

Table 20 shows the estimated costs associated with re-review of a PAR and additional materials by an appeal committee. The estimate assumes that the re-review of a PAR would take four times as long as the initial review, or 74.4 minutes.

<table>
<thead>
<tr>
<th>Process Element</th>
<th>Time per PAR</th>
<th>Cost per PAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-review PAR and Additional Materials</td>
<td>74.4 minutes</td>
<td>$105.84</td>
</tr>
</tbody>
</table>

As shown in the table, reviewing additional information provided by the public for a PAR review would require approximately $106 per PAR in addition to the costs of the initial review.

5.2.2.4 Total Annual Costs

Annual costs for obtaining PARs, operating supporting systems, reviewing PARs, and accepting public input (appeals) are shown in Table 21. The table presents costs for four scenarios and considers three rates of public input for each. These scenarios include:

- Reviewing and coding all recordable crashes.
- Reviewing and coding only interstate and intrastate hazardous materials (HM) crashes.

63 Estimates are based on actual costs of the PAR coding process during the study.
• Reviewing and coding interstate and intrastate HM crashes after removing crashes for which a post-crash inspection identifies a pre-crash out-of-service (OOS) condition; for the purposes of this study, the proportion of these crashes is estimated at 5 percent.

• Reviewing and coding interstate and intrastate HM crashes after removing two types of crashes: (1) those for which a post-crash inspection identifies a pre-crash OOS condition, and (2) single-vehicle “attributable” crashes.

Table 21. Estimated Annual Costs for a National PAR Review Process

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Initial Review</th>
<th></th>
<th>Appeal</th>
<th></th>
<th>Operating Costs</th>
<th>Total Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of PARs</td>
<td>Cost</td>
<td>Public Input Rate</td>
<td>Number of PARs</td>
<td>Cost</td>
<td>Costs*</td>
</tr>
<tr>
<td>All Crashes</td>
<td>130,000</td>
<td>$3,439,800</td>
<td>10%</td>
<td>13,000</td>
<td>$1,375,920</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25%</td>
<td>32,500</td>
<td>$3,439,800</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50%</td>
<td>65,000</td>
<td>$6,879,600</td>
<td>$850,000</td>
</tr>
<tr>
<td>Interstate and Intrastate HM Only</td>
<td>100,000</td>
<td>$2,646,000</td>
<td>10%</td>
<td>10,000</td>
<td>$1,058,400</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25%</td>
<td>25,000</td>
<td>$2,646,000</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50%</td>
<td>50,000</td>
<td>$5,292,000</td>
<td>$850,000</td>
</tr>
<tr>
<td>Remove Pre-Crash OOS (~5 %)</td>
<td>95,000</td>
<td>$2,513,700</td>
<td>10%</td>
<td>9,500</td>
<td>$1,005,480</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25%</td>
<td>23,750</td>
<td>$2,513,700</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50%</td>
<td>47,500</td>
<td>$5,027,400</td>
<td>$850,000</td>
</tr>
<tr>
<td>Remove Single-Vehicle Attributable and Pre-Crash OOS (~13%)</td>
<td>82,650</td>
<td>$2,186,919</td>
<td>10%</td>
<td>8,265</td>
<td>$874,768</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25%</td>
<td>20,663</td>
<td>$2,186,919</td>
<td>$850,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50%</td>
<td>41,325</td>
<td>$4,373,838</td>
<td>$850,000</td>
</tr>
</tbody>
</table>

*Assumes $500,000 to obtain PARs and $350,000 to operate and maintain systems.

The total annual costs for a PAR review process range from approximately $3.9 million to $11.2 million.

5.3 TIMEFRAMES

One concern is the timeliness of the review and weighting of any crashes. The above analysis assumes that the reviews are completed on crashes used in the Safety Measurement System (SMS), which uses a 24-month time period. It is possible that the timeframe for the entire process—including the submittal of the PAR by law enforcement, its receipt by FMCSA, analysis to make a crash weighting determination, possible appeal of the analysis results, and final disposition of the appeal—could exceed the 24-month analysis period used by the SMS.
5.4 OBSERVATIONS

- The resources required for implementing a crash weighting determination process would depend primarily upon the nature of the process defined by the Agency.

- Annual costs for crash weighting determinations would likely vary, depending on the number of crashes reviewed each year and the number of appeals.

- The time and costs identified above are based on the methods used for this analysis, in particular, the sole use of the PAR for a crash weighting determination; use of additional data sources, such as MCMIS data or supplemental documentation about the crash, would require additional resources.
6 CONCLUSIONS

The Federal Motor Carrier Safety Administration’s (FMCSA) assessment of crash weighting focuses on three questions:

- Do Police Accident Reports (PARs) provide sufficient, consistent, and reliable information to support crash weighting determinations?
- Would a crash weighting determination process offer an even stronger predictor of crash risk than overall crash involvement, and how would crash weighting be implemented in the Safety Measurement System (SMS)?
- Depending upon the analysis results for the questions above, how might FMCSA manage the process for making crash weighting determinations, including public input to the process?

The following are conclusions resulting from the analyses described above. Although these conclusions will inform Agency decision-making regarding crash weighting, they are not definitive and additional analysis may be needed to address the study questions.

6.1 DO PARS PROVIDE SUFFICIENT, CONSISTENT, AND RELIABLE INFORMATION TO SUPPORT CRASH WEIGHTING DETERMINATIONS?

- Although 91 percent of PARs met the criteria to be reviewed for a critical reason determination, the information on the PAR may not be reliable. For a large number of PARs, a low match rate was found between fields on the PAR and similar fields in the Fatality Analysis Reporting System (FARS). This could be due to the additional information and analysis used in creating FARS records, which was not available for this study. These results suggest that PARs may not provide sufficient information to support crash weighting determinations.

- For 9 percent of PARs, the reviewers could not determine that a commercial motor vehicle (CMV) was involved, that a CMV was regulated by FMCSA, or that the crash was recordable. These PARs were often incomplete or contained illegible or redacted information.

- Coding crash events based solely on the Motor Carrier Management Information System (MCMIS) data for either single-vehicle attributable crashes or crashes with a post-crash inspection with a pre-crash out-of-service (OOS) condition was not always consistent with coding results based on a PAR review.

6.2 WOULD A CRASH WEIGHTING DETERMINATION PROCESS OFFER AN EVEN STRONGER PREDICTOR OF CRASH RISK THAN OVERALL CRASH INVOLVEMENT?

- Modifying the SMS Crash Indicator to include crash weighting improves its ability to predict future crash rates when fatal crashes alone are used. However, fatal crashes represent less than 3 percent of all crashes in the MCMIS.
• Analysis using all crashes shows that incorporating crash weighting determinations does not consistently improve the Crash Indicator when the various weighting approaches are applied.

6.3 HOW MIGHT FMCSA MANAGE THE PROCESS FOR MAKING CRASH WEIGHTING DETERMINATIONS?

• The FMCSA would need to establish a process with the States to receive and manage PAR data.

• The range of costs for implementing a system for accepting and analyzing public input is conservatively estimated to be four times that of the initial PAR review. Annual costs could range from $3.9 million to $11.2 million, depending on the number of PARs reviewed, the number of appeals, and the process established by the Agency.

• The timeframe for the entire process—including the submittal of the PAR by law enforcement, its receipt by FMCSA, analysis to make a crash weighting determination, possible appeal of the analysis results, and final disposition of the appeal—could exceed the 2-year analysis period used by the SMS.
APPENDIX A  POLICE ACCIDENT REPORT CODING GUIDELINES

This appendix to the Federal Motor Carrier Safety Administration (FMCSA) Crash Weighting Analysis presents guidelines for coding Police Accident Reports (PARs) used by the PAR reviewers. All of the PAR reviewers had previous experience with the format and content of PARs, with the critical event/critical reason methodology, and with interpreting and understanding the nuances of crash reporting. Reviewers also had experience with studies, such as the Large Truck Crash Causation Study (LTCCS), that involved the processing of large volumes of PARs to identify unique crash variables.

PAR REVIEW PROCESS

FMCSA’s “Crash Weighting Analysis” employed a review process based on that developed for the LTCCS, particularly the methodology for assigning the critical event and critical reason. The critical event and critical reason are defined as follows:

- **Critical Event:** The event that immediately led to the crash and that put the vehicle or vehicles on a course that made the crash unavoidable. In this study, the PAR reviewers assigned the critical event to the vehicle or other party, such as a pedestrian, responsible for the action or inaction that made the crash inevitable.

- **Critical Reason:** The immediate reason for the critical event or the failure leading to the critical event. The critical reason was identified to describe the role of the driver or vehicle involved in the crash event. For example, if a commercial motor vehicle (CMV) driver decides to drive too fast for the roadway type, the CMV driver would be assigned the critical reason.

The PAR review process comprised four steps:

- **Step 1. Review PAR for Relevancy and Completeness:** The PAR reviewers first checked each PAR to ensure that at least one of the vehicles listed was a CMV; that the CMV was regulated by FMCSA; and that the crash event met the severity criteria for a recordable crash. If a reviewer could not determine from the PAR that these criteria were met, he or she created a record for that crash but did not complete a full review; the number of CMVs was entered as “0” and the review process ended.

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65 Any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle (1) has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 10,001 pounds or more; (2) is designed or used to transport more than 8 passengers (including the driver) for compensation; (3) is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation; or (4) is used in transporting hazardous materials (HM) as defined under 49 U.S.C. 5103 and transported in a quantity requiring placarding under 49 CFR, subtitle B, chapter I, sub-chapter C.
66 Fatal, injury, or tow-away.
• **Step 2. Review Crash and Vehicle Information:** The PAR reviewers examined the remaining PARs to understand the nature of the crash events, including the basic crash information (crash date and time, crash severity, number of vehicles involved, number of CMVs, weather and road surface condition, traffic-way type, first harmful event); vehicle information (configuration, cargo body type, weight, class, hazardous materials (HM) information, license plate number and State, motor carrier information); driver information (driver condition, driver action immediately prior to the crash, alcohol test results, citations, license class, endorsements, restrictions or license status); and the crash diagram and narrative description. Reviewers crosschecked the data in the driver and vehicle sections to ensure that the PAR contained sufficient information to determine the critical event/critical reason; if the PAR did not contain enough information, the reviewer assigned the critical reason as “unable to assign critical reason.”

• **Step 3. Determine the Critical Event and Critical Reason:** After carefully reviewing the information on the PAR, reviewers determined the vehicle(s) (or other party) that committed the critical event and assigned a critical reason to each CMV involved in the crash. (Reviewers did not assign a critical reason to the non-CMVs.) There were five critical reason choices: truck/bus driver, truck/bus vehicle, environment, not assigned to this truck/bus driver/vehicle, and unable to assign critical reason. Reviewers also selected from among a number of critical reason justifications.

• **Step 4. Enter Crash and Vehicle Information into the Data Collection Tool:** Reviewers entered relevant data from the PAR, as well as the critical reason and critical reason justification, into a data collection tool. (See below.) Reviewers entered information for each CMV involved in the crash. No information was recorded for the non-CMVs. (In addition, reviewers did not record driver identifying information due to privacy issues.)

These steps are shown in Figure A1.
DATA ELEMENTS COLLECTED IN THE PAR COLLECTION TOOL

To support a uniform method for collecting data from the PARs, FMCSA developed an online data collection tool. Using this tool, the PAR reviewers entered crash and vehicle information, the critical reason, and the critical reason justification for each PAR reviewed. The PAR reviewers extracted information from specific sections of the PAR as entered by the police officer. Although the reviewers interpreted (coded) the critical reason and the critical reason justification, they entered the remaining elements directly from the PAR without interpretation. The PAR reviewers did not interpret information found elsewhere on the PAR if it differed from the specified field.

Table A1 shows the information collected from the PARs and entered in the data collection tool. The PAR reviewers collected information for each data element shown, unless it was not available on the PAR. Several data elements were used to match the information on the PAR to a corresponding record in the Fatality Analysis Reporting System (FARS) database, the National
Motor Vehicle Crash Causation Survey (NMVCCS), or the Motor Carrier Management Information System (MCMIS).

**Table A1. PAR Data Captured by Collection Tool**

<table>
<thead>
<tr>
<th>Type of Data</th>
<th>Reason for Including</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System-Generated Information</strong></td>
<td></td>
</tr>
<tr>
<td>1  Record ID #</td>
<td>Database record number</td>
</tr>
<tr>
<td>2  Date of review</td>
<td>Identifies when review was conducted</td>
</tr>
<tr>
<td>3  Start time of review</td>
<td>Used to calculate time to enter record</td>
</tr>
<tr>
<td>4  End time of review</td>
<td>Used to calculate time to enter record</td>
</tr>
<tr>
<td>5  User ID</td>
<td>Identifies who conducted review</td>
</tr>
<tr>
<td><strong>Crash Information on the PAR</strong></td>
<td></td>
</tr>
<tr>
<td>6  Scanned PAR file name</td>
<td>Used to match database record to a PAR</td>
</tr>
<tr>
<td>7  Reporting State</td>
<td>Used to match PAR to records in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>8  PAR number</td>
<td>Identifies State report number</td>
</tr>
<tr>
<td>9  Record source</td>
<td>Identiﬁes source of record</td>
</tr>
<tr>
<td>10 Report/case # from the source</td>
<td>Used to match PAR to records in FARS</td>
</tr>
<tr>
<td>11 Crash date</td>
<td>Used to match PAR to records in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>12 Crash time (as appears on PAR)</td>
<td>Used to match PAR to records in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>13 Crash severity</td>
<td>Used to categorize records by severity</td>
</tr>
<tr>
<td>14 Total # of vehicles involved in crash event</td>
<td>Used to identify single- versus multi-vehicle crashes</td>
</tr>
<tr>
<td>15 # of CMVs involved in crash event</td>
<td>Used to identify CMV involvement</td>
</tr>
<tr>
<td>16 Weather condition</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>17 Roadway surface condition</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>18 Traffic-way type</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>19 First harmful event in the crash event</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td><strong>Vehicle and Carrier Information &amp; Critical Reason Results</strong></td>
<td></td>
</tr>
<tr>
<td>20 Vehicle # involved in crash</td>
<td>Used to match PAR to records in MCMIS/FARS</td>
</tr>
<tr>
<td>21 Vehicle type</td>
<td>Used to verify vehicle type in MCMIS/FARS/NMVCCS</td>
</tr>
<tr>
<td>22 Vehicle license plate #</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>23 Vehicle license plate State</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>24 Initial impact area on the vehicle*</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>25 Driver contributing factors</td>
<td>Used to assess reliability of PAR with respect to data in FARS</td>
</tr>
<tr>
<td>26 Carrier U.S. DOT #</td>
<td>Used to match PAR to records in MCMIS/FARS</td>
</tr>
<tr>
<td>27 Carrier MC #</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>28 Carrier name</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>29 Street address</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>30 City</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>31 State</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>32 Zip code</td>
<td>Used to match PAR to records in MCMIS</td>
</tr>
<tr>
<td>33 Critical reason (required)</td>
<td>Used to capture critical reason determination and compare to NMVCCS</td>
</tr>
<tr>
<td>34 Critical reason justification (required)</td>
<td>Identifies a justification for critical reason determination</td>
</tr>
<tr>
<td>35 Justification description</td>
<td>Captures text explanation for “other” critical reason</td>
</tr>
</tbody>
</table>
The following sections describe how the PAR reviewers collected the data elements shown in Table A1.

**Crash Information**

The following information was entered once for each PAR:

**Scanned PAR File Name**

The name given to the file when the PAR was scanned and saved electronically as a PDF file. For example, 2008_MA_0123.pdf, where:

- 2008 is the PAR year of the crash event.
- MA is the State abbreviation.
- 0123 is the FARS crash number.

This was a required field.

**Reporting State**

The State reporting the crash event, usually found as part of the PAR number; for example, the following PAR number is from Massachusetts: MA0123456789. This was a required field.

**PAR Number**

The number assigned by the State to the PAR, usually following the State abbreviation, for example, MA0123456789.

**Record Source**

The source of the PAR under review. This was chosen from a drop-down list with the following items:

- FARS – selected if the source of the PAR was the FARS.
- NMVCCS – selected if the source of the PAR was the NMVCCS.

This information was not on the PAR.

**Report/Case # from Source**

Found on the PAR, the number assigned to the PAR by the FARS or NMVCCS.
Crash Date

The date of the crash event. This was a required field.

Crash Time

The time of the crash event. This was a required field.

Crash Severity

The severity of the crash event. The values were chosen from a drop-down list with the following items:

- Fatality
- Injury
- Tow-away

Reviewers selected the severity with the highest priority for the crash; the priority was the same as the order in the drop-down list.

Total # of Vehicles Involved in Crash Event

The total number of all vehicles involved in the crash event (CMVs and non-CMVs). This was a required field.

# of CMVs Involved in Crash Event

The number of CMVs involved in the crash event. This was a required field.

Weather Conditions

The weather conditions at the time of the crash event. This was chosen from a drop-down list that varied depending on the choices in the FARS for the year of the crash. When the weather condition was obtained from the PAR, the value was matched to one in the list. (For example, if a 2010 PAR had a value of “Snowing,” the reviewer selected “Snow” from the drop-down list.) The lists for the different years are displayed in Table A2.

Table A2. Weather Conditions

<table>
<thead>
<tr>
<th>Crash Event Year: 2008 and 2009</th>
<th>Crash Event Year:2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear/Cloudy</td>
<td>Clear</td>
</tr>
<tr>
<td>-----</td>
<td>Cloudy</td>
</tr>
<tr>
<td>Rain</td>
<td>Rain</td>
</tr>
<tr>
<td>Crash Event Year: 2008 and 2009</td>
<td>Crash Event Year:2010</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Sleet, Hail</td>
<td>Sleet, Hail (Freezing Rain or Drizzle)</td>
</tr>
<tr>
<td>Snow or blowing snow</td>
<td>Snow</td>
</tr>
<tr>
<td>-----</td>
<td>Blowing Snow</td>
</tr>
<tr>
<td>Fog, Smog, Smoke</td>
<td>Fog, Smog, Smoke</td>
</tr>
<tr>
<td>Severe Crosswinds</td>
<td>Severe Crosswinds</td>
</tr>
<tr>
<td>Blowing Sand, Soil, Dirt</td>
<td>Blowing Sand, Soil, Dirt</td>
</tr>
<tr>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>-----</td>
<td>Not Reported</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Roadway Surface Condition

The condition of the roadway surface at the time of the crash. This was chosen from a drop-down list that varied depending on the choices in the FARS for the year of the crash. When the roadway surface condition was obtained from the PAR, the value was matched to one in the list. (For example, if a 2008 PAR has a value of “Moving Water,” the reviewer selected “Water (Standing, Moving)” from the drop-down list.) The lists for the different years are displayed in Table A3.
### Table A3. Roadway Surface Conditions

<table>
<thead>
<tr>
<th>Crash Event Year: 2008 and 2009</th>
<th>Crash Event Year: 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----</td>
<td>Non-Traffic-Way Area</td>
</tr>
<tr>
<td>Dry</td>
<td>Dry</td>
</tr>
<tr>
<td>Wet</td>
<td>Wet</td>
</tr>
<tr>
<td>Snow or Slush</td>
<td>Snow</td>
</tr>
<tr>
<td>-----</td>
<td>Slush</td>
</tr>
<tr>
<td>Ice/Frost</td>
<td>Ice/Frost</td>
</tr>
<tr>
<td>Water (Standing, Moving)</td>
<td>Water (Standing, Moving)</td>
</tr>
<tr>
<td>Sand, Mud, Dirt, Gravel</td>
<td>Sand</td>
</tr>
<tr>
<td>-----</td>
<td>Mud, Dirt, Gravel</td>
</tr>
<tr>
<td>Oil</td>
<td>Oil</td>
</tr>
<tr>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>-----</td>
<td>Not Reported</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### Traffic-Way Type

The traffic-way type on which the crash event occurred. This was chosen from a drop-down list that varied depending on the choices in the FARS for the year of the crash. When the traffic-way type was obtained from the PAR, an equivalent value was selected from the list. The lists for the different years are displayed in Table A4.

### Table A4. Traffic-Way Types

<table>
<thead>
<tr>
<th>Crash Event Year: 2008 and 2009</th>
<th>Crash Event Year: 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----</td>
<td>Non-Traffic-Way Area</td>
</tr>
<tr>
<td>Not Physically Divided (Two-Way Traffic-Way)</td>
<td>Two-Way, Not Divided</td>
</tr>
<tr>
<td>Not Physically Divided (With Two-Way Continuous Left-Turn Lane)</td>
<td>Two-Way, Not Divided With a Continuous Left-Turn Lane</td>
</tr>
<tr>
<td>Divided Highway, Median Strip (without traffic barrier)</td>
<td>Two-Way, Divided, Unprotected (Painted &gt; 4 Feet) Median</td>
</tr>
<tr>
<td>Divided Highway, Median Strip (with traffic barrier)</td>
<td>Two-Way, Divided, Positive Median Barrier</td>
</tr>
<tr>
<td>One-Way Traffic-Way</td>
<td>One-Way Traffic-Way</td>
</tr>
<tr>
<td>Entrance/Exit Ramp</td>
<td>Entrance/Exit Ramp</td>
</tr>
<tr>
<td>-----</td>
<td>Not Reported</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### First Harmful Event in the Crash Event

The first injury or damage-producing event of the crash (identified on the PAR). This was chosen from a drop-down list that varied depending on the choices in the FARS for the year of the crash.
When the first harmful event was obtained from the PAR, an equivalent value was selected from the list. The lists for the different years are displayed in Table A5.

**Table A5. First Harmful Events**

<table>
<thead>
<tr>
<th>Crash Event Year: 2008 and 2009</th>
<th>Crash Event Year: 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category: Non-Collision Harmful Events</strong></td>
<td></td>
</tr>
<tr>
<td>Rollover/Overturn</td>
<td>Rollover/Overturn</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>Fire/Explosion</td>
</tr>
<tr>
<td>Immersion</td>
<td>Immersion</td>
</tr>
<tr>
<td>Gas Inhalation</td>
<td>Gas Inhalation</td>
</tr>
<tr>
<td>Jackknife (Harmful to This Vehicle)</td>
<td>Jackknife (Harmful to This Vehicle)</td>
</tr>
<tr>
<td>Injured in Vehicle (Non-Collision)</td>
<td>Injured in Vehicle (Non-Collision)</td>
</tr>
<tr>
<td>Pavement Surface Irregularity (Ruts, Potholes, Grates, etc.)</td>
<td>Pavement Surface Irregularity (Ruts, Potholes, Grates, etc.)</td>
</tr>
<tr>
<td>Other Non-Collision</td>
<td>Other Non-Collision</td>
</tr>
<tr>
<td>Thrown or Falling Object</td>
<td>Thrown or Falling Object</td>
</tr>
<tr>
<td>Cargo/Equipment Loss or Shift (Harmful to This Vehicle)</td>
<td>Cargo/Equipment Loss or Shift (Harmful to This Vehicle)</td>
</tr>
<tr>
<td>Fell/Jumped from Vehicle</td>
<td>Fell/Jumped from Vehicle</td>
</tr>
<tr>
<td>Vehicle Occupant Struck or Run over by Own Vehicle</td>
<td>Vehicle Occupant Struck or Run over by Own Vehicle</td>
</tr>
<tr>
<td><strong>Category: Collision with Motor Vehicle In-Transport:</strong></td>
<td></td>
</tr>
<tr>
<td>Motor Vehicle In-Transport</td>
<td>Motor Vehicle In-Transport</td>
</tr>
<tr>
<td>Motor Vehicle In-Transport on Different Roadway</td>
<td>Motor Vehicle In-Transport on Different Roadway</td>
</tr>
<tr>
<td>CMV In-Transport Strikes/Is Struck by Objects Set-in-Motion by Another CMV In-Transport</td>
<td>CMV In-Transport Strikes/Is Struck by Objects Set-in-Motion by Another CMV In-Transport</td>
</tr>
<tr>
<td>Motor Vehicle In Motion Outside the Traffic-Way</td>
<td>Motor Vehicle In Motion Outside the Traffic-Way</td>
</tr>
<tr>
<td><strong>Category: Collision with Object Not Fixed:</strong></td>
<td></td>
</tr>
<tr>
<td>Pedestrian</td>
<td>Pedestrian</td>
</tr>
<tr>
<td>Pedalcyclist</td>
<td>Pedalcyclist</td>
</tr>
<tr>
<td>Railway Vehicle</td>
<td>Railway Vehicle</td>
</tr>
<tr>
<td>Live Animal</td>
<td>Live Animal</td>
</tr>
<tr>
<td>Ridden Animal or Animal Drawn Conveyance</td>
<td>Ridden Animal or Animal Drawn Conveyance</td>
</tr>
<tr>
<td>Other Object (Not Fixed)</td>
<td>Other Object (Not Fixed)</td>
</tr>
<tr>
<td>Non-Motorist on Personal Conveyance</td>
<td>Non-Motorist on Personal Conveyance</td>
</tr>
<tr>
<td>Parked Motor Vehicle</td>
<td>Parked Motor Vehicle</td>
</tr>
<tr>
<td>Crash Event Year: 2008 and 2009</td>
<td>Crash Event Year: 2010</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Working Motor Vehicle</td>
<td>Working Motor Vehicle</td>
</tr>
</tbody>
</table>

**Category: Collision with Fixed Object:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Fixed Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder</td>
<td>Boulder</td>
</tr>
<tr>
<td>Building</td>
<td>Building</td>
</tr>
<tr>
<td>Ground</td>
<td></td>
</tr>
<tr>
<td>Impact Attenuator/Crash Cushion</td>
<td>Impact Attenuator/Crash Cushion</td>
</tr>
<tr>
<td>Bridge Overhead Structure</td>
<td>Bridge Overhead Structure</td>
</tr>
<tr>
<td>Bridge Pier or Support</td>
<td>Bridge Pier or Support</td>
</tr>
<tr>
<td>Bridge Parapet End</td>
<td></td>
</tr>
<tr>
<td>Bridge Rail</td>
<td>Bridge Rail (Includes Parapet)</td>
</tr>
<tr>
<td>Guardrail Face</td>
<td>Guardrail Face</td>
</tr>
<tr>
<td>Guardrail End</td>
<td>Guardrail End</td>
</tr>
<tr>
<td>Concrete Traffic Barrier</td>
<td>Concrete Traffic Barrier</td>
</tr>
<tr>
<td>Cable Barrier</td>
<td>Cable Barrier</td>
</tr>
<tr>
<td>Other Traffic Barrier</td>
<td>Other Traffic Barrier</td>
</tr>
<tr>
<td>Traffic Sign Support/Signal</td>
<td>Traffic Sign Support</td>
</tr>
<tr>
<td>Utility Pole/Light Support</td>
<td></td>
</tr>
<tr>
<td>Other Post, Other Pole or Other Supports</td>
<td>Other Post, Other Pole or Other Supports</td>
</tr>
<tr>
<td>Culvert</td>
<td>Culvert</td>
</tr>
<tr>
<td>Highway/Traffic sign Post/Sign</td>
<td></td>
</tr>
<tr>
<td>Overhead Sign Support/Sign</td>
<td></td>
</tr>
<tr>
<td>Luminarie/Light Support</td>
<td></td>
</tr>
<tr>
<td>Curb</td>
<td>Curb</td>
</tr>
<tr>
<td>Ditch</td>
<td>Ditch</td>
</tr>
<tr>
<td>Embankment</td>
<td>Embankment</td>
</tr>
<tr>
<td>Embankment-Rock, Stone, or Concrete</td>
<td></td>
</tr>
<tr>
<td>Embankment-Material type Unknown</td>
<td></td>
</tr>
<tr>
<td>Fence</td>
<td>Fence</td>
</tr>
<tr>
<td>Wall</td>
<td>Wall</td>
</tr>
<tr>
<td>Fire Hydrant</td>
<td>Fire Hydrant</td>
</tr>
<tr>
<td>Shrubbery</td>
<td>Shrubbery</td>
</tr>
<tr>
<td>Tree (Standing Only)</td>
<td>Tree (Standing Only)</td>
</tr>
<tr>
<td>Snow Bank</td>
<td>Snow Bank</td>
</tr>
<tr>
<td>Mail Box</td>
<td>Mail Box</td>
</tr>
<tr>
<td>Other Fixed Object</td>
<td>Other Fixed Object</td>
</tr>
</tbody>
</table>

**Category: Not Reported and Unknown:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Fixed Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Reported</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>
**Vehicle and Carrier Information**

The following information was entered for each CMV involved in a crash event:

**Vehicle # Involved in the Crash**

The number assigned to the vehicle on the PAR. For example, if there were six total vehicles involved in the crash, and the CMV being coded was number four, the value “4” would be entered as the vehicle number. This was a required field.

**Vehicle Type**

A drop-down list of the vehicle types for the CMV:

- Truck
- Bus
- Light vehicle with HM placard

If the vehicle type was not a field on the PAR, the reviewer selected the appropriate value based on other PAR fields, such as vehicle class, vehicle configuration, etc.

**Vehicle License Plate Number**

The license plate number for the vehicle as found on the PAR.

**Vehicle License Plate State**

A drop-down list of States that issued the license plate number for the vehicle.

**Driver Contributing Factors**

Up to four driver contributing factors as indicated on the PAR. These were chosen from four drop-down lists that varied depending on the choices in the FARS for the year of the crash. When a driver contributing factor was identified on the PAR, the value was matched to one in the list or an equivalent value was selected. The lists for the different years are displayed in Table A7.
<table>
<thead>
<tr>
<th>Crash Event Year: 2008</th>
<th>Crash Event Year: 2009</th>
<th>Crash Event Year: 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td><strong>Physical/Mental Condition:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drowsy, Sleepy, Asleep Fatigued</td>
<td>Drowsy, Sleepy, Asleep Fatigued</td>
<td>-----</td>
</tr>
<tr>
<td>Ill, Passed Out/Blackout</td>
<td>Ill, Passed Out/Blackout</td>
<td>-----</td>
</tr>
<tr>
<td>Emotional (e.g. Depression, Angry, Disturbed)</td>
<td>Emotional (e.g. Depression, Angry, Disturbed)</td>
<td>-----</td>
</tr>
<tr>
<td>Aggressive Driving / Road Rage</td>
<td>Aggressive Driving / Road Rage</td>
<td>Aggressive Driving / Road Rage</td>
</tr>
<tr>
<td>Mentally Challenged</td>
<td>Mentally Challenged</td>
<td>Mentally Challenged</td>
</tr>
<tr>
<td>Reaction to or Failure to Take Drugs/Medication</td>
<td>Reaction to or Failure to Take Drugs/Medication</td>
<td>Reaction to or Failure to Take Drugs/Medication</td>
</tr>
<tr>
<td>Under the Influence of Alcohol, Drugs or Medication</td>
<td>Under the Influence of Alcohol, Drugs or Medication</td>
<td>-----</td>
</tr>
<tr>
<td>Operating the Vehicle in Careless or Inattentive Manner</td>
<td>Operating the Vehicle in Careless or Inattentive Manner</td>
<td>-----</td>
</tr>
<tr>
<td>Restricted to Wheelchair</td>
<td>Restricted to Wheelchair</td>
<td>-----</td>
</tr>
<tr>
<td>Impaired Due to Previous Injury</td>
<td>Impaired Due to Previous Injury</td>
<td>-----</td>
</tr>
<tr>
<td>Other Physical Impairment</td>
<td>Other Physical Impairment</td>
<td>-----</td>
</tr>
<tr>
<td>Mother of Dead Fetus</td>
<td>Mother of Dead Fetus</td>
<td>Mother of Dead Fetus</td>
</tr>
<tr>
<td><strong>Miscellaneous Factors:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traveling on Prohibited Traffic-Ways</td>
<td>Traveling on Prohibited Traffic-Ways</td>
<td>Traveling on Prohibited Traffic-Ways</td>
</tr>
<tr>
<td>Legally Driving on Suspended or Revoked License</td>
<td>Legally Driving on Suspended or Revoked License</td>
<td>Legally Driving on Suspended or Revoked License</td>
</tr>
<tr>
<td>Leaving Vehicle Unattended in Roadway</td>
<td>Leaving Vehicle Unattended in Roadway</td>
<td>Leaving Vehicle Unattended in Roadway</td>
</tr>
<tr>
<td>Improper Loading of Vehicle With Passengers or Cargo</td>
<td>Improper Loading of Vehicle With Passengers or Cargo</td>
<td>Improper Loading of Vehicle With Passengers or Cargo</td>
</tr>
<tr>
<td>Crash Event Year: 2008</td>
<td>Crash Event Year: 2009</td>
<td>Crash Event Year: 2010</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Towing or Pushing Improperly</td>
<td>Towing or Pushing Improperly</td>
<td>Towing or Pushing Improperly</td>
</tr>
<tr>
<td>Failure to Dim Lights or to Have Lights on When Required</td>
<td>Failure to Dim Lights or to Have Lights on When Required</td>
<td>Failure to Dim Lights or to Have Lights on When Required</td>
</tr>
<tr>
<td>Operating Without Required Equipment</td>
<td>Operating Without Required Equipment</td>
<td>Operating Without Required Equipment</td>
</tr>
<tr>
<td>Following Improperly</td>
<td>Following Improperly</td>
<td>Following Improperly</td>
</tr>
<tr>
<td>Improper or Erratic Lane Changing</td>
<td>Improper or Erratic Lane Changing</td>
<td>Improper or Erratic Lane Changing</td>
</tr>
<tr>
<td>Failure to Keep in Proper Lane</td>
<td>Failure to Keep in Proper Lane</td>
<td>Failure to Keep in Proper Lane</td>
</tr>
<tr>
<td>Illegal Driving on Shoulder, Ditch, Sidewalk or Median</td>
<td>Illegal Driving on Shoulder, Ditch, Sidewalk or Median</td>
<td>Illegal Driving on Shoulder, Ditch, Sidewalk or Median</td>
</tr>
<tr>
<td>Making Improper Entry To or Exit From Traffic-Way</td>
<td>Making Improper Entry To or Exit From Traffic-Way</td>
<td>Making Improper Entry To or Exit From Traffic-Way</td>
</tr>
<tr>
<td>Starting or Backing Improperly</td>
<td>Starting or Backing Improperly</td>
<td>Starting or Backing Improperly</td>
</tr>
<tr>
<td>Opening Closure into Moving Traffic or While Vehicle is in Motion</td>
<td>Opening Closure into Moving Traffic or While Vehicle is in Motion</td>
<td>Opening Closure into Moving Traffic or While Vehicle is in Motion</td>
</tr>
<tr>
<td>Passing Where Prohibited or School Bus Displaying Warning Not to Pass</td>
<td>Passing Where Prohibited or School Bus Displaying Warning Not to Pass</td>
<td>Passing Where Prohibited or School Bus Displaying Warning Not to Pass</td>
</tr>
<tr>
<td>Passing on Wrong Side</td>
<td>Passing on Wrong Side</td>
<td>Passing on Wrong Side</td>
</tr>
<tr>
<td>Passing With Insufficient Distance, Inadequate Visibility</td>
<td>Passing With Insufficient Distance, Inadequate Visibility</td>
<td>Passing With Insufficient Distance, Inadequate Visibility</td>
</tr>
<tr>
<td>Operating the Vehicle in an Erratic, Reckless or Negligent Manner</td>
<td>Operating the Vehicle in an Erratic, Reckless or Negligent Manner</td>
<td>Operating the Vehicle in an Erratic, Reckless or Negligent Manner</td>
</tr>
<tr>
<td>Police or Law Enforcement Officer</td>
<td>Police or Law Enforcement Officer</td>
<td>Police or Law Enforcement Officer</td>
</tr>
<tr>
<td>Police Pursuing This Driver or Police Officer in Pursuit</td>
<td>Police Pursuing This Driver or Police Officer in Pursuit</td>
<td>Police Pursuing This Driver or Police Officer in Pursuit</td>
</tr>
<tr>
<td>Failure to Yield Right-of-Way</td>
<td>Failure to Yield Right-of-Way</td>
<td>Failure to Yield Right-of-Way</td>
</tr>
<tr>
<td>Failure to Obey Traffic Signs, Control Devices or Traffic Officers</td>
<td>Failure to Obey Traffic Signs, Control Devices or Traffic Officers</td>
<td>Failure to Obey Traffic Signs, Control Devices or Traffic Officers</td>
</tr>
<tr>
<td>Crash Event Year: 2008</td>
<td>Crash Event Year: 2009</td>
<td>Crash Event Year: 2010</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Passing Through or Around Barrier</td>
<td>Passing Through or Around Barrier</td>
<td>Passing Through or Around Barrier</td>
</tr>
<tr>
<td>Failure to Observe Warnings or Instructions on Vehicles Displaying Them</td>
<td>Failure to Observe Warnings or Instructions on Vehicles Displaying Them</td>
<td>Failure to Observe Warnings or Instructions on Vehicles Displaying Them</td>
</tr>
<tr>
<td>Failure to Signal Intentions</td>
<td>Failure to Signal Intentions</td>
<td>Failure to Signal Intentions</td>
</tr>
<tr>
<td>Driving Too Fast for Conditions</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Driving in Excess of Posted Maximum</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Driving Less Than Posted Minimum</td>
<td>Driving Less Than Posted Minimum</td>
<td>Driving Less Than Posted Minimum</td>
</tr>
<tr>
<td>Racing</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Making Right Turn From Left-Turn Lane, Left Turn from Right-Turn Lane</td>
<td>Making Right Turn From Left-Turn Lane, Left Turn from Right-Turn Lane</td>
<td>Making Right Turn From Left-Turn Lane, Left Turn from Right-Turn Lane</td>
</tr>
<tr>
<td>Making Other Improper Turn</td>
<td>Making Other Improper Turn</td>
<td>Making Other Improper Turn</td>
</tr>
<tr>
<td>Driving Wrong Way on One-Way Traffic</td>
<td>Driving Wrong Way on One-Way Traffic</td>
<td>Driving Wrong Way on One-Way Traffic</td>
</tr>
<tr>
<td>Driving on Wrong Side of Road (Intentional or Unintentional)</td>
<td>Driving on Wrong Side of Road (Intentional or Unintentional)</td>
<td>Driving on Wrong Side of Road (Intentional or Unintentional)</td>
</tr>
<tr>
<td>Operator Inexperience</td>
<td>Operator Inexperience</td>
<td>Operator Inexperience</td>
</tr>
<tr>
<td>Unfamiliar with Roadway</td>
<td>Unfamiliar with Roadway</td>
<td>Unfamiliar with Roadway</td>
</tr>
<tr>
<td>Stopped in Roadway (Vehicle Not Abandoned)</td>
<td>Stopped in Roadway (Vehicle Not Abandoned)</td>
<td>Stopped in Roadway (Vehicle Not Abandoned)</td>
</tr>
<tr>
<td>Underriding a Parked Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Locked Wheel</td>
<td>Locked Wheel</td>
<td>Locked Wheel</td>
</tr>
<tr>
<td>Overcorrecting</td>
<td>Overcorrecting</td>
<td>Overcorrecting</td>
</tr>
<tr>
<td>Getting Off/Out of or On/In to a Vehicle</td>
<td>Getting Off/Out of or On/In to a Vehicle</td>
<td>Getting Off/Out of or On/In to a Vehicle</td>
</tr>
<tr>
<td><strong>Vision Obscured By:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rain, Snow, Fog, Smoke, Sand, Dust</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Reflected Glare, Bright sunlight, Headlights</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Crash Event Year: 2008</td>
<td>Crash Event Year: 2009</td>
<td>Crash Event Year: 2010</td>
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<tr>
<td>-----------------------</td>
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<td>------------------------</td>
</tr>
<tr>
<td>Curve, Hill, or Other Design Features (Including Traffic Signs, Embankment)</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Building, Billboard, Other Structures</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Trees, Crops, Vegetation</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Motor Vehicle (Including Load)</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Parked Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Splash or Spray of Passing Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Inadequate Defrost or Defog System</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Inadequate Lighting System</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Obstructing Angles on Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Mirrors</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Broken or Improperly Cleaned Windshield</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Trees, Crops, Vegetation</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Motor Vehicle (Including Load)</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Parked Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Splash or Spray of Passing Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Inadequate Defrost or Defog System</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Inadequate Lighting System</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Obstructing Angles on Vehicle</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Mirrors</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Broken or Improperly Cleaned Windshield</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Other Visual Obstruction</td>
<td>-----</td>
<td>-----</td>
</tr>
</tbody>
</table>

**Skidding, Swerving, Sliding Due To:**

<table>
<thead>
<tr>
<th>Severe Crosswind</th>
<th>Severe Crosswind</th>
<th>Severe Crosswind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind From Passing Truck</td>
<td>Wind From Passing Truck</td>
<td>Wind From Passing Truck</td>
</tr>
<tr>
<td>Slippery or Loose Surface</td>
<td>Slippery or Loose Surface</td>
<td>Slippery or Loose Surface</td>
</tr>
<tr>
<td>Tire Blowout or Flat</td>
<td>Tire Blowout or Flat</td>
<td>Tire Blowout or Flat</td>
</tr>
<tr>
<td>Debris or Objects in Road</td>
<td>Debris or Objects in Road</td>
<td>Debris or Objects in Road</td>
</tr>
<tr>
<td>Ruts, Holes, Bumps in Road</td>
<td>Ruts, Holes, Bumps in Road</td>
<td>Ruts, Holes, Bumps in Road</td>
</tr>
<tr>
<td>Live Animals in Road</td>
<td>Live Animals in Road</td>
<td>Live Animals in Road</td>
</tr>
<tr>
<td>Vehicle in Road</td>
<td>Vehicle in Road</td>
<td>Vehicle in Road</td>
</tr>
<tr>
<td>Phantom Vehicle</td>
<td>Phantom Vehicle</td>
<td>Phantom Vehicle</td>
</tr>
<tr>
<td>Pedestrian, Pedal Cyclist, or Other Non-Motorist</td>
<td>Pedestrian, Pedal Cyclist, or Other Non-Motorist</td>
<td>Pedestrian, Pedal Cyclist, or Other Non-Motorist</td>
</tr>
<tr>
<td>Ice, Snow, Slush, Water, Sand, Dirt, Oil, Wet Leaves on Road</td>
<td>Ice, Snow, Slush, Water, Sand, Dirt, Oil, Wet Leaves on Road</td>
<td>Ice, Snow, Slush, Water, Sand, Dirt, Oil, Wet Leaves on Road</td>
</tr>
<tr>
<td>Trailer Fishtailing or Swaying</td>
<td>Trailer Fishtailing or Swaying</td>
<td>Trailer Fishtailing or Swaying</td>
</tr>
</tbody>
</table>

**Special Circumstances:**

<table>
<thead>
<tr>
<th>Driver Has Not Complied With Learner’s Permit or</th>
<th>Driver Has Not Complied With Learner’s Permit or</th>
<th>Driver Has Not Complied With Learner’s Permit or</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash Event Year: 2008</td>
<td>Crash Event Year: 2009</td>
<td>Crash Event Year: 2010</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>GDL Restrictions</td>
<td>GDL Restrictions</td>
<td>GDL Restrictions</td>
</tr>
<tr>
<td>Driver Has Not Complied With Physical or Other Imposed Restrictions</td>
<td>Driver Has Not Complied With Physical or Other Imposed Restrictions</td>
<td>Driver Has Not Complied With Physical or Other Imposed Restrictions</td>
</tr>
<tr>
<td>Driver has a Driving Record or License from More Than 1 State</td>
<td>Driver has a Driving Record or License from More Than 1 State</td>
<td>Driver has a Driving Record or License from More Than 1 State</td>
</tr>
<tr>
<td>Hit and Run Vehicle Driver</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Non-Traffic Violation Charged (Manslaughter, Homicide)</td>
<td>Non-Traffic Violation Charged (Manslaughter, Homicide)</td>
<td>Non-Traffic Violation Charged (Manslaughter, Homicide)</td>
</tr>
<tr>
<td>Other Non-Moving Traffic Violations</td>
<td>Other Non-Moving Traffic Violations</td>
<td>Other Non-Moving Traffic Violations</td>
</tr>
</tbody>
</table>

### Devices in Vehicle With Potential for Distractions:

<table>
<thead>
<tr>
<th></th>
<th>Crash Event Year: 2008</th>
<th>Crash Event Year: 2009</th>
<th>Crash Event Year: 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Telephone Present in Vehicle</td>
<td>Cellular Telephone Present in Vehicle</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Cellular Telephone in Use in Vehicle</td>
<td>Cellular Telephone in Use in Vehicle</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Computer/Fax Machines/Printers</td>
<td>Computer/Fax Machines/Printers</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Onboard Navigation System</td>
<td>Onboard Navigation System</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Two-Way Radio</td>
<td>Two-Way Radio</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Head-Up Display</td>
<td>Head-Up Display</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

**Carrier U.S.DOT #**

A unique FMCSA-issued identifier for the CMV; the value was entered as found on the PAR.

**Carrier MC #**

Another unique FMCSA-issued identifier for the CMV. This field was entered **ONLY** if the carrier’s U.S. DOT number was not provided in the PAR.

**Carrier Name and Address**

Includes the following fields:

- Carrier name
- Street address
- City
Critical Reason and Critical Reason Justification

The critical reason describes the role of the driver or vehicle involved in the crash. For each PAR, a critical reason was assigned by a PAR coder after a thorough review of the PAR. (The PAR does not identify a critical reason.) In addition to assigning a critical reason, PAR reviewers selected a critical reason justification associated with the driver’s or vehicle’s actions to explain how the critical reason was determined.

Critical Reason

This field was required.

The following were the critical reason choices for the PAR reviewers:

1. Truck/Bus Driver – used as a result of the driver’s actions or inactions that lead to the crash, including:
   a. A driver who was incapable of action due to a physical condition just prior to the crash (falling asleep, physical impairment such as a heart attack);
   b. A situation where the driver did not perceive a critical situation due to the level of cognitive awareness (inattentiveness, failure to conduct proper surveillance of his/her surroundings);
   c. A driver decision error that led to risky driving behavior (driving too fast or too slow for conditions or the roadway type, illegal maneuvers, aggressive driving behavior); and
   d. A situation where the driver responded in an inappropriate way that resulted in the crash (panic/freezing response, overcompensation, poor directional control).

2. Truck/Bus Vehicle – used as a result of a vehicle mechanical failure or component degradation that led to the crash, including:
   a. Brake failure or degraded capability;
   b. Tire failure or degradation;
   c. Steering, suspension, transmission, engine failure;
   d. Light failure or vehicle related vision obstruction; and
   e. Cargo shift, trailer attachment failure or jackknife.

3. Environment – used in a situation where the driver suddenly encountered either a highway-related factor or a weather-related factor that led to the crash. Reviewers considered if the driver was aware of the particular factor prior to the crash. If the PAR did not indicate the condition occurred immediately prior to the crash, the presumption was that the condition was ongoing prior to the crash and the driver proceeded in spite of the risk.
a. Highway conditions include missing, inadequate or erroneous/defective signs/signals; view obstructed by roadway design or other vehicles; sudden encounter with poor roadway conditions; slick roadway conditions.

b. Weather conditions include sudden, onset rain, snow, fog, wind gusts, sun glare, and blowing debris.

4. Not assigned to this driver/vehicle – driver’s or vehicle’s action or condition did not lead to the crash.

5. Unable to assign critical reason – insufficient information in the PAR to assign the critical reason to this vehicle.

Critical Reason Justification

Relates to the driver’s or vehicle’s actions and explains how the critical reason was determined. This justification was not on the PAR but determined by the PAR coder after a thorough PAR review. Reviewers selected from among a group of standard justification explanations associated with each of the five critical reason choices. If no explanation seemed relevant, the coders chose “Other” from the list. This was a required field.

Table A8 lists the justifications associated with each critical reason.

**Table A8. Critical Reason Justifications**

<table>
<thead>
<tr>
<th>1. Critical Reason: Truck/Bus Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category: Recognition Error/Poor Judgment</strong></td>
</tr>
<tr>
<td>Driver was following too close for conditions.</td>
</tr>
<tr>
<td>Driver was going too fast for conditions.</td>
</tr>
<tr>
<td>Driver was going too slow for traffic stream.</td>
</tr>
<tr>
<td>Driver exhibited aggressive driving behavior.</td>
</tr>
<tr>
<td>Truck/bus struck the rear of a vehicle.</td>
</tr>
<tr>
<td>Driver was aware of dangerous atmospheric conditions.</td>
</tr>
<tr>
<td>Driver was aware of ongoing highway conditions.</td>
</tr>
<tr>
<td>Other.</td>
</tr>
</tbody>
</table>

**Category: Intersection/Crossing Path**

| Driver turned across path of another vehicle at a junction without a traffic control device present. |
| Driver turned across path at a junction in violation of a traffic control device. |
| Driver performed a wide turn from a portion of wrong lane. |
| Driver performed a wide turn and struck object on road. |
| Other. |

**Category: Decision Error**

| Driver misjudged gap or other’s speed. |
| Driver had false assumption of other’s actions. |
| Truck/bus was disabled as a result of a driver action that caused the vehicle to stop operating. |
| Driver did not obey a traffic control device. |
Driver executed an inadequate evasive action.
Driver executed an illegal maneuver.
Other.

**Category: Mechanical Failure**
Truck/bus lost control as a result of mechanical failure.
Driver actions caused the cargo shift/loss.
Other.

**Category: Erratic Actions/Unsafe Driving**
Driver failed to drive safely due to physical condition.
Driver failed to drive safely due to distraction or inattention.
Driver failed to drive safely due to inadequate surveillance.
Driver failed to drive safely by exercising poor directional control or overcompensating.
Truck/bus swung or jackknifed and resulting in a crash (if no extenuating circumstances).
Other.

**Category: Lane Change**
Truck/bus encroached into a lane occupied by another motor vehicle.
Truck/bus traveled over the lane line or off the road.
Other.

**Category: Other**
Truck/bus struck pedestrian - pedestrian's actions were NOT deliberate.
Truck/bus struck animal - driver had time for evasive action.
Driver actions or inactions led to crash.
Other.

2. **Critical Reason: Truck/Bus Vehicle**

**Category: Vehicle issue**
Truck/bus was disabled in travel lane and was struck by other vehicle.
Truck/bus failure or degraded vehicle component(s) led to the crash.
Truck/bus cargo shift/loss caused loss of control leading to a crash.
Truck/bus disabled as a result of a mechanical breakdown.
Other.

3. **Critical Reason: Environment**

**Category: Road**
Unanticipated roadway issue.
Traffic control signs/signals: missing; erroneous; defective; inadequate.
Road issue/defect (e.g., low bridge without appropriate signage; sudden roadway deterioration; etc.)
Truck/bus driver's view was obstructed by roadway design/signage or by other vehicles.
Truck/bus cargo shift/loss caused by unanticipated roadway issue.
Truck/bus struck animal - driver had NO time for evasive action.
<table>
<thead>
<tr>
<th>Category: Weather</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unanticipated environmental condition.</td>
</tr>
<tr>
<td>Truck/bus swung or jackknifed caused by sudden unanticipated environmental condition.</td>
</tr>
<tr>
<td>Truck/bus cargo shift/loss caused by unanticipated environmental condition.</td>
</tr>
<tr>
<td>Truck/bus disabled as a result of an unseen or sudden weather event.</td>
</tr>
<tr>
<td>Other.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Critical Reason: Not Assigned to This Driver/Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category: Other Vehicle Reason</td>
</tr>
<tr>
<td>Truck/bus had the right of way.</td>
</tr>
<tr>
<td>Truck/bus stopped safely before being struck.</td>
</tr>
<tr>
<td>Truck/bus is the lead vehicle and was stopped at traffic light and struck in rear.</td>
</tr>
<tr>
<td>Truck/bus is the lead vehicle, stopped in traffic, struck in rear and pushed into another vehicle or object.</td>
</tr>
<tr>
<td>Truck/bus performed a wide turn from correct lane and struck vehicle making an illegal maneuver.</td>
</tr>
<tr>
<td>Truck/bus turned in compliance with a traffic control.</td>
</tr>
<tr>
<td>Truck/bus encroached into another lane/off road to avoid crash.</td>
</tr>
<tr>
<td>Truck/bus struck pedestrian/non-motorist. Pedestrian//non-motorist actions were deliberate.</td>
</tr>
<tr>
<td>Truck/bus mechanical problem found, but is not responsible for crash.</td>
</tr>
<tr>
<td>Truck/bus disabled as a result of previous crash.</td>
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<tr>
<td>Critical event not coded to truck/bus driver/vehicle.</td>
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<td>PAR information not consistent.</td>
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<tr>
<td>Not enough information to make a determination.</td>
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<td>Other.</td>
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</tbody>
</table>

**Justification Description**

Used with a critical reason justification of “Other” or to document additional details to support the critical reason justification. This field was not required.

**CRITICAL REASON CODING**

PAR reviewers used a modified version of the LTCCS critical event and critical reason methodology to assess the role of the CMV in a crash event. Critical events were assigned to a
vehicle or responsible “Other” party involved in the crash. Based on the critical event, a critical reason was coded for each involved CMV to indicate the role of the CMV driver or vehicle.

**Differences from LTCCS Methodology**

The following five crash situations followed different rules than those specified in the LTCCS:

1. **Right-of-way**: A truck or bus that had the right-of-way to make an on-road maneuver was not assigned the critical event, even when that maneuver made the crash inevitable. When the CMV did not commit the critical event, it was not coded with the “truck/bus driver” or “truck/bus vehicle” critical reasons.

2. **Multiple qualifying vehicles**: In the LTCCS coding methodology, vehicles not involved in the first harmful event could not be coded with the critical event. In this study, if the review of the PAR revealed that more than one CMV contributed to the crash event, each of those CMVs was coded with the critical event. For example, if two CMVs were involved in a crash with a passenger vehicle and it was determined that both CMVs made errors, both CMVs would be coded with the critical event. Each vehicle would also be coded with the appropriate critical reason.

3. **Disabled vehicles**: Any truck or bus that became disabled in the travel lane due to a driver error or vehicle problem could be coded with the critical event and the appropriate critical reason. In the LTCCS coding methodology, the vehicle striking the disabled truck or bus was assigned the critical reason.

4. **Cargo spillage**: For any on-road cargo spillage leading to a crash, the motor carrier responsible for the cargo committed the critical event and was coded with the appropriate critical reason. In the LTCCS coding methodology, the vehicle striking the spilled cargo was coded with the critical event and critical reason.

5. **Pedestrian crashes**: If a pedestrian was assigned the critical event for a crash, the critical reason could not be coded as “truck/bus driver or truck/bus vehicle.”

**Examples of Crash Situations**

The following are examples of crash events and the resulting critical event and critical reason determinations. These examples do not represent all crash scenarios.

**Example 1. Non-contact encroachment by a non-CMV**

**Discussion**: A non-CMV traveling from the opposite direction crosses the centerline into the CMV’s travel lane. The CMV driver attempts to avoid the crash by steering right and by doing so departs the roadway and strikes a tree. The action of the non-CMV made the crash inevitable. If the CMV driver had not taken evasive action, the truck would have collided with the non-CMV. When it did take evasive action, the truck hit the tree.
Figure A2. Non-Contact Encroachment By Non-CMV

**Critical Event and Reason:** The critical event was committed by the non-CMV. The critical reason for the CMV is coded as “not assigned to this vehicle.”

**Example 2. Lane change maneuver by both vehicles**

**Discussion:** The non-CMV was initially driving the wrong way in the CMV’s lane. The CMV driver swerved into the oncoming lane to avoid the non-CMV. The non-CMV returned to its original lane and was struck by the CMV.

Figure A3. Lane-Change Maneuver By Both Vehicles

**Critical Event and Reason:** The critical event was committed by the CMV. The critical reason is coded as the CMV “truck/bus driver.”

**Guideline:** The CMV driver should have steered to the right to attempt to avoid the crash. The critical reason is coded to the CMV driver, if there was a driver error, or to the CMV, if there was a mechanical malfunction.

**Example 3. CMV strikes a pedestrian**

**Discussion:** Pedestrian enters travel lane and is struck.
**Figure A4. CMV Strikes a Pedestrian**

**Critical Event and Reason:** The critical event was committed by the CMV and the critical reason is assigned to the CMV driver, unless the pedestrian is assigned the critical event for the crash.

**Guideline:** The critical event is assigned to the CMV and the critical reason coded to the CMV driver in pedestrian-related crashes unless the PAR indicates that the pedestrian's action resulted in the critical event, such as attempting a deliberate act (e.g., suicide, crossing road unsafely outside of pedestrian walkway, etc.). If the PAR does not indicate the pedestrian was responsible for the crash (e.g., walking along the edge of the roadway, etc.), the CMV driver is assigned the critical reason for the crash.

**Example 4. CMV strikes an animal**

**Discussion:** Animal enters travel lane and is struck.

**Figure A5. CMV Strikes an Animal**
**Critical Event and Reason:** The critical event was committed by the CMV, but the critical reason is coded to the environment.

**Guideline:** The critical reason is not assigned to the CMV driver in most animal-related crashes. The assumption is that animals can appear at any time without any notice and enter the path of the CMV or run into the side of a CMV. This situation is considered to be a manifestation of the environment.

However, if the animal had been standing in the road, and the CMV had enough time to observe the animal and to stop or take evasive action, the CMV would be coded with the critical event and the CMV driver would be coded with the critical reason.

**Example 5. CMV disabled and stopped in the travel lane at time of impact from a following non-CMV**

**Discussion:** A CMV is disabled and stopped in the travel lane due to a mechanical breakdown.

**Critical Event and Reason:** The critical event was committed by the CMV and the critical reason is coded to the CMV vehicle.

**Guideline:** A CMV should be in good condition when the trip started and should not be stopped on a travel lane due to mechanical malfunctions. Warning devices are not a consideration for assessing critical reasons.
However, if the CMV has been disabled by a previous crash or disabled by a sudden roadway event (large pothole, debris blown under the CMV, etc.), the CMV is not coded with the critical event for the crash.

**Example 6. CMV spins out due to weather-related conditions and is struck by another vehicle**

**Discussion:** A CMV spins out due to weather-related roadway surface conditions and is struck by another vehicle while still in the travel lanes.

![Figure A7. CMV Spins Out Due to Weather Conditions and Is Struck by Another Vehicle](image)

**Critical Event and Reason:** The critical event was committed by the CMV and the critical reason is coded to the CMV driver.

**Guideline:** The rationale is that the driver was traveling too fast for conditions and the driver was not in control of the vehicle. The driver should have adjusted his/her speed to the conditions.

However, for unexpected cataclysmic environmental or roadway conditions (e.g., earthquake, washed out roadway, tornado, flood, etc.), the critical event would be coded to the CMV but the critical reason coded to the environment.

**Example 7. CMV successfully stopped in travel lane due to a previous collision and is subsequently struck by another vehicle**

**Discussion:** A crash event occurs and the CMV successfully avoids the previous collision and stops. A vehicle trailing behind the CMV is unable to stop and hits the CMV.
Critical Event and Reason: The critical event was committed by the non-CMV and the critical reason is coded to the CMV as “not assigned to this driver/vehicle.”

Guideline: Critical events are not assigned to the CMV if the CMV is stopped in traffic due to a previous collision.

Example 8. CMV swings wide into adjacent travel lane to make either a right or left turn at an intersection

Discussion: The wide turning maneuver can occur at an intersection, driveway, or junction and it involves the CMV partially or fully departing its original travel lane to attempt a turning maneuver. Another vehicle attempts to pass the CMV and is either struck by the CMV or it strikes the side of the CMV.

The following image shows a right-turn collision:
Figure A9. CMV Swings Wide into Adjacent Travel Lane-Right Turn at Intersection

The following image shows a left-turn collision:
Figure A10. CMV Swings Wide into Adjacent Travel Lane-Left Turn at Intersection

Critical Event and Reason: The critical event was committed by the CMV and the critical reason is coded as “truck/bus driver.”

Guideline: For crashes where both vehicles are in the same direction of travel and the CMV swings wide to make a turn, the CMV committed the critical event and the CMV driver is coded with the critical reason for a driving error (making a turn from a portion of the wrong lane).

If the CMV is located in the correct lane for turning and there is a shoulder area adjacent to that lane, then the CMV is not responsible if another vehicle attempts to pass the CMV using that shoulder area.

If the CMV driver initiates a turn and the CMV strikes an object on the roadside (e.g., utility pole, etc.), the CMV committed the critical event and the CMV driver is coded with the critical reason.

Example 9. Intersection crash involving one vehicle making a left turn in front of another vehicle traveling in a straight path
Scenario 1: A non-CMV is in an intersection turning left on a green arrow. A CMV from the opposite direction (going straight) has a red light and does not stop and the crash occurs.

Discussion: When a vehicle does not obey a traffic control device, it does not have the right-of-way, and this fact is considered when assigning critical events and critical reasons.

Critical Event and Reason: The critical event was committed by the CMV and the critical reason is assigned to the CMV “truck/bus driver.”

Guideline: When there is an indication that a CMV driver has violated a traffic control device making a crash inevitable, the CMV is assigned the critical reason.

Scenario 2: A non-CMV is in an intersection waiting to turn left on a green light. The traffic light changes from green to yellow and this vehicle starts to turn left. A CMV from the opposite direction (going straight) does not stop with a yellow light and the crash occurs.

Discussion: Consideration is given to the legality of passing through or turning during a yellow light cycle according to local law. In this case the assumption is that it is legal to enter an intersection on a green light and then turn on a yellow light. Thus, the non-CMV has the right of way.
**Critical Event and Reason:** The critical event was committed by the CMV and the critical reason is assigned to the CMV “truck/bus driver.”

**Guideline:** If the light turns yellow for the non-CMV making the left turn, the light for the CMV coming from the opposite direction (going straight) would also be yellow. The critical reason is therefore coded to the CMV driver because the CMV must yield the right-of-way with a yellow caution light.

**Scenario 3:** A non-CMV is in an intersection waiting to turn left on a green light. The traffic light changes from yellow to red and this vehicle starts to turn left. A CMV from the opposite direction (going straight) does not stop with a red light and the crash occurs.

**Discussion:** Violation of a traffic control device is considered when assessing responsibility and assigning critical events and critical reasons.

**Critical Event and Reason:** The critical event was committed by the CMV and the critical reason is assigned to the CMV “truck/bus driver.”

**Guideline:** If the light turns red for the non-CMV making the left turn, the light for the CMV coming from the opposite direction going straight would also be red. When there is an indication that a CMV has violated a traffic control device, the critical reason is assigned to that CMV driver.

**Scenario 4:** A non-CMV is in an intersection turning left with unknown traffic controls. A CMV from the opposite direction (going straight) does not stop with unknown traffic controls and the crash occurs. Both drivers are claiming the right of way and the investigating officer cannot determine who had the right of way.

**Discussion:** When the PAR does not make a determination of which driver violated the traffic controls, the coder does not assign a critical event to either vehicle.

**Critical Event and Reason:** The critical reason is coded as “unable to assign critical reason.”

**Guideline:** When the evidence does not indicate that the CMV is responsible for the critical event, the CMV cannot be coded with the critical reason.

**Example 10. Intersection crash, intersecting straight paths**
**Figure A12. Intersection Crash, Intersecting Straight Paths**

**Scenario 1:** The CMV approaches the intersection when the light changes to red.

**Discussion:** The CMV driver does not stop in time and strikes the other vehicle.

**Critical Event and Reason:** The critical event was committed by the CMV and the critical reason is coded to the CMV “truck/bus driver.”

**Guideline:** The vehicle that violates the traffic control device (and thus does not have the right-of-way) makes the crash inevitable and is assigned the critical event.

**Scenario 2:** The two vehicles collide and both drivers claim they had a green light.

**Discussion:** If evidence does not indicate that the CMV was responsible for the critical event, the CMV driver cannot be assigned the critical reason.

**Critical Event and Reason:** The critical reason is coded as “unable to assign critical reason.”

**Guideline:** Since it is not known which vehicle had the right-of-way and no other information is available, the critical reason cannot be assigned.

**Example 11. Multiple CMVs involved in a crash**
**Scenario 1**: A CMV bus (V1) is in the number one lane and abruptly changes lanes to the left into the number two lane in front of a tractor-trailer (V2) and then immediately decelerates due to slower moving forward traffic.

**Discussion**: The tractor-trailer cannot stop and impacts the rear plane of the bus. A third vehicle, a straight truck (V3), was traveling behind the tractor-trailer in the number two lane and cannot stop in time and impacts the rear plane of the tractor-trailer.
Critical Event and Reason:

- Vehicle 1 – The critical event was committed by the bus and the driver of the bus is assigned the critical reason. The bus driver made an unsafe lane change and encroached into the path of the tractor-trailer making the crash inevitable.
- Vehicle 2 – The tractor semi-trailer is not responsible and is coded with the critical reason “not assigned to this driver/vehicle.” The action of the bus made the crash inevitable.
- Vehicle 3 – The driver of the straight truck is responsible for his/her actions. The driver was following too closely to respond to unexpected actions of the tractor-trailer. This vehicle is assigned a critical event and the critical reason is coded as “truck/bus driver.”

Guideline: Each CMV involved in a crash is assigned a critical event and critical reason. The bus made the first impact of the crash inevitable. The tractor semi-trailer was not responsible for the first impact or for being hit from behind. The straight truck was responsible for the second impact because it was following too close to the tractor-trailer.

Scenario 2: A CMV bus (V1) is stopped in the number two lane due to stopped forward traffic. Trailing behind the bus in the same travel lane and direction is a CMV tractor semi-trailer (V2) that decelerates and avoids striking the bus. Behind the tractor-trailer is a third vehicle, a CMV straight truck (V3), also in the number two lane.

Discussion: The third vehicle, straight truck, cannot stop in time and rear-ends the second vehicle, the tractor semi-trailer (Impact #1). The second vehicle is then pushed forward into the back of the bus (Impact #2). The investigating officer cited the second vehicle for inadequate stop lamp visibility. This information is part of the PAR.

Critical Event and Reason:

- Vehicle 1 – The driver of the bus was not responsible for the crash event. The bus was simply stopped in its travel lane due to congested forward traffic. This vehicle did not commit the critical event and is coded with the critical reason of “not assigned to this driver/vehicle.”
- Vehicle 2 – A critical event was committed by the tractor semi-trailer as a result of the mechanical defect. The critical reason is the faulty stop lamp. When the PAR indicates a CMV has a mechanical defect that made the crash inevitable, the critical event is assigned to the CMV. The critical reason is coded as “truck/bus vehicle.”
- Vehicle 3 – If it is decided that the straight truck hit Vehicle 2 because it was following too closely, a critical event was committed by the straight truck. The straight truck is given a critical event and the driver is coded with the critical reason of “truck/bus driver.” If it is decided that the straight truck failed to stop in time as a result of the faulty stop lamp on Vehicle 2, the straight truck would not be coded with a critical event and the critical reason “not assigned to this vehicle” would be coded to Vehicle 3.
**Guideline:** Critical events and reasons are assigned based on the driver and vehicle conditions and actions of each truck or bus involved in the crash.

*Figure A14. Multiple CMVs Involved in a Crash – Scenario 2*
Critical Reason Assignments in Common Crash Scenarios

The following examples demonstrate common crash scenarios found on the PARs and the resulting critical reason determinations.

Example 1. The CMV is the only vehicle involved in the crash.
   a. **Critical reason assigned to CMV driver or vehicle**
      o Driver actions or inactions led to crash
      o Failure or degraded vehicle component(s) led to the crash
   b. **Critical reason assigned to environment**
      o Sudden environmental condition
      o Sudden roadway issue

Example 2. The CMV changes direction that results in a crash.
   a. **Critical reason assigned to CMV driver or vehicle**
      o Turn across path at a junction in violation of a traffic control device
      o Wide right turns
      o Lane change maneuvers without having the right-of-way
   b. **Critical reason “Not assigned to this driver/vehicle”**
      o Turn in compliance with a traffic control device (e.g., turning with a green turn arrow, etc.)

Example 3. A lead vehicle is either in the process of stopping or is stopped.
   a. **Critical reason assigned to CMV driver or vehicle**
      o Striking the rear of a lead vehicle either in the process of stopping or is stopped
      o Striking the rear of other vehicles stopping for a lead vehicle
   b. **Critical reason “Not assigned to this driver/vehicle”**
      o CMV lead vehicle stopped and was struck in rear
      o CMV lead vehicle stopped, struck in rear, and subsequently pushed into another vehicle or object

Example 4. A trailer swing or jackknife occurs to the CMV.
   a. **Critical reason assigned to CMV driver or vehicle**
      o Results in a crash

   **Critical reason assigned to environment**
      o Sudden environmental condition

Example 5. Load shift of the CMV.
   a. **Critical reason assigned to CMV driver or vehicle**
      o Results in a crash

Example 6. Cargo spillage by the CMV.
   a. **Critical reason assigned to CMV driver or vehicle**
      o Results in a crash
Example 7. CMV mechanical problem.
   a. Critical reason assigned to CMV driver or vehicle
      o Tire failure
      o Steering failure
      o Brake failure
      o Degraded braking capability
      o Drive train failure
      o Trailer attachment failure
      o Other

Example 8. CMV disabled in the travel lane.
   a. Critical reason assigned to CMV driver or vehicle
      o Regardless of whether the driver turned on warning devices
   Critical reason assigned to environment
      o When vehicle is disabled due to sudden-onset weather or roadway condition

Example 9. CMV right-of-way violation.
   a. Critical reason assigned to CMV driver or vehicle
      o CMV violates a traffic control device
         • Runs a stop sign
         • Runs a signal light
      o CMV enters a traffic-way and fails to yield

Example 10. Ongoing environmental conditions.
   a. Critical reason assigned to CMV driver or vehicle
      o Ongoing rain
      o Ongoing snow
      o Ongoing sleet
      o Ongoing fog
      o Ongoing sun glare
      o Previous rock slide
   b. Critical reason assigned to environment
      o Sudden onset of rain
      o Sudden onset of snow
      o Sudden onset of sleet
      o Sudden onset of fog
      o Isolated patch of black ice
      o Sudden rock slide
      o Blowing debris
      o Wind gust
      o Sudden sun glare

Example 11. Ongoing highway conditions.
   a. Critical reason assigned to CMV driver or vehicle
      o Construction
o Deteriorated surface
o Low bridge with appropriate signage

b. Critical reason assigned to environment
   o Traffic control signs/signals: missing, erroneous, defective, inadequate
   o Low bridge without appropriate signage
   o Traffic control signs
   o Sudden roadway deterioration
      ▪ Sink hole
      ▪ Bridge collapse
      ▪ Washout
EXAMPLE PAR

The blue dots on the following image indicate relevant areas of interest for a PAR review:

[Image of the Georgia Uniform Motor Vehicle Accident Report form]

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**Note:** The image contains a form used by the Georgia Department of Transportation for recording motor vehicle accident information. The form includes fields for details such as accident number, date, time, road of occurrence, and various other details related to the accident and its circumstances. The form is designed to be filled out by law enforcement or accident investigation officers and includes sections for driver and vehicle information, as well as details about the accident scene and damages. The form is used to capture comprehensive data for insurance, legal, and statistical purposes. The blue dots indicate areas of interest for a PAR review, which likely refer to specific fields or sections that need to be reviewed for accuracy or completeness.
### Overlay

Georgia Department of Transportation  Version 2.0

**Back of the Accident Report Form**

The back of the report contains items for all vehicles. This is where the reporting officer records remarks, draws required diagrams, and records what may have contributed to the accident.

### Remarks

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<th>Remarks</th>
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### Indicate on this Diagram What Happened

- Number of Occupants
- Point of Initial Contact
- Damage to Vehicles

### Citations - Vehicle # 85

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<th>Location At Area Of Impact</th>
<th>Road Comp.</th>
<th>Road Def.</th>
<th>Road Obstr.</th>
<th>Construction/Maintenance Zone</th>
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### Citations - Vehicle # 101

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### Occupants: 103

| Last Name | First | Address | City | State | Zip | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
|-----------|-------|---------|------|-------|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|           |       |         |      |       |     |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

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A-39
Continuation Sheet

The continuation sheet (DOT 523C) is used when there is insufficient space on the DOT 523 for injuries, witnesses, and remarks or diagram.

The accident number, N.C.I.C. number, and the accident date must be included and appear the same as it does on the original report. A separate continuation should not be submitted unless it contains information.

<table>
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<th>Accident Date</th>
<th>Georgia Uniform Motor Vehicle Report Continuation</th>
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</table>

Injured Taken To: By:
Witness - Name Address:
Phone:

Additional Remarks:

Sample Continuation page
Figure B-1. Example PAR – Illegible with Missing Diagram

Figure B-2. Example PAR – Missing Motor Carrier Information
Figure B-1. Example PAR - Illegible with Missing Diagram
Figure B-1. Example PAR - Illegible with Missing Diagram (continued)
Figure B-1. Example PAR - Illegible with Missing Diagram (continued)
Figure B-1. Example PAR - Illegible with Missing Diagram (continued)
Figure B-1. Example PAR - illegible with Missing Diagram (continued)
**Figure B-2. Example PAR - Missing Motor Carrier Information**

- **Date of Crash:** 05/13/06
- **Time:** 14:20
- **Location:** Beaver Avenue and Highfields Road
- **Type of Accident:** Vehicle vs. Vehicle
- **Vehicle #1:**
  - Make: Chevrolet
  - Model: Monte
  - Year: 2002
  - License Plate: 08/2006
- **Vehicle #2:**
  - Make: Peterbilt
  - Model: 330
  - Year: 1997
  - License Plate: 03/2009

**Description:**

- **Vehicle #1** was traveling west on Beaver Avenue.
- **Vehicle #2** was traveling east on Beaver Avenue.
- **Vehicle #1** crossed over the double-yellow line and struck **Vehicle #2**.
- **Driver #1** was pronounced dead at the scene.
- **Driver #2** stated he began slowing down when he saw **Vehicle #1** cross the double-yellow line, stating he believed **Vehicle #1** was going to turn into a driveway. When **Vehicle #1** passed the driveway, **Driver #2** brought **Vehicle #2** to a complete stop prior to the impact.

**Note:** The diagram provided by Munster County P.A.C.T. Team is not to scale.
APPENDIX C  CRASH WEIGHTING BENEFITS: 
ANALYSIS APPROACH AND RESULTS 

This appendix provides additional analysis results and describes the technical details of the analysis approaches used to address the following questions: (1) Would crash weighting offer an even stronger predictor of crash risk than overall crash involvement; and (2) How might crash weighting be implemented in the Federal Motor Carrier Safety Administration’s (FMCSA) Safety Measurement System (SMS). These approaches are described below:

- The Wilcoxon-Mann-Whitney statistical test, which compares projected future crashes of carriers and drivers based on how their previous crashes have been weighted.
- A negative binomial regression model, which predicts future crashes of carriers and drivers based on weighting the previous crashes.
- Assessment of the safety benefits of various crash weighting approaches using the SMS Effectiveness Test (ET). (See Section 4 for a summary of this analysis and results.)

AVAILABLE DATA

For all analyses, FMCSA used motor carrier and driver crashes from the calendar year 2009 and 2010 “pre-period” to compare or predict future crashes in 2011 and 2012. The subset of crashes with crash weighting determinations from 2009-2010 included:

- Fatal crashes from 2009 to 2010 that Police Accident Report (PAR) reviewers assigned a critical reason. These crashes represented approximately 2 percent of the total crashes in the Motor Carrier Management Information System (MCMIS) and 75 percent of the fatal crashes in the MCMIS.

- Single-vehicle crashes from the MCMIS considered “attributable” to the motor carrier. 68 These crashes represented about 13 percent of the crashes in the MCMIS.

Together, these two groups of crashes accounted for 15 percent of the crashes in the MCMIS. Given the small percentage of total crashes with crash weighting determinations, the Agency performed all analyses both with all crashes and with just those carriers that had fatal crashes in the 2009-2010 pre-period. The fatal crash models were calculated to determine what happens when there are larger percentages of crashes with crash weighting determinations.

The study applied a number of screens to both carriers and drivers to ensure that there were no large changes in data relevant to the analysis and that the carrier or driver continued to operate in the “future crash” period:

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68 Single-vehicle crashes are defined when the field “number of vehicles involved in the crash” equaled one in the MCMIS database. This study considered a single-vehicle crash to be attributable to the CMV when the event code description did not indicate a collision with a pedestrian, a motor vehicle in transport, a train or pedalcycle, an animal, work zone maintenance equipment, other/unknown movable object, or “other.”
• **Screens for Carrier Data Set:** (1) Must have been under FMCSA jurisdiction in December 2010;\(^{69}\) (2) must have been domiciled in the United States; (3) must have had a crash in the pre-period (2009 or 2010); (4) must have had a crash or inspection in the post-period (2011 or 2012); (5) must have had positive average Power Units (PUs) in both the pre-and post-periods;\(^{70}\) (6) average PUs in the pre-period must have been less than twice as much and more than one-half as much as the post-period; and (7) the carrier had a reasonable crash-to-PU ratio in the pre-period.\(^{71}\)

• **Screens for Driver Data Set:** (1) Must have had a crash in the pre-period (2009 or 2010); (2) must have had five or more inspections in the post-period to ensure that drivers were actively on the road for a significant portion of the post-period (2011 or 2012); (3) must have had a valid driver’s license number; and (4) must have had a license from the United States or Canada.

All analysis in this study used crash rates for motor carriers and crash counts for drivers. These rates and counts are defined as follows:

• **Carrier Crash Rate:** Number of crashes the motor carrier has been involved in divided by the carrier’s average PUs multiplied by 100 (crashes per 100 PUs).

• **Carrier Adjusted Crash Rate:** A crash rate adjusted for high utilization (high Vehicle Miles Traveled (VMT) per PU). In each carrier segment,\(^{72}\) the crash rate denominator is increased for carriers with high utilization by multiplying the carriers’ average PUs by their Utilization Factor.\(^{73}\)

• **Driver Crash Count:** Number of crashes the driver has been involved in.

**COMPARING FUTURE CRASHES USING CRASH WEIGHTING**

**Model Selection**

The Wilcoxon-Mann-Whitney test is a widely used non-parametric test to determine if there are statistically significant differences between two independent groups. The test was selected because it is a simple, robust test that is very resilient to differences in data, including the characteristics of entities in a group, number of entities within a group, distribution (does not require normal distribution), and data type (only requires ordinal data). These traits are

---

\(^{69}\) Active interstate or intrastate hazardous materials carriers.

\(^{70}\) Derived by adding the motor carrier's current PUs, PUs 6 months ago, and PUs 18 months ago, and dividing by 3. Positive average PUs imply that the motor carrier had at least one PU during those three time periods.

\(^{71}\) “Reasonable” in this case means that either the carrier’s average PUs was higher than its crash count for the pre-period, or that the carrier had no more than 50 inspections for the pre-period (indicating that the carrier is small/inactive enough that it’s reasonable for them to have more crashes than PUs).

\(^{72}\) Carrier segment is defined in the SMS Methodology according to the carrier’s fleet mix (based on the ratio of straight and combination vehicles). Breaking out these two segments ensures that carriers with fundamentally different types of vehicles and operations are not compared with each other. See the SMS Methodology for more details [here.](http://csa.fmcsa.dot.gov/Documents/SMSMethodology.pdf)

\(^{73}\) See the SMS Methodology for more explanation of the Utilization Factor at [here.](http://csa.fmcsa.dot.gov/Documents/SMSMethodology.pdf)
particularly useful for the data set at hand, because crash counts and rates are not normally distributed and the groups of carriers and drivers analyzed are of varying size.

**Wilcoxon-Mann-Whitney Technical Details**

The Wilcoxon-Mann-Whitney test is conducted by taking two groups of numbers and ranking them all from smallest to largest. The sums of the ranks for each group are compared and a statistical test is performed to see whether the difference is significant or could reasonably be attributed to random variation. The test is calculated as:

Calculate the test statistic \( U \) as:

\[
U_1 = R_1 - \frac{n_1(n_1 - 1)}{2}
\]

Where:

- \( n_1 \) = the sample size for sample 1
- \( R_1 \) = the sum of the ranks in sample 1

For large samples, \( U \) is approximately normally distributed and the Z-statistic is calculated to determine the p-value.

\[
z = \frac{U - m_U}{\sigma_U}
\]

Where:

\[
m_U = \frac{n_1n_2}{2}
\]

And:

\[
\sigma_U = \sqrt{\frac{n_1n_2(n_1 + n_2 + 1)}{12}}
\]

For small samples, the \( U \) statistic is compared directly against a table of known critical values to get the significant level. All tests were calculated in the statistical software R, which applies corrections for continuity and ties that slightly alter the formula for standard deviation and resulting significance level.

---

74 “Significance” in this analysis is defined where the p-value is less than or equal to 0.05.
75 “Large” is generally considered to mean “greater than or equal to 20.”
Analysis Approach and Results

Approach

The FMCSA used the Wilcoxon-Mann-Whitney test to compare future crashes of carriers and drivers (crashes per PU for carriers and crash counts for drivers) for four mutually exclusive groups based on how and whether their previous crashes were weighted:

- **Assigned Crashes**: Carriers or drivers with at least one crash in the pre-period assigned to the commercial motor vehicle (CMV) and no “not assigned” crashes. (See below.) “Assigned crashes” include both fatal crashes for which the critical reason was assigned to the CMV and single-vehicle crashes considered to be attributable.

- **Not Assigned Crashes**: Carriers or drivers with at least one crash in the pre-period that was not assigned to the CMV and no “assigned crashes.” “Not assigned crashes” include fatal crashes for which the PAR reviewers did not assign the critical reason to the CMV.

- **Both Assigned and Not Assigned Crashes**: Carriers or drivers with both “assigned crashes” and “not assigned crashes” in the pre-period.

- **Neither Assigned nor Not Assigned Crashes**: Carriers or drivers with no weighted crashes in the pre-period.

Carriers or drivers in these groups may have had any number of crashes without an assignment.

The Agency ran the Wilcoxon-Mann-Whitney test several times to see if the results changed based on driver activity level (as measured by the driver’s number of inspections in 2011-2012), carrier size, or carrier segment. This appendix shows the results and significance levels for these analyses.

Analysis Results

Carrier Results – All Crashes (43,465 Carriers)

Table C1 shows the characteristics of the four groups of carriers used in this analysis.

---

76 Size groups are defined by the average number of PUs the carrier has: (1) more than 0 to 5, (2) more than 5 to 15, (3) more than 15 to 50, (4) more than 50 to 500, (5) more than 500.
Table C1. Characteristics of Grouped Carriers Using All Crashes

<table>
<thead>
<tr>
<th>Carrier Group</th>
<th>Number of Carriers</th>
<th>Number of Future Crashes</th>
<th>PUs</th>
<th>Average PUs of Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned</td>
<td>10,606</td>
<td>37,449</td>
<td>712,627</td>
<td>67.19</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>1,033</td>
<td>1,951</td>
<td>37,481</td>
<td>36.28</td>
</tr>
<tr>
<td>Both</td>
<td>783</td>
<td>38,693</td>
<td>755,895</td>
<td>965.38</td>
</tr>
<tr>
<td>Neither</td>
<td>31,043</td>
<td>30,731</td>
<td>649,744</td>
<td>20.93</td>
</tr>
<tr>
<td>Total</td>
<td>43,465</td>
<td>108,824</td>
<td>2,155,746</td>
<td>49.60</td>
</tr>
</tbody>
</table>

As shown in this summary table, the “both” group has the fewest carriers (783), and includes much larger carriers. The “neither” group has the most carriers, followed by the “assigned” and “not assigned” groups. These differences are to be expected, since any carrier in the “both” group must have had at least two crash involvements in the pre-period, while carriers in the “assigned,” “not assigned,” and “neither” groups may have had as little as one crash. The Wilcoxon-Mann-Whitney test is designed to accommodate variation in the size (number of carriers in the group) and shape of the distributions under consideration, so all carrier groups were included in the analysis. Although crash and PU totals are provided for each group in the table, the Wilcoxon-Mann-Whitney test does not use these totals, but the individual crash rates of the carriers within the groups.

The Wilcoxon-Mann-Whitney test was run to compare the future crash rates of two of the groups; the group with higher future crash rates was determined by comparing the U statistics. The significance level of the statistic is also provided by the test; differences between groups were deemed significant for p-values less than or equal to 0.05. In the results tables below, the p-value is bolded in cases where the p-value is small enough to indicate significance.

Table C2 describes the Wilcoxon-Mann-Whitney results when the four groups of carriers defined above are compared to one another without breaking out the carrier groups by segment or size.
Table C2. Carrier Model, All Crashes Included (43,465 Carriers)

<table>
<thead>
<tr>
<th>Carrier Group with Higher Crash Rates</th>
<th>Carrier Group with Lower Crash Rates</th>
<th>Significance Level of the Difference Between the Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both</td>
<td>Assigned</td>
<td>&lt; 2.2E-16</td>
</tr>
<tr>
<td>Both</td>
<td>Not Assigned</td>
<td>&lt; 2.2E-16</td>
</tr>
<tr>
<td>Both</td>
<td>Neither</td>
<td>&lt; 2.2E-16</td>
</tr>
<tr>
<td>Assigned</td>
<td>Not Assigned</td>
<td>1.65E-06</td>
</tr>
<tr>
<td>Assigned</td>
<td>Neither</td>
<td>&lt; 2.2E-16</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>Neither</td>
<td>7.60E-06</td>
</tr>
</tbody>
</table>

When carriers were stratified by size, again there were fewer significant differences for some groups (described below), but the ordering of groups was generally the same as in the non-stratified analysis:

- **Carriers with more than 0 and up to 5 Average PUs**: The “assigned” group had higher future crash rates than the “not assigned” and “neither” groups.

- **Carriers with more than 5 and up to 15 Average PUs**: The “assigned” group had higher future crash rates than the “neither” group.

- **Carriers with more than 15 and up to 50 Average PUs**: All results were significant and the order of carrier groups remained the same.

- **Carriers with more than 50 and up to 500 Average PUs**: All results were significant and the order of carrier groups remained the same.

- **Carriers with more than 500 Average PUs**: Carriers in the “both” group had higher future crash rates than carriers in the “not assigned” group and the “neither” group, and carriers in the “assigned” group had higher future crash rates than carriers in the “both” and “neither” groups.

When carriers were stratified by segment—straight and combination—the results were very similar to the non-stratified analysis, but there were fewer significant differences for the straight segment:

- **Combination Carriers**: All results were significant and the ordering of carrier groups by future crash rate remained the same.
• **Straight Carriers**: The “both” group had higher future adjusted crash rates than all three other groups, and the “assigned” group had higher adjusted crash rates than the “neither” group, but there were no other significant differences.

Note that when carriers are stratified by segment, crash rates are calculated using adjusted PUs.\(^7\)

When carriers were stratified by both size and segment, there were fewer significant results, likely due to the number of carriers in each group. However, one statistically significant result differed from the non-stratified results: For straight carriers with more than 500 adjusted PUs, the “neither” group had higher future crash rates than the “not assigned” group, with a p-value of 4.87E-8.

**Carrier Results – Fatal Crashes (3,071 Carriers)**

Table C3 shows the characteristics of the four groups of carriers involved in at least one fatal crash in the pre-period.

<table>
<thead>
<tr>
<th>Carrier Group</th>
<th>Number of Carriers</th>
<th>Number of Future Crashes</th>
<th>PUs</th>
<th>Average PUs of Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned*</td>
<td>824</td>
<td>6,433</td>
<td>114,651</td>
<td>139.14</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>1,619</td>
<td>14,430</td>
<td>257,548</td>
<td>159.08</td>
</tr>
<tr>
<td>Both</td>
<td>187</td>
<td>26,009</td>
<td>533,445</td>
<td>2,852.65</td>
</tr>
<tr>
<td>Neither</td>
<td>441</td>
<td>3,997</td>
<td>107,364</td>
<td>243.46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,071</strong></td>
<td><strong>50,869</strong></td>
<td><strong>1,013,008</strong></td>
<td><strong>329.86</strong></td>
</tr>
</tbody>
</table>

*Does not include single-vehicle attributable crashes, because this analysis was restricted to grouping carriers using only the PAR coding method of assignment.

The table shows that, similar to the all-crash model, the “both” group in the fatal crash model has the fewest carriers (187) and includes much larger carriers. The “not assigned” group has the most carriers, followed by the “assigned” and “neither” groups. Because this analysis uses only fatal crashes to determine the carrier groups, the number in the “not assigned” group increases, since carriers in the “both” group moved to this group if their “assigned” crash was an attributable single-vehicle crash (not included in this analysis).

Table C4 describes the Wilcoxon-Mann-Whitney results for the four groups of carriers based on fatal crashes.

---

\(^7\) Adjusted PUs = average PUs × Utilization Factor.
Table C4. Carrier Model, Fatal Crashes Only (3,071 Carriers)

<table>
<thead>
<tr>
<th>Carrier Group with Higher Crash Rates</th>
<th>Carrier Group with Lower Crash Rates</th>
<th>Significance Level of the Difference Between the Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both</td>
<td>Not Assigned</td>
<td>1.24E-07</td>
</tr>
<tr>
<td>Both</td>
<td>Assigned</td>
<td>2.03E-07</td>
</tr>
<tr>
<td>Both</td>
<td>Neither</td>
<td>2.81E-09</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>Assigned</td>
<td>0.79490</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>Neither</td>
<td>0.10990</td>
</tr>
<tr>
<td>Assigned</td>
<td>Neither</td>
<td>0.20930</td>
</tr>
</tbody>
</table>

For the carrier fatal crash analysis, the carrier groups were restricted to those carriers that had a fatal crash in 2009-2010. The goal was to approximate what the analysis and crash rate results might look like if all PARs were coded. Thus, crashes where PARs were not available were not used for grouping the carriers. When the same stratifications by carrier size and segment, as described above, were applied, the only significant result was that carriers with both assigned and not assigned crashes had higher future crash rates than carriers in the “assigned,” “not assigned,” and “neither” groups. The lack of any other significant differences likely reflects the small size of the carrier groups resulting from the fatal crash data set.

Driver Results – All Crashes (24,781 Drivers)

The FMCSA performed similar analyses for drivers, by comparing across driver groups the number of crashes in the post-period. Table C5 shows the characteristics of these driver groups.

Table C5. Characteristics of Grouped Drivers Using All Crashes

<table>
<thead>
<tr>
<th>Driver Group</th>
<th>Number of Drivers</th>
<th>Number of Future Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned</td>
<td>4,158</td>
<td>658</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>412</td>
<td>39</td>
</tr>
<tr>
<td>Both</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Neither</td>
<td>20,204</td>
<td>2,685</td>
</tr>
<tr>
<td>Total</td>
<td>24,781</td>
<td>3,382</td>
</tr>
</tbody>
</table>
As shown, the “neither” group has the largest number of drivers, followed by the “assigned” and “not assigned” groups. The “both” group has very few drivers.

Table C6 displays results for drivers who had five or more inspections in the post-period. The results were functionally identical\textsuperscript{78} when the test was conducted on drivers with varying levels of inspections in the post-period.

**Table C6. Driver Model, All Crashes Included (24,781 Drivers)**

<table>
<thead>
<tr>
<th>Driver Group with Higher Crash Counts</th>
<th>Driver Group with Lower Crash Counts</th>
<th>Significance Level of the Difference Between the Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assigned</td>
<td>Both</td>
<td>0.997100</td>
</tr>
<tr>
<td>Assigned</td>
<td>Neither</td>
<td>0.009022</td>
</tr>
<tr>
<td>Assigned</td>
<td>Not Assigned</td>
<td>0.000001</td>
</tr>
<tr>
<td>Both</td>
<td>Neither</td>
<td>0.933500</td>
</tr>
<tr>
<td>Both</td>
<td>Not Assigned</td>
<td>0.605400</td>
</tr>
<tr>
<td>Neither</td>
<td>Not Assigned</td>
<td>0.000029</td>
</tr>
</tbody>
</table>

The significant results are that the “assigned” group had a higher future crash count than the “not assigned” group or the “neither” group, and that the “not assigned” group had a higher future crash count than the “neither” group. There were no significant differences between the “both” group and any other group of drivers, probably because there were only seven drivers who had both an “assigned” and a “not assigned” crash in the pre-period.

**Driver Results – Fatal Crashes (609 Drivers)**

Table C7 displays the results for drivers who had a fatal crash and had five or more inspections in the post-period. The “both” group contained no drivers, so it was not used.

**Table C7. Driver Model, Fatal Crashes Only (609 Drivers)**

<table>
<thead>
<tr>
<th>Driver Group with Higher Crash Counts</th>
<th>Driver Group with Lower Crash Counts</th>
<th>Significance Level of the Difference Between the Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Assigned</td>
<td>Neither</td>
<td>0.886400</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>Assigned</td>
<td>0.833900</td>
</tr>
<tr>
<td>Neither</td>
<td>Assigned</td>
<td>0.959500</td>
</tr>
</tbody>
</table>

\textsuperscript{78} For tests where the result was significant, the ordering of groups was the same as in the analysis shown.
The test derived no statistically significant results for the comparison of future crash count distributions among any driver groups. This is likely due to the small numbers of drivers and future crashes used.

PREDICTING FUTURE CRASHES USING CRASH WEIGHTING

Model Selection

The negative binomial model is a predictive regression model that is commonly used in crash analysis because it has an additional parameter to correct for over-dispersed data. The data for both carriers and drivers for the all crash analysis is over-dispersed, as is the data for the carrier fatal crash analysis; the driver fatal crash data is not over-dispersed, and may have been better examined with a simple Poisson Regression Model. It is unlikely that this would have produced significant results, given the small size of the data set available. The regression model allows the user to predict future crashes or crash rates for an entity based on prior characteristics. In this case, different characteristics of prior crash involvement are used to predict future crash rates for carriers (using average PUs as the exposure factor) and crash counts for drivers.

Negative Binomial Technical Details

The negative binomial model is a specific sub-case of a Poisson Regression Model, with an additional over-dispersion parameter. The counts model assigns the dependent variable a Poisson distribution. In this context, the model calculates the probability of a given number of “successes” as a function of the dependent variables. Successes are defined as future crash rates for this analysis.

The negative binomial distribution is presented below.

\[
P(X = r) = n^{-1}C_{r-1} p^r (1-p)^{n-r}
\]

Where:

\[
n = \text{Number of events.}
\]
\[
r = \text{Number of successful events.}
\]
\[
p = \text{Probability of success on a single trial.}
\]

\[
n^{-1}C_{r-1} = \{ (n-1)! / [(n-1)-(r-1)]! \} / (r-1)!
\]

The negative binomial model results indicate which models are statistically significant with a p-value below .05. Then the models can be compared to each other using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The closer each statistic is to zero, the stronger the model. The AIC and BIC are each calculated via the formula:

---

79 Data is over-dispersed when the variance is larger than the mean, which is a common occurrence with crash data.
-2 * log(L) + k*p

Where:

L = Likelihood function.

p = Number of parameters in the model.

k = Penalty coefficient (k = 2 under AIC, and k = log(n) under BIC).

The penalty coefficient prevents the inclusion of weakly predictive variables by providing a net increase in the criterion. The formula exp((AIC_i − AIC_j)/2) provides the relative likelihood that model j is a better fit than model i. Thus, to achieve a standard significance of .05, a difference in AIC values of at least 6 is desirable to say that one model is better than another: exp((-6)/2) = .0498. This assessment should still be weighed against the possibility of over-fitting, which is why this analysis required the BIC to also show an improved model. A variable that reduces both the AIC and BIC when included is considered a net improvement to the model.

Analysis Approach and Results

Approach

This study used the negative binomial regression model to determine which of four categories of pre-period (calendar years 2009 and 2010) crashes was the best predictor of future crashes. These categories were tested as individual predictors and combinations of predictors for future crash rates.

- **All Crashes**: All reportable crashes.

- **Single-Vehicle Attributable Crashes**: Single-vehicle crashes considered to be attributable to the CMV.

- **Coded Assigned Crashes**: Crashes for which the PAR reviewers assigned a critical reason to the CMV.

- **Not Assigned Crashes**: Crashes reviewed but not assigned to the CMV.

The analysis was performed by taking individual carrier records or driver records and analyzing their future crash rate or crash count, respectively, based on their prior crash rate or count for the above combinations. All analysis was calculated via the STATA 10 statistical package.

Analysis Results

Carrier Results – All Crashes (43,465 Carriers)

Table C8 shows each combination of variables used to predict the carrier’s future crash rate. Each row represents one model, where if a variable is named in a column that variable is included in that model. The next two columns present the AIC and BIC, where the smaller
numbers indicate a stronger model. The last column indicates if the model was statistically significant.

### Table C8. Carrier Model, All Crashes Included (43,465 Carriers)

<table>
<thead>
<tr>
<th>Pre Period Crash Rate Variables</th>
<th>Criteria</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All Crash Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-Vehicle (SV) Attributable Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coded Assigned Crash Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Assigned Crash Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistically Significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Crashes</td>
<td>118,753</td>
<td>118,779</td>
</tr>
<tr>
<td>SV Attributable</td>
<td>118,738</td>
<td>118,773</td>
</tr>
<tr>
<td>Assigned</td>
<td>118,740</td>
<td>118,783</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>118,733</td>
<td>118,785</td>
</tr>
<tr>
<td>SV Attributable</td>
<td>120,963</td>
<td>120,989</td>
</tr>
<tr>
<td>Assigned</td>
<td>121,510</td>
<td>121,536</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>121,578</td>
<td>121,604</td>
</tr>
</tbody>
</table>

In this carrier model, neither “assigned” nor “not assigned” crash rates were statistically significant predictors of future crash rates. The “single-vehicle attributable” crash rate was a statistically significant predictor, but had moderately higher AIC and BIC values than other significant models, indicating that it was not as strong as other predictors. The combination of all crash data with “single-vehicle attributable” crash data produced a stronger model than only using all crash data. All of the remaining models were comparable predictors of future crash rates, as evidenced by their similar AIC and BIC values.

These analyses were also performed on the combination and straight carrier segments individually. Note that when carriers are stratified by segment, crash rates are calculated using adjusted PUs. The results from each of these tests were comparable to the all-crash model, and are available upon request.
Carrier Results – Fatal Crashes (3,071 Carriers)

Table C9 shows the combination of pre-period fatal crash rates that are used to predict future crash involvement. The study did not include single-vehicle attributable crashes in this analysis.81

Table C9. Carrier Model, Fatal Crashes Only (3,071 Carriers)

<table>
<thead>
<tr>
<th>Pre-Period Crash Rate Variables</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AIC</td>
</tr>
<tr>
<td>Fatal Crash Rate</td>
<td>14,716</td>
</tr>
<tr>
<td>Fatal Crashes Assigned</td>
<td>14,718</td>
</tr>
<tr>
<td>Fatal Crashes Assigned Not Assigned</td>
<td>14,719</td>
</tr>
<tr>
<td>Assigned</td>
<td>14,819</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>14,860</td>
</tr>
</tbody>
</table>

The “not assigned” crash rate was the only non-statistically significant variable. This suggests that “not assigned” crashes are not as strong a predictor of future crashes as the other variables. The other combinations of variables are statistically significant, with the “assigned” crashes having the highest AIC/BIC, indicating that it is not as strong as the other models.

Driver Results – All Crashes (40,720 Drivers)

Table C10 presents the types of crashes included as variables in each model, the assessment criteria (AIC/BIC), and statistical significance used to predict drivers’ future crash involvement.

81 There are very few cases in which a fatal single-vehicle attributable crash would not have a critical reason coded.
Table C10. Driver Model, All Crashes Included (40,720 Drivers)

<table>
<thead>
<tr>
<th>Pre-Period Crash Data Variables</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All Crash Count</strong></td>
<td><strong>Single-Vehicle (SV) Attributable Count</strong></td>
</tr>
<tr>
<td>Crashes</td>
<td>31,933</td>
</tr>
<tr>
<td>Crashes SV Attributable</td>
<td>31,911</td>
</tr>
<tr>
<td>Crashes SV Attributable Coded Assigned</td>
<td>31,913</td>
</tr>
<tr>
<td>Crashes Not Assigned</td>
<td>31,930</td>
</tr>
<tr>
<td>Crashes SV Attributable Not Assigned</td>
<td>31,909</td>
</tr>
<tr>
<td>SV Attributable</td>
<td>31,942</td>
</tr>
<tr>
<td>Coded Assigned</td>
<td>31,973</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>31,969</td>
</tr>
</tbody>
</table>

Neither “coded assigned” crashes nor “not assigned” crashes were statistically significant predictors of future crashes. The remaining models have similar AIC and BIC values, suggesting that they are comparable predictors of future crashes, though the models that include both “single-vehicle attributable” crashes and total crashes appear to be stronger than models that do not include one of those variables.

**Driver Results – Fatal Crashes (977 Drivers)**

Table C11 shows the combination of pre-period fatal crashes used to predict a driver’s future crash involvement. The study did not include single-vehicle attributable crashes in this analysis.  

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82 There are very few cases in which a fatal single-vehicle attributable crash would not have a critical reason coded in the FARS.
Table C11. Driver Model, Fatal Crashes Only (977 Drivers)

<table>
<thead>
<tr>
<th>Pre-Period Crash Data Variables</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal Crash Count</td>
<td></td>
</tr>
<tr>
<td>Coded Assigned Count</td>
<td></td>
</tr>
<tr>
<td>Not Assigned Count</td>
<td>AIC</td>
</tr>
<tr>
<td></td>
<td>BIC</td>
</tr>
<tr>
<td></td>
<td>Statistically Significant?</td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td>1,171</td>
</tr>
<tr>
<td>Coded Assigned</td>
<td>1,186</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td>1,149</td>
</tr>
<tr>
<td>Coded Assigned</td>
<td>1,168</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td>1,093</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>1,112</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td>1,030</td>
</tr>
<tr>
<td>Coded Assigned</td>
<td>1,055</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Coded Assigned</td>
<td>1,147</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>1,162</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1,091</td>
</tr>
<tr>
<td>Not Assigned</td>
<td>1,105</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

No variables from this test were statistically significant predictors, likely due to the small sample of drivers with fatal crashes that met the data screens.

IMPLEMENTING CRASH WEIGHTING IN THE SMS

Model Selection

The SMS ET was developed to evaluate the effectiveness of the SMS, especially with respect to the motor carriers that are being identified as exceeding the Intervention Threshold. Motor carriers that exceed the Intervention Threshold are prioritized by FMCSA to receive interventions. The SMS ET can be applied to all of the Behavior Analysis and Safety Improvement Categories (BASICs), but this analysis focuses on modifying the weights in the Crash Indicator to see if applying different weights for assigned and not assigned crashes produces a more effective SMS. (A summary of the analysis and results are in Section 4.)

SMS ET Technical Details

The SMS ET uses historical data to examine the future adjusted crash rate of the population of motor carriers with a Crash Indicator BASIC above the Intervention Threshold. The test was accomplished by:

1. Defining the ET carrier population. To be included in the ET, carriers must (a) demonstrate some level of activity in both the 24-month SMS time period and the 18-month “post-
identification crash period,” as many of the carriers in the MCMIS no longer operate; and (b) provide reasonable exposure data, as carriers often self-report PUs and VMT, which are therefore subject to error. Approximately 278,000 motor carriers pass these screening criteria, and are included in the ET.

Performing a simulated SMS identification run that calculates carrier percentile ranks for each BASIC as of January 2011 using historical data from calendar years 2009 and 2010. This time period was used to allow sufficient time (18 months) for the “post-identification crash period” to calculate future adjusted crash rates, as well as extra time to allow for the time lag in crash reporting.

Observing each carrier’s crash involvement over the 18-month period immediately following the simulated SMS timeframe (i.e., the post-identification crash period, January 2011 to June 2012).

Depicting the relationship between the percentile ranks (from 0 to 100) in the Crash Indicator and subsequent post-SMS carrier crash involvement. A timeline of the ET is presented in Figure C1.

![Figure C1. SMS ET Timeline](image)

The SMS ET compares the future adjusted crash rate of those carriers exceeding the Intervention Threshold in the Crash Indicator under various weighting schemes. All weighting schemes are compared to the baseline, which is the current SMS Crash Indicator. (A weighting scheme that would improve the model would identify carriers with higher future adjusted crash rates.)

**Analysis Approach and Results**

The analysis results presented in this section include those described in Section 4 as well as five additional models.

Table C12 describes the severity weight changes to the current SMS Crash Indicator. The SMS ET results presented in Section 4 of this report are marked with an asterisk (*). Each model or set

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83 The Intervention Threshold for the Crash Indicator is 65 for general freight carriers, 60 for placardable hazardous materials carriers, and 50 for passenger carriers.

84 At the time of this study, SMS Methodology Version 3.0. CSMS Methodology Version 3.0: [http://csa.fmcsa.dot.gov/Documents/SMSMethodology.pdf](http://csa.fmcsa.dot.gov/Documents/SMSMethodology.pdf)
of models is intended to investigate a question about the predictive strength of “assigned” and “not assigned” crashes. “Assigned crashes” here include single-vehicle attributable crashes as well as coded fatal crashes assigned to the CMV, as in the Wilcoxon-Mann-Whitney comparative analysis.

Table C12. SMS ET Runs with Variety of Severity Weights

<table>
<thead>
<tr>
<th>Model</th>
<th>Assigned Crash Weight</th>
<th>Not Assigned Crash Weight</th>
<th>Model Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0*</td>
<td>-</td>
<td>-</td>
<td>Baseline</td>
</tr>
<tr>
<td>1*</td>
<td>+3</td>
<td>-0.5</td>
<td>Medium weight for “assigned crashes,” decreased weight for “not assigned crashes”</td>
</tr>
<tr>
<td>2</td>
<td>+6</td>
<td>-0.5</td>
<td>High weight for “assigned crashes,” decreased weight for “not assigned crashes”</td>
</tr>
<tr>
<td>3</td>
<td>+4</td>
<td>+2</td>
<td>Increased weight for “assigned” and “not assigned crashes”</td>
</tr>
<tr>
<td>4</td>
<td>-0.5</td>
<td>-0.5</td>
<td>Decreased weight for “assigned” and “not assigned crashes”</td>
</tr>
<tr>
<td>5</td>
<td>+1</td>
<td>Not Included</td>
<td>Remove “not assigned crashes,” do not include severity weight for fatal/injury and HM spill crashes</td>
</tr>
<tr>
<td>6*</td>
<td>+1</td>
<td>Not Included</td>
<td>Remove “not assigned crashes,” add additional weight for “assigned crashes”</td>
</tr>
<tr>
<td>7</td>
<td>+5</td>
<td>Not Included</td>
<td>Remove “not assigned crashes,” add high additional weight for “assigned crashes”</td>
</tr>
</tbody>
</table>

* Included in Section 4 of this report.

Models 1 and 2 were selected to determine the change in adjusted crash rate if “assigned crashes” receive a higher weight, undetermined crashes are weighted in the middle, and “not assigned crashes” have the lowest weight.

Models 3 and 4 test the assumptions that “assigned crashes” should be weighted more heavily than “not assigned crashes.”

Models 5, 6, and 7 explore scenarios where “not assigned crashes” are removed altogether, and then various weights for “assigned crashes” are explored.

Table C13 presents the future adjusted crash rates of carriers (by segment) that are above the Intervention Threshold under each of the tested models. Adjusted crash rates were calculated under two scenarios: An all-crash model that replicates the SMS as currently constructed, and a
fatal crash model that only includes fatal crashes. The shaded boxes indicate where the future adjusted crash rate is larger than the baseline.

Table C13. SMS ET Run Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Future Crash Rate of Carriers per 100 Adjusted PU above Intervention Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All Crash Model</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Straight</td>
</tr>
<tr>
<td>0*</td>
<td>(Baseline) Baseline</td>
<td>2.99</td>
</tr>
<tr>
<td>1*</td>
<td>Medium weight for “assigned crashes,” decreased weight for “not assigned crashes”</td>
<td>3.01</td>
</tr>
<tr>
<td>2</td>
<td>High weight for “assigned crashes,” decreased weight for “not assigned crashes”</td>
<td>2.99</td>
</tr>
<tr>
<td>3</td>
<td>Increased weight for “assigned” and “not assigned crashes”</td>
<td>2.73</td>
</tr>
<tr>
<td>4</td>
<td>Decreased weight for “assigned” and “not assigned crashes”</td>
<td>3.04</td>
</tr>
<tr>
<td>5</td>
<td>Remove “not assigned crashes,” do not include severity weight for fatal/injury and HM spill crashes</td>
<td>2.83</td>
</tr>
<tr>
<td>6*</td>
<td>Remove “not assigned crashes,” add additional weight for “assigned crashes”</td>
<td>2.95</td>
</tr>
<tr>
<td>7</td>
<td>Remove “not assigned crashes,” add high additional weight for “assigned crashes”</td>
<td>2.89</td>
</tr>
</tbody>
</table>

*Included in Section 4 of this report.

The all-crash model included approximately 1,500 carriers in the straight segment and 3,000 carriers in the combination segment above the threshold. The fatal crash model included approximately 150 carriers in the straight segment and 300 carriers in the combination segment above the Intervention Threshold.
The all-crash model showed that no combination of crash weights provides a strictly higher adjusted crash rate (for both the straight and combination carrier segments). The small sample size of coded and single-vehicle crashes likely plays a role in these results.

Under the fatal crash model, models 5, 6, and 7 all provide higher future adjusted crash rates than the baseline. This suggests that models incorporating crash weighting may have the potential to increase the effectiveness of the Crash Indicator; however, given the small numbers of carriers and the concentration on fatal crashes, this result is inconclusive.
This appendix describes the calculation of carrier measures and percentile ranks for the Crash Indicator, one of the seven Behavior Analysis and Safety Improvement Categories (BASICS) of the Federal Motor Carrier Safety Administration’s (FMCSA) Safety Measurement System. The Crash Indicator is defined as:

Histories or patterns of high crash involvement, including frequency and severity, based on information from State-reported crash reports.

The crash history used by the Crash Indicator is not specifically a behavior; rather, it is the consequence of behavior and may indicate a problem that warrants attention.

The Carrier Safety Measurement System (CSMS) assesses the Crash Indicator using relevant State-reported crash data reported in the Motor Carrier Management Information System (MCMIS). Individual carriers’ Crash Indicator measures also incorporate carrier size in terms of Power Units (PU) and annual Vehicle Miles Traveled (VMT). These measures are used to generate percentile ranks that reflect each carrier’s safety posture relative to carriers in the same segment with similar numbers of crashes.

**CALCULATION OF CRASH INDICATOR MEASURE**

The Crash Indicator measure is calculated as the sum of severity and time-weighted crashes divided by carrier average PUs multiplied by a Utilization Factor, as follows:

\[
\text{Crash Indicator Measure} = \frac{\text{Total of time and severity weighted applicable crashes}}{\text{Average PUs x Utilization Factor}}
\]

In this equation, the terms are defined as follows:

**Applicable Crash.** An applicable crash is a State-reported crash that meets the reportable crash standard during the past 24 months. A reportable crash is one that results in at least one fatality, at least one injury where the injured person is taken to a medical facility for immediate medical attention, or at least one vehicle towed from the scene as a result of disabling damage caused by the crash (i.e., tow-away).

**Crash Severity Weight.** A crash severity weight places more weight on crashes with more severe consequences. For example, a crash involving an injury or fatality is weighted more heavily than a crash where only a tow-away occurred. A hazardous materials (HM) release also increases the weight of a crash, as shown in Table D1.

---

Table D1. Crash Severity Weights for Crash Indicator

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Crash Severity Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involves tow-away but no injury or fatality</td>
<td>1</td>
</tr>
<tr>
<td>Involves injury or fatality</td>
<td>2</td>
</tr>
<tr>
<td>Involves an HM release</td>
<td>Crash Severity Weight (from above) + 1</td>
</tr>
</tbody>
</table>

**Time Weight.** A time weight of 1, 2, or 3 is assigned to each applicable crash based on the time elapsed since the crash occurred. This time-weighting places more emphasis on recent crashes relative to older crashes. Crashes that occurred within six months of the measurement date receive a time weight of 3. Crashes that occurred more than six months after and up to 12 months before the measurement date receive a time weight of 2. All crashes that happened later (more than 12 months but within the past 24 months of the measurement date) receive a time weight of 1.

**Time- and Severity-Weighted Crash.** A time and severity-weighted crash is a crash’s severity weight multiplied by its time weight.

**Average PUs.** PUs are used in part to account for each carrier’s level of exposure when calculating the BASIC measure. A carrier’s total number of PUs is calculated using the numbers of owned, term-leased, and trip-leased PUs (trucks, tractors, hazardous material tank trucks, motor coaches, and school buses) contained in the MCMIS Census data. The average PUs for each carrier is calculated using (1) the carrier’s current total PUs, (2) the total PUs the carrier had six months ago, and (3) the total PUs the carrier had 18 months ago. The average PU calculation is shown below:

$$AveragePU = \frac{PU_{Current} + PU_{6Months} + PU_{18Months}}{3}$$

**Utilization Factor.** The Utilization Factor is a multiplier that adjusts the average PU values based on the utilization in terms of VMT per average PU where VMT data in the past 24 months are available. The primary sources of VMT information in the Census are: (1) Form MCS-150, filled out by the carrier, and (2) Form MCS-151, filled out by law enforcement as part of an investigation. Carriers are required to update their MCS-150 information biennially. In cases where the VMT data has been obtained multiple times over the past 24 months for the same carrier, the most current positive VMT figure is used. The Utilization Factor is calculated from the following three steps:
1. Carrier Segment. Each motor carrier is placed into one of two segments:

   Combination Segment: Combination trucks/motor coach buses constitute 70 percent or more of the total PU.

   Straight Segment: Straight trucks/other vehicles constitute more than 30 percent of the total PU.

2. VMT per Average PU. The VMT per average PU is derived by taking the most recent positive VMT data and dividing it by the average PUs (defined above).

3. Utilization Factor. Given the information from steps 1 and 2 above, the Utilization Factor is determined from Table D2 and Table D3.

   **Table D2. Utilization Factors for Combination Segment**

<table>
<thead>
<tr>
<th>VMT per Average PU</th>
<th>Utilization Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 80,000</td>
<td>1</td>
</tr>
<tr>
<td>80,000 - 160,000</td>
<td>1 + 0.6[(VMT per PU - 80,000) / 80,000]</td>
</tr>
<tr>
<td>160,000 - 200,000</td>
<td>1.6</td>
</tr>
<tr>
<td>&gt; 200,000</td>
<td>1</td>
</tr>
<tr>
<td>No Recent VMT Information</td>
<td>1</td>
</tr>
</tbody>
</table>

   **Table D3. Utilization Factors for Straight Segment**

<table>
<thead>
<tr>
<th>VMT per Average PU</th>
<th>Utilization Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20,000</td>
<td>1</td>
</tr>
<tr>
<td>20,000 - 60,000</td>
<td>VMT per PU / 20,000</td>
</tr>
<tr>
<td>60,000 - 200,000</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 200,000</td>
<td>1</td>
</tr>
<tr>
<td>No Recent VMT Information</td>
<td>1</td>
</tr>
</tbody>
</table>
CALCULATION OF CRASH INDICATOR PERCENTILE RANK

Based on the Crash Indicator measures, the CSMS applies data sufficiency standards and safety event groupings to assign a percentile rank to carriers. A carrier’s percentile rank may prompt an intervention. The calculation is as follows:

1. Carrier Segment. Determine the carrier’s segment:
   - Combination Segment: Combination trucks/motor coach buses constitute 70 percent or more of the total PU.
   - Straight Segment: Straight trucks/other vehicles constitute more than 30 percent of the total PU.

2. Safety Event Group. For carriers with two or more applicable crashes, place each carrier into one of ten groups based on carrier segment and number of crashes, as shown in Table C4 and Table C5.

   **Table D4. Safety Event Groups for Crash Indicator: Combination Segment**
   
<table>
<thead>
<tr>
<th>Safety Event Group</th>
<th>Number of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>2-3</td>
</tr>
<tr>
<td>Combination 2</td>
<td>4-6</td>
</tr>
<tr>
<td>Combination 3</td>
<td>7-16</td>
</tr>
<tr>
<td>Combination 4</td>
<td>17-45</td>
</tr>
<tr>
<td>Combination 5</td>
<td>46+</td>
</tr>
</tbody>
</table>

   **Table D5. Safety Event Groups for Crash Indicator: Straight Segment**

<table>
<thead>
<tr>
<th>Safety Event Group</th>
<th>Number of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight 1</td>
<td>2</td>
</tr>
<tr>
<td>Straight 2</td>
<td>3-4</td>
</tr>
<tr>
<td>Straight 3</td>
<td>5-8</td>
</tr>
<tr>
<td>Straight 4</td>
<td>9-26</td>
</tr>
<tr>
<td>Straight 5</td>
<td>27+</td>
</tr>
</tbody>
</table>

3. Percentile Rank. Within each group, rank all the carriers’ Crash Indicator measures in ascending order. Transform the ranked values into percentiles from 0 (representing the lowest indicator measure) to 100 (representing the highest indicator measure). Remove carriers that did not have a crash recorded in the previous 12 months. The remaining carriers retain the aforementioned percentiles.
APPENDIX E  PEER REVIEW FINDINGS AND RECOMMENDATIONS

PEER REVIEWERS

- Sam Faucette, Safety Director, Old Dominion Freight: http://www.linkedin.com/pub/sam-faucette/50/611/b49
- H. Scott Mathews: http://www.ce.cmu.edu/people/faculty/matthews.html
- Peter Savolainen: http://engineering.wayne.edu/profile/peter.savolainen/
- Bob Scopatz: http://www.linkedin.com/pub/bob-scopatz/24/a97/519
- Eric Teoh, Insurance Institute for Highway Safety

REVIEW CRITERIA

The reviewers were asked to evaluate the report based on eight criteria:

1. **Clarity of Hypothesis**

   All reviewers found the hypothesis clear, with one suggestion to clearly define crash weighting. The FMCSA addressed this recommendation in the final version of the report.

2. **Validity of Research Design**

   The reviewers generally found that the research design was valid. There were many recommendations to provide further details and explanation on the research design. The FMCSA addressed several of these recommendations in the final version of the report.

   The reviewers also suggested that the design be extended beyond fatal crashes. The Agency did not address this recommendation as the decision to use fatal crashes alone was based on data constraints.

3. **Quality of Data Collection Activities**

   The reviewers generally supported the quality of data collection activities but asked for additional details in the report about the data collection process. The final version of the report provided details on the data collection tool; the Police Accident Report (PAR) reviewers’ level of expertise, background, and training; and the quality assurance process.

   One reviewer questioned why the data collection process did not include a review of the narrative to identify some of the crash elements (first harmful event and driver contributing factors) instead of limiting the review to the information from the data field on the PAR. This comment was addressed by including a detailed explanation of how this approach supported the study objectives.
4. Robustness and Depth of Analysis Methods

In general the reviewers accepted the analysis methods. Some offered specific suggestions for further justification of the approach. The final version of the report provided additional details on the analysis approach and results.

One reviewer did suggest that the analysis would be stronger if it focused on predicting future “weighted” crashes rather than all crashes. This analysis was not conducted due to the limitations of the available data.

5. Appropriateness of Methods for Hypotheses Being Tested

Reviewers raised some questions, offered some suggestions, and asked for further in-depth justification of the methods employed. The final version of the report explained in greater detail the analysis approach and why specific methods were selected.

6. Extent to Which Conclusions Follow Analysis

Reviewers generally found that the conclusions followed the analysis.

One reviewer suggested that further conclusions be drawn—for example, that there be a uniform reporting standard for PARs. This is beyond the scope of this study and was not addressed in the final version of the report.

7. Strengths and Limitations of the Overall Product

Overall, the reviewers found the study valuable and the analysis and results sound. The reviewers did point out potential limitations of the report, which were explained in the final version.

8. Specific Recommendations for Improvement of the Product

Reviewers had a number of recommendations for improvement. The final version of the report addressed most of these concerns by providing additional explanation on the study approach. Examples of areas in the report that were expanded to provide more description include:

(1) The data collection tool.

(2) The coders’ expertise in terms of experience and training.

(3) The quality assurance process.

(4) The available data sets used in the analysis.

(5) The process and approach for linking the PAR to other available data sources.

(6) The statistical analysis approach and results.

(8) Summary of process cost estimates.

(9) Why a sample of crashes cannot support national implementation of crash weighting determinations.

The final report did not address the following suggestions related to study design:

(1) Employ a larger sample of PARs with varying severity.

(2) Design the analysis to predict future “weighted” crashes.

(3) Draw more concrete conclusions.

CONCLUSION

Overall, the peer review did not result in any strong criticism of the study approach or results. Among the suggestions included were:

- Provide additional detail and explanation on tools and methods used for the study. The majority of these comments were addressed in the final report.

- Include a larger sample of PARs and coded crashes of varying severity. This was not addressed in the final report due to limitations of the available data.

- Shift the focus of the report to predicting future “weighted” crashes rather than all future crashes. This was not addressed in the final report due to limitations of the available data.