CRASH WEIGHTING ANALYSIS – REPORT TO CONGRESS

Pursuant to the Explanatory Statement
Accompanying the Transportation, Housing and Urban Development,
and Related Agencies Appropriations Bill, 2014 (P.L. 113-76, Division L)
and Senate Report 113-45 Accompanying Senate Bill 1243

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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.[1] 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.

[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.

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]

- The FMCSA's SMS Effectiveness Test 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 report of FMCSA's 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 focused on the procedural issues surrounding a program that weights crashes differently and feasibility of implementing such a program. The study did not focus on any other implications of the program. The Agency will seek comments on this study and the other implications of implementing such a program though 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?

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

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[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.
[4] "Safety Measurement System (SMS): Carrier Populations and Crash Involvement," January 23, 2014.
[5] *The Carrier Safety Measurement System (CSMS) Effectiveness Test by Behavior Analysis Safety Improvement Categories (BASICs),* January 2014.
http://csa.fmcsa.dot.gov/Documents/CSMS_Effectiveness_Test_Final_Report.pdf

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. In this case, the study focused on crashed that involved 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.[6] Thus, to create a database for the purposes of this analysis, FMCSA obtained 10,892 PARs from two national datasets: the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) and the National Motor Vehicle Crash Causation Survey (NMVCCS).[7]

Depending upon State procedures, most PARs do not indicate the reason for a crash; therefore, 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.[8] 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

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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 FARS from 2008-2010 and 387 PARs for recordable crashes (fatality, injury, or tow-away) from the 2005-2007 NMVCCS.
[8] For details on the LTCCS methodology, go to http://www.ai.fmcsa.dot.gov/ltccs/default.asp?page=method.

Agency used several crash data sources, including PARs, NMVCCS, and MCMIS. Each section of the report identifies the source of the data used for the particular analysis.

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 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.

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.

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 towaway). 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.

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 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 1. PAR Coding Results: CMV Critical Reason Outcomes

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

The five critical reason outcomes shown in Table 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).

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 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.

3.2.1 Comparison of PARs with FARS

Approach

After linking PARs to records in 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
- Roadway surface condition
- Weather 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 2.

Table 2. Results of PARs –FARS Comparison

Data Field	PARs/FARS Match	PARs/FARS Non-Match	Missing PAR Data
Driver Contributing Factors	12.6%	5.3%	82.0%
First Harmful Event	46.9%	5.6%	47.5%
Traffic-Way Flow	52.4%	14.9%	32.8%
Weather Conditions	95.7%	3.2%	1.1%
Roadway Surface Conditions	96.7%	2.3%	1.0%

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.

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 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]

[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."

- 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]

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 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.

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.

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 carriers.[11] Crash weights were derived based on the critical reason assignments for the 10,892 PARs that were reviewed and single-vehicle attributable crashes

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[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.

[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.

identified in MCMIS. The Agency employed various statistical and analytical approaches to assess crash weighting benefits, in particular the SMS Effectiveness Test (ET) Methodology.

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.

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 FARS that were coded for a critical reason using the PAR, single-vehicle attributable crashes identified in MCMIS, and all other crashes in 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]

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.

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

[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.

rate for carriers above the intervention threshold would be higher for the modified Crash Indicator than for the current approach; however, the analysis results showed that these average crash rates were nearly identical.[13]

4.3 Crash Weighting Using Fatal Crashes Alone

This data set consisted of fatal crashes from the PAR data set obtained from FARS that were coded for a critical reason based on the PAR and all other fatal crashes in 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 MCMIS.

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.

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.

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.

5.1 Crash Weighting Determination Process

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.

5.1.2 Analysis Results

The proposed process for crash weighting determinations includes 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.

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.[15]

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.[16] The FMCSA considered a number of scenarios in developing these estimates, from reviewing only single-vehicle crashes and those for which a post-crash inspection identified a pre-crash OOS condition to reviewing all recordable crashes.

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[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.

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.

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.

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 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.

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 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.