Estimating Motor Carrier Management Information System Crash File Underreporting from Carrier Records

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FOREWORD

The Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System (MCMIS) crash file houses data on truck- and bus-involved crashes occurring in the United States. The analysis of this file is central in supporting FMCSA's mission to reduce crashes, injuries, and fatalities involving large trucks and buses. It is widely thought that the MCMIS crash file does not contain all reportable crashes.[i] Some motor carriers have claimed that they have in their own files records of crashes that meet the MCMIS reporting criteria but are not found in the MCMIS crash file.

The present project investigates the claim that motor carriers have a substantial number of crashes in their own records that should be (but are not) contained in the MCMIS crash file, and it estimates the degree of underreporting to the file. The study found that, for the carriers studied, the MCMIS crash file contained about 66 percent of the crashes that met the MCMIS reporting criteria. In addition, about 25 percent of the crashes that carriers identified as reportable did not meet the MCMIS reporting criteria, and about 6 percent of the crashes involving their vehicles that had been reported to MCMIS were missing altogether from the carrier crash records supplied.

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[i] A reportable crash is a crash that meets all of the criteria for crashes that are required to be reported to the Agency by the States.

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16. Abstract

This FMCSA-sponsored research investigated the claim that motor carriers have a substantial number of crashes in their own records that are not contained in the Motor Carrier Management Information System (MCMIS) crash file. Based on the results of that investigation, this report presents estimates of the degree of underreporting to the file. Crash records were obtained from a set of motor carriers who identified crashes that, in their judgment, met the reporting thresholds for the MCMIS crash file. Carrier records were matched to the MCMIS crash file to determine how many had been reported to MCMIS. Unmatched records were then searched for in State crash records to determine how many had a crash report filed. The remaining carrier records (not found in the MCMIS file or State crash files) were used to determine the number of remaining crashes that qualified for reporting to the MCMIS file but went unreported.

The study found that, for the carriers studied, the MCMIS crash file contained about 66 percent of their crashes that met the MCMIS reporting criteria. About 25 percent of the crashes carriers identified as reportable did not meet the MCMIS reporting criteria. In addition, the carrier records were missing about 6 percent of MCMIS-reportable crashes altogether. An estimated 56 percent of the crashes that should have been but were not reported to MCMIS likely did not have a police report filed. The other 44 percent were not uploaded because the vehicle was miscoded in the original police report as a light vehicle, the U.S. Department of Transportation (USDOT) number was missing or incorrect in the police report, or errors in the State data system resulted in the case being missed.

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SI* (MODERN METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		Length		
in	inches	25.4	Millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		Area		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		Volume (volumes greater than 1,000L shall be shown in m^3)		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		Mass		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		Temperature (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		Illumination		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Approximate Conversions from SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		Length		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		Area		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
Ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		Volume		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		Mass		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2,000 lb)	T
		Temperature (exact degrees)		
°C	Celsius	1.8c+32	Fahrenheit	°F
		Illumination		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		Force and Pressure or Stress		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

Acronym	Definition
CMV	commercial motor vehicle
EMS	emergency medical services
FARS	Fatality Analysis Reporting System
FMCSA	Federal Motor Carrier Safety Administration
GES	General Estimates System (of the National Automotive Sampling System)
GVWR	gross vehicle weight rating
GCWR	gross combination weight rating
Hazmat	hazardous materials
MCMIS	Motor Carrier Management Information System
MMUCC	Model Minimum Uniform Crash Criteria
NHTSA	National Highway Traffic Safety Administration
PAR	police accident report
SaDIP	State Safety Data Quality Improvement Program
SUT	single-unit truck
TS	tractor-semitrailer
UMTRI	University of Michigan Transportation Research Institute
USDOT	U.S. Department of Transportation
VIN	vehicle identification number

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EXECUTIVE SUMMARY

OVERVIEW

The Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System (MCMIS) crash file houses data on truck- and bus-involved crashes occurring in the United States. The analysis of this file is central in supporting FMCSA's mission to reduce crashes, injuries, and fatalities involving large trucks and buses. The data in the MCMIS Crash file are extracted by the States from their own crash records and are uploaded to MCMIS through the SAFETYNET system. It is critical that the data in the crash file be timely, accurate, and complete in order for the Agency to perform its mission.

The present project investigated the claim that motor carriers have a substantial number of crashes in their records that should be (but are not) contained in the MCMIS crash file, and it estimated the degree of underreporting to the file. For this investigation, crash records were obtained from a sample of motor carriers. These carrier records were matched to the MCMIS crash file to determine how many had been reported to that file. The University of Michigan Transportation Research Institute (UMTRI) then searched for unmatched crash records from the carriers' files in State crash databases to determine how many of the State databases had an associated crash report. The remaining carrier crash reports—not found in the MCMIS file or State crash files—were then evaluated to determine how many of them should have been reported to MCMIS.

STUDY APPROACH

The goals of this project were to determine how many additional crashes in carrier records qualified to be in the MCMIS crash file, estimate the magnitude of underreporting, if any, and identify factors associated with underreporting.[ii]

To accomplish this, six carriers were recruited to obtain their crash records for analysis. Carriers were selected based on three primary considerations:

- The carriers' crash records were required to include a sufficient number of MCMIS crashes within the three most recent years (at the time of the study) to allow for meaningful analysis.
- The carriers and fleets had to be sufficiently diverse to permit analysis of known factors relevant to underreporting. The primary characteristics of interest were:
    - The types of vehicles in the fleet (i.e., straight trucks, tractor-semitrailers, and tractor-double-trailer combinations).

[ii] States are required to report large truck and bus crashes without regard to whether they are commercial vehicles, so trucks and buses operated by government agencies or non-commercial entities would also be included. However, the focus of the present study is on underreporting of crashes involving commercial carriers.

- The nature of the operation (i.e., private carrier versus for-hire).
  - The area of the operation (regional versus national).
- The carriers had to be willing to supply their complete crash data for the project.

The sampled carriers supplied a total of 58,333 crash records; out of these, 8,392 were identified as meeting the MCMIS crash reporting criteria.

It should be noted that the carriers were not randomly selected for this study but were rather a sample of convenience. The carriers were those who were willing to share their data, under certain restrictions, and who met certain requirements, based on the factors discussed above. Accordingly, caution is required in drawing conclusions about the MCMIS crash file as a whole. However, the carriers participating constituted a reasonable mix of trucking operations.

The MCMIS crash files for years 2012–14 were used in the project and were extracted on April 9, 2015.[iii] States are expected to upload crash records within 90 days of the crash occurring, so the file extract used in this research in all likelihood contained the vast majority of crashes eventually uploaded into the system for these years. A total of 4,777 crash records for the selected carriers were extracted for analysis.

Two sets of data linkages were used to meet the objectives of this project. In the first, carrier crash records were linked to the corresponding records in the MCMIS crash file. This process identified several critical categories, as shown in Table 1, of crashes of interest:

1. Crashes carriers identified as MCMIS-reportable found in the MCMIS file. (A)
2. Crashes identified as reportable by carriers, but not found in the MCMIS file. (B)
3. Crashes not identified by carriers as reportable, but in the MCMIS file. (C)
4. Crashes in the MCMIS crash file but not in the carriers' files. (D)

Table 1. Critical categories from the intersection of carrier and MCMIS crash files for evaluation.

Carrier file	Present in MCMIS file	Not present in MCMIS file
Reportable	A	B
Not reportable	C	
Not present	D	

After the initial carrier-file/MCMIS-file linking, UMTRI searched in State files for crashes not found in the MCMIS file. If found in State files, UMTRI then determined whether the crashes (as coded in the State data files) met the MCMIS reporting criteria. For this step, crash data were obtained for the 3-year period (2012–14) from 15 States. The 15 States included Florida, Georgia, Idaho, Louisiana, Maryland, Michigan, Missouri, Nebraska, New Jersey, New Mexico,

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[iii] Crashes occurring during this timeframe that were uploaded to MCMIS after April 9, 2015, would have not been included in the extracted dataset.

New York, Ohio, Oregon, Utah, and Washington. All crash records (not just those pertaining to commercial vehicle crashes) were obtained for each State. It was important to use complete crash files in order to account for the possibility that commercial vehicles were misclassified as light vehicles or something other than a vehicle that qualified for the MCMIS file. Given the geographical diversity of the States from which crash data were obtained, it is likely that the results for these States were, taken as a whole, generally representative of the entirety of the United States.

Finally, this study reviewed individual carrier records that were not found in MCMIS or State crash data systems, but which the carriers believed met the MCMIS reporting thresholds. The purpose of this review was to judge whether the crashes qualified as MCMIS-reportable.

STUDY FINDINGS

This study estimated a significant amount of underreporting to the MCMIS crash file for the carriers who cooperated in the study. For those carriers, it appears that the MCMIS crash file contained about 66 percent of the crashes that it would have had if all MCMIS-reportable crashes had been captured in State crash databases and if all reportable records in State crash databases had been uploaded to the MCMIS crash file.

About 56 percent of the missing crashes apparently had no police report filed. These crashes were in the carriers' crash data, but were not found in State crash data. If no crash report was filed, the case could not appear in the MCMIS crash file. Many of these crashes could be considered minor, in that they met the "towed/disabled vehicle" reporting criterion only. It is not possible to determine in retrospect why a crash report was not filed for these crashes, but this observation is consistent with the general level of underreporting of traffic crashes.(1,2) Many of the unreported crashes were deer or other animal strikes, with radiator leaks or punctured fuel tanks effectively disabling the vehicles. That crash reports were not filed for such incidents is not surprising, even if they technically qualified for the MCMIS crash file.

Among crashes that were reported to State crash files but not found in MCMIS, several factors contributed to this upload failure. In about half of the cases, the USDOT number was either missing or incorrect. These were most likely cases where the reporting police office failed to recognize the need to capture that information, was unable to identify the correct number, or simply transcribed the information incorrectly. About 24 percent of the records missed involved medium- and heavy-duty trucks that were misclassified as light vehicles. Two-axle single unit trucks (SUTs) were overrepresented among crashes that were missed. Many of the trucks in cases identified by carriers as MCMIS-reportable were classified as light vehicles by the reporting officers. This suggests a problem in determining a vehicle's gross vehicle weight rating (GVWR) correctly, which is one of the fundamental steps in determining whether the crash should be reported to MCMIS. Similarly, crashes involving only trucks with in-State plates were unreported at a higher rate than crashes involving trucks with out-of-State plates. Police officers may be less likely to recognize intrastate trucks (as compared to interstate trucks) as meeting the vehicle-type reporting threshold for the Federal MCMIS database.

Finally, in about half of the crashes in State files not reported to MCMIS, the coded crash severity met the MCMIS severity threshold, and at least one vehicle met the MCMIS vehicle criteria. Allowing for some errors in matching, this points to problems within State systems for identifying crashes in their data that meet the MCMIS reporting standards and uploading them to the national file.

CONCLUSIONS

Ultimately, the MCMIS crash file is compiled from State crash data files. Thus, in some sense, the data collectors are the law enforcement officers who may be called upon to cover crashes involving large trucks. The Bureau of Labor Statistics estimates that there were 653,740 police and sheriff's patrol officers of all levels in the United States in 2015. These are the men and women who completed the crash reports on which the MCMIS crash file is based. From 2012 to 2014, about 370,000 large trucks were involved in reported traffic crashes per year, on average. Considering just crashes reportable to the MCMIS file, there were 136,000 large trucks involved annually. That means that if the crash reporting load were distributed evenly among all police officers in the United States, each officer would encounter a truck in a crash about every 1.8 years, and a truck in a MCMIS-reportable crash about every 5 years.

Underreporting problems in general were more acute at the margins of the MCMIS reporting threshold definitions. Large trucks were reported at a higher rate than vehicles closer in GVWR to the reporting threshold boundary. Reporting officers apparently had greater difficulty recognizing a medium-duty truck as one that met the commercial vehicle definition as compared to larger trucks. Tractor-semitrailers were reported at a higher rate than two-axle SUTs. The GVWR threshold is in principle a clear line between reportable and not, but some officers had trouble applying it accurately.

That police officers at the scene were so critical to the current reporting process suggests moving to a system that reduces reliance on the reporting officers to identify vehicles meeting the inclusion threshold, instead importing that information into the crash data by other, automatic means, not subject so directly to human error. This could be accomplished through linkage with other systems or through automated data collection from the vehicles at the crash sites. The problem of less severe crashes going unreported by the police is not unique to truck and bus crashes. The parties involved may not have notified the police, or the police may have had higher priorities, or, for a variety of reasons, may have simply not filled out a police accident report (PAR). However, the tendency for this to occur was more common for less severe crashes. The current study of large truck and MCMIS crashes, the prior evaluations of State reporting to MCMIS, and the recent national study of all traffic crashes all showed that reporting is more complete for more severe crashes. Thus, one possible means of reducing the percentage of unreported crashes would be to increase the severity threshold of reportable crashes.

LIMITATIONS

The primary limitation of this study is that the carriers whose data were used were not a random sample, but rather a sample of convenience of the population of carriers with crashes in the MCMIS crash file. Thus, it is not statistically valid to make inferences about the accuracy of the results. In addition, UMTRI only used data from 15 States to search for unreported crashes. Evaluations of State reporting have shown that States vary in the completeness of their reporting, so the set of States may have been biased toward or against full reporting. However, the study was intended to be an exploration of reporting problems that may merit further research, and as such, has clearly identified certain areas for further work.

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1. INTRODUCTION

The Motor Carrier Management Information System (MCMIS) crash file is a central component supporting the Federal Motor Carrier Safety Administration's (FMCSA) mission to reduce fatalities, injuries, and crashes involving large trucks and buses. The data in the MCMIS crash file are extracted by the States from their own crash records and uploaded to MCMIS through the SAFETYNET system. The MCMIS crash file is one source that FMCSA uses to identify trends in motor carrier safety and it is part of a system to identify unsafe motor carriers for interventions. As such, it is critical that the data in the crash file be timely, accurate, and complete.

FMCSA has long conducted safety data quality improvement programs to measure the timeliness, accuracy, and completeness of reporting to the crash file. A previous project at the University of Michigan Transportation Research Institute (UMTRI) evaluated MCMIS crash reporting from 44 States, some more than once.[iv] The FMCSA State Safety Data Quality (SSDQ) Program also has assisted individual States by analyzing reporting processes and methods used to identify appropriate cases for the MCMIS crash file. For this effort, analysts at the John A. Volpe National Transportation Systems Center continually monitor the timeliness, accuracy, and completeness of data reported by the States.[v] Finally, FMCSA's DataQs program allows carriers and drivers to request a review of the accuracy of the crash records attributed to them.

Despite these efforts, it is widely thought that the MCMIS crash file does not contain all of the crashes that meet the database's reporting criteria. A common estimate of the rate of reporting is 85 percent. Some motor carriers have claimed that they have in their own files records of crashes that meet the MCMIS reporting criteria but were never uploaded to the MCMIS crash file.

The present project investigated the claim that motor carriers have a substantial number of crashes in their own records that are not contained in the MCMIS crash file and, by extension, develops estimates of the degree of underreporting to the file. To accomplish this, UMTRI obtained, from a set of carriers, records of crashes that, according to the carriers' judgments, met the reporting thresholds for the MCMIS crash file. These carrier records were matched to the MCMIS crash file to determine how many had been reported to that file. UMTRI then searched for unmatched crash records from the carriers' files in State crash databases to determine how many of the State databases had an associated crash report. The remaining carrier crash reports—not found in the MCMIS file or State crash files—were then evaluated to determine how many of them should have been reported to MCMIS.

[iv] Many of these reports can be found at http://www.umtri.umich.edu/our-results/publications?title=mcmis&field_authors_value

[v] See the webpage at http://ai.fmcsa.dot.gov/mapping/ssdq/

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2. MCMIS REPORTING CRITERIA AND TRAFFIC CRASHES

In principle, the MCMIS reporting criteria are clear and simple and therefore can easily be applied by States to determine whether a particular crash record has the elements necessary to qualify for reporting. Table 2 shows the reporting criteria for the MCMIS crash file. A significant advantage of these definitions is that they are clear and concise, and they should be applicable in the same way in all States. The definitions do not depend on State definitions or standards. Consider injury severity; the KABCO injury scale (K=fatal, A=incapacitating, B=non-incapacitating but evident, etc.), is common across State crash files nationally, but it is relatively crude and can be applied in different ways in different places. However, an injury characterized as "severe enough to be transported for immediate medical attention" is highly likely to be identified in the same way anywhere in the United States and is much less ambiguous. Likewise, a vehicle towed due to disabling damage would be disabled anywhere.

Table 2. Vehicle and crash severity threshold for MCMIS crash file.*

Element	Severity Threshold
Vehicle	Truck with GVWR over 10,000 lb or gross combination weight rating (GCWR) over 10,000 lb *or* Bus with seating for at least nine, including the driver *or* Vehicle displaying a hazardous materials placard.
Crash	Fatality *or* Injury transported to a medical facility for immediate medical attention *or* Vehicle towed due to disabling damage.

*A MCMIS-reportable crash must meet at least one vehicle threshold and one crash threshold.

However, though the information needed to apply the definitions is simple, State crash report forms do not necessarily capture all that simple information. A recurring problem, documented in previous studies performed by UMTRI (see Section 4) that investigated crashes potentially qualifying for MCMIS reporting in State datasets, was the inability of local authorities to identify injured persons who had been transported from the scene of the crash to receive immediate medical attention. While State data often included information on emergency medical service (EMS) runs, implying that EMS were at the scene, they did not reliably report whether any of the injured were actually transported. Moreover, these studies found that it could not be assumed that even the most severe nonfatal injuries were transported necessarily for medical attention. The analogous situation in identifying crashes with towed/disabled vehicles was also true. A vehicle may have been recorded as damaged and towed, but whether the vehicle was towed due to damage or for some other reason was not always captured on crash reports.

Moreover, to be included in the MCMIS crash file, a "crash" must first appear in a State's crash data. States set their own reporting thresholds, but these thresholds are reasonably similar across jurisdictions. States define crashes, for the most part, based on guidelines found in the National Safety Council's *Manual on Classification of Motor Vehicle Traffic Accidents.*[3] A traffic accident (or crash, to use the more common term) includes injury or damage to persons or property, involves one or more motor vehicles in-transport on a public trafficway, and is the result of an "unstabilized situation." There are detailed definitions for elements of each of these criteria, but the most salient and pertinent characteristics are defined as follows:

- **Injury and damage** includes any injury to persons as a result of the crash, and any damage to vehicles or property. Damage to wildlife is excluded from the property damage that defines a crash. Similarly, mechanical vehicle failure from normal operations, such as tire blow-outs or a broken fan belt, are also excluded from the property damage used to determine whether a traffic crash has occurred.[(4)]
- **Disabling damage** prevents the vehicle from being operated normally in daylight after simple repairs. Thus, damage to a headlight would not qualify as disabling, nor would a flat tire (since a simple repair would allow the vehicle to operate normally).[(5)]
- **"In-transport"** means on a roadway or in a trafficway. It does not imply actually "in motion"; in-transport vehicles may be stopped. "In-transport" refers to motor vehicles on the roadway (even if abandoned or driverless) or in motion outside of a roadway, such as in a median, on a shoulder or roadside, even if driverless. "In-transport" excludes vehicles that are parked in a legal parking area. Thus, an in-transport vehicle is any motor vehicle that has any part on the travel portion of a roadway, whether stopped, driverless, or not, as well as any motor vehicle in motion on any other portion of a trafficway. The most common exclusion is a legally parked vehicle, which is not an in-transport vehicle, but any other vehicle, stopped entirely off the roadway, is also not an in-transport vehicle.[(6)]
- A **trafficway** is defined as any road or way that is open to the public by right (as in the case of public roads) or custom (such as the travel ways of parking lots that are used by the public, even if on private property). A roadway is the portion of a trafficway that is ordinarily used for motor vehicle travel, including the roadway shoulders, if any.[(7)]
- An **"unstabilized"** situation refers to a continuous set of events that are not under human control. Unstabilized events that involve motor vehicles on public traffic ways that result in a death, injury, or property damage constitute a traffic crash. The reference to "human control" excludes actions resulting from deliberate intent, (although FMCSA currently allows for events when a CMV driver deliberately crashes to kill himself). It also excludes homicides, as when a person uses a vehicle to attempt to kill another[(8)] and cataclysms, which are defined as natural events such as avalanches, mudslides, tornados, and earthquakes.[(9)]

Thus, a motor vehicle traffic accident is an unstabilized set of events resulting in property damage or injury that involves one or more in-transport motor vehicles on a public trafficway that was not the result of a cataclysm.

This is a lengthy explanation, but useful nonetheless in helping to sort out events that should end up in the MCMIS crash file from those that should not. These crash reporting criteria are the first filters through which crashes must pass before making it to the MCMIS crash file. Crashes are inherently chaotic events and therefore often resist concise classification.

Carriers, in identifying crashes as "U.S. Department of Transportation (USDOT) reportable" in their own files, must deal with the same ambiguities. Some events are clearly traffic crashes involving vehicles and crash severities that meet the MCMIS reporting threshold. For others, the answer will not be so clear or easily determined. For example, a carrier may know that a vehicle was towed but not know whether it was towed because it was disabled or for some other reason. They may know that a person was injured but not whether the person was transported for immediate medical attention. Moreover, not all events in carrier files that incur an economic loss are traffic crashes. A truck that required a tow after getting stuck in a muddy field while making a delivery was not involved in a traffic crash. A truck that knocked down a pole in a customer's lot while making a pickup was not involved in a traffic crash.

Table 3 shows the annual number of trucks involved in traffic crashes for the period covered by this study, classified by the MCMIS crash severity levels. The estimates of the number of trucks involved in crashes were derived from the Fatality Analysis Reporting System (FARS) file and the National Automotive Sampling System (NASS) General Estimates System (GES) file. Both are compiled by the National Highway Traffic Safety Administration (NHTSA). FARS is a census file of fatal motor vehicle crashes, while GES is a nationally representative sample of police-reported crashes.[10,11] Each file is the standard source for its respective area of coverage. The combination of FARS for fatal crash involvements and GES for nonfatal involvements provides the most accurate estimate in publicly available data of truck crash involvements in U.S. crashes that meet the MCMIS crash severity threshold (36.8 percent).

Table 3. Annual average trucks in crashes, 2012–14.

Crash Severity	Number	Percent
Fatal	3,824	1.0%
Injured/transported	45,941	12.4%
Towed/disabled	86,920	23.4%
All other	234,405	63.2%
Total	**371,089**	**100.0%**

Data Source: National Highway Traffic Safety Administration (NHTSA), Fatality Analysis Reporting System (FARS) and General Estimates System (GES).

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3. PROBLEM STATEMENT

This project investigated the claim that a significant number of crashes are not reported to the MCMIS crash file, using carrier records of MCMIS-reportable crashes. A set of carrier crash records, identified by carriers as MCMIS-reportable, were obtained. The goals of the project were: 1) to determine how many additional crashes in carrier records qualified to be in the MCMIS crash file; 2) to estimate the magnitude of underreporting, if any; and 3) to identify factors associated with underreporting.

Figure 1 illustrates the possible relationship between all crashes, crashes that qualify for reporting to the MCMIS crash file, and crashes actually reported to the MCMIS crash file. In addition, the dotted circle shows a hypothetical "true" set of traffic crashes. These are crashes that qualify as traffic crashes within a State but which *may* not all appear in the State's crash file. To date, studies of MCMIS crash file completeness have focused on the crashes within the solid circles. In those studies, the approach was to identify crashes that met the MCMIS criteria within the circle of State-reported crashes, link those crashes to the crashes actually reported to MCMIS, and then evaluate the results. The portion of the "MCMIS-qualifying" circle that fell outside the circle of crashes actually reported to MCMIS was a measure of underreporting. The analogous portion of the circle of crashes reported to MCMIS that does not coincide with MCMIS-qualifying crashes showed over-reporting. The UMTRI evaluations found examples of both circumstances (see Section 4).

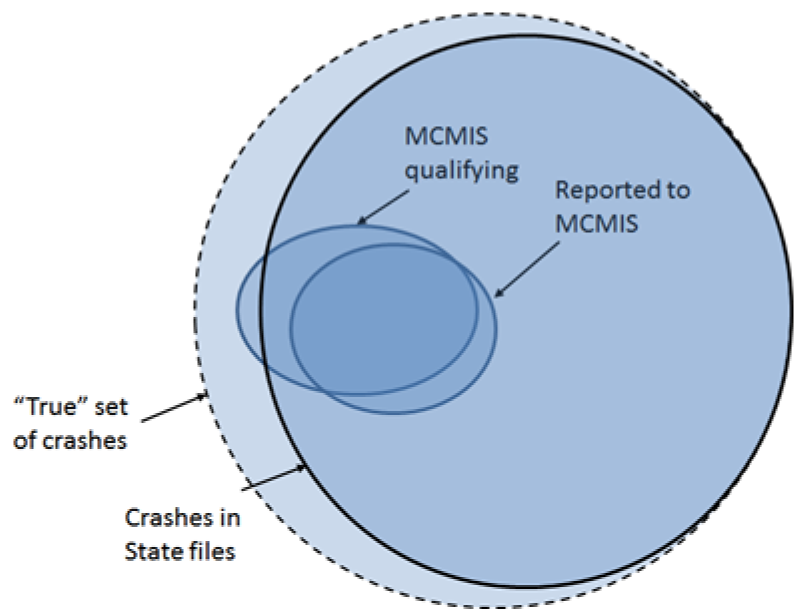

Figure 1. Diagram. Large truck crash reporting to the MCMIS crash file in relation to all crashes, all crashes in State files, and all crashes qualifying for inclusion in MCMIS.

The current research utilizes an arguably independent source of representative data. Many motor carriers maintain their own records of traffic crashes involving their vehicles. These records may cross-cut each of the circles represented in Figure 1, or even lie outside all of them. Figure 2 illustrates the concept of carrier "crash" records juxtaposed against public crash records. "Crash" is in quotes because motor carriers may include other types of events in their records that result in economic loss, not just motor vehicle traffic crashes under the definitions used by enforcement agencies. These loss events can include events such as rutting lawns when backing for deliveries, or vandalism when the vehicle is parked. Thus, in the diagram, a portion of the carrier records falls outside even the true set of traffic crashes.

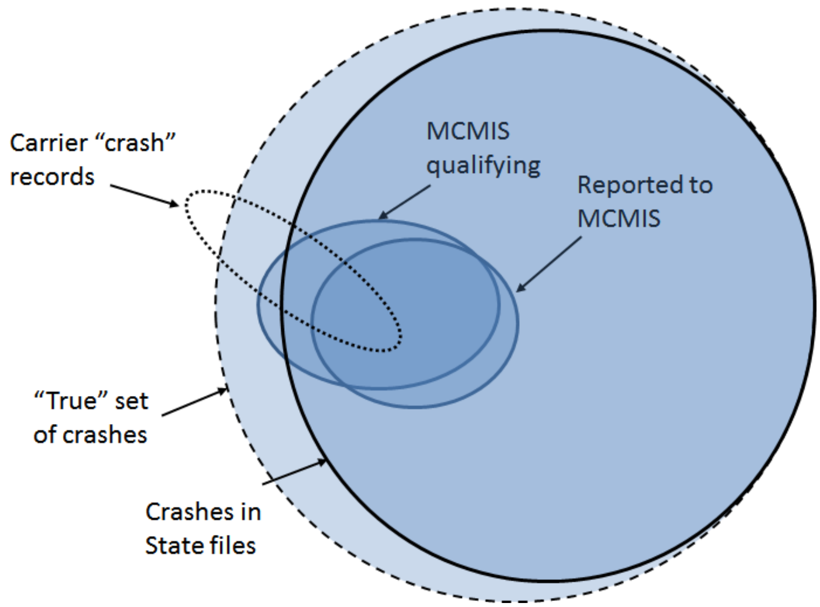

Figure 2. Diagram. Illustration of how carrier crash reports may be cross-cutting.

The diagram in Figure 2 also illustrates that the carrier crash records may fall into a hierarchy of other categories:

1. Events that are not traffic crashes.
2. Crashes that may not appear in State crash files.
3. Crashes that are in State files but do not qualify for reporting to MCMIS.
4. Crashes that do not qualify for reporting to MCMIS but were reported in the MCMIS crash file.
5. Crashes that qualify for reporting to MCMIS but were not reported.
6. Crashes that qualify for reporting to MCMIS and were reported.

The current research essentially classified carrier crash records into the above-mentioned crash categories and then computed reporting rates.

4. PRIOR RESEARCH

Although it has long been assumed that not all traffic crashes are reported, there has been relatively little research to estimate the degree of underreporting to police crash files. A 1981 survey of 279 drivers estimated that 47.1 percent of all crashes were not reported to State crash data files. Survey respondents reported the number of crashes they had been involved in and the number that were police-reported. UMTRI followed up by searching crash databases to confirm the respondents' recollections and generally confirmed them. Rates of reporting varied by crash severity. A police report was filed on about 75 percent of tow-away crashes, 78.7 percent of injury crashes, and 84.7 percent of crashes "requiring doctor treatment."[(12)]

NHTSA more recently conducted a survey of households in 2009 and 2010 to estimate crash underreporting. The same general protocol was followed, in that survey respondents were asked to report the number of traffic crashes they had been involved in, and whether a crash report had been completed. It was estimated that about 31 percent of traffic crashes were unreported, with a crash defined as involving at least one moving motor vehicle and a person injured or a vehicle damaged. The study was based on the responses of telephone respondents only; UMTRI did not attempt to search police databases for the crashes to confirm reporting status of the crashes. Not surprisingly, less-severe crashes were more likely to be unreported than more-severe crashes. About 36 percent of vehicle-damage-only crashes were unreported, compared with about 15 percent of crashes in which a person was injured.[(13)]

The prior studies were based on all crashes, involving all motor vehicles, reported to State crash databases. UMTRI conducted a series of evaluations of State crash datasets to estimate the amount of underreporting from those files to the MCMIS crash file. These studies were different from the previously reported research, in that they focused on crashes already in State files, and attempted to determine how comprehensively States identified crashes qualifying for the MCMIS crash file and then uploaded them accordingly.

UMTRI, using State crash data, independently identified crashes that met the MCMIS reporting criteria, matched those cases to the MCMIS crash file to determine which were reported and which were not, and then compared those that should have been reported (but were not) to those that had been correctly reported to identify characteristics of crashes and vehicles associated with lower reporting rates. These State evaluations identified a fairly consistent set of factors that were associated with underreporting, as follows:

- Crashes involving tractor-semitrailers tended to be reported to MCMIS at a higher rate than crashes involving straight trucks, which tend to be smaller vehicles.[(14,15)]
- Fatal crashes tended to be reported at higher rates than non-fatal crashes, and crashes with transported injuries tended to be reported at higher rates than crashes where the most severe damage was a vehicle towed due to disabling damage.[(16,17)]
- Crashes involving clearly identifiable interstate trucks tended to be reported at higher rates than crashes involving only intrastate trucks.[(18,19)]
- Crashes covered by State police tended to be reported at higher rates than those covered by local police or county sheriffs.[(20,21)]

- Crashes from States that captured on the crash report all the information needed to extract MCMIS-reportable crashes automatically had higher reporting rates than those that used manual review.[22,23,24]

In addition, FMCSA has maintained for several years a continuing evaluation of the MCMIS crash file at an aggregate level, comparing counts of fatal crashes in MCMIS and NHTSA's FARS file and comparing the number of total crashes reported to the MCMIS file from a State with the number predicted for that State. This information, along with other measures, (e.g., compliance with time reporting requirements) is used to rate each State on its overall reporting completeness.[vi]

The current study extends the evaluation of underreporting to the MCMIS crash file by starting from carrier crash datasets. In this way, it is similar to the Greenblatt, et al., (1981) and Davis (2015) studies for NHTSA. Those studies surveyed drivers to obtain a count of crashes based on drivers' recollections, and then determined if there had been police reports on the crashes. In the case of Greenblatt, et al., UMTRI searched crash databases to validate the recollections. The present study advances beyond those studies, at least from a methodological point of view, in that it starts with carrier crash records, then attempts to determine if relevant crashes were reported to State files and subsequently to the MCMIS crash file. Carriers have an incentive to maintain records of crashes and similar events as part of managing their businesses. Whether they keep the records in accordance with crash data collection standards and whether they apply correctly the criteria for traffic crashes and crashes reportable to the MCMIS dataset are subordinate questions.

[vi] See the State Safety Data Quality mapping tool at https://ai.fmcsa.dot.gov/DataQuality/.

5. DATA

5.1 CARRIER DATA

A set of six carriers were recruited to supply their crash records for analysis. Carriers were selected based on three primary considerations:

- The carriers' crash records were required to include a sufficient number of MCMIS crashes within the 3 most recent years (at the time of the study) to allow for meaningful analysis.
- The carriers and fleets had to be sufficiently diverse to permit analysis of known factors relevant to underreporting. The primary characteristics of interest were:
  - Whether the carrier operated straight trucks, tractor-semitrailers, or tractor-double-trailer combinations.
  - Whether the carrier was private or for-hire.
  - Whether the carrier operated regionally or nationally.
- The carriers had to be willing to supply their complete crash data for the project.

The MCMIS crash and census files were analyzed to identify candidate carriers with sufficient crashes recorded within the 3-year timeframe (2012–14), as well as carriers that fit the other criteria. Carriers on the resulting list were recruited for participation in the project. The carriers were assured that their data would be held securely, that no personally identifiable information would be included in any report, that the report would include only aggregate results, and that FMCSA would not have access to the carriers' crash data.

Study data were held in password-protected servers and stripped of any personally identifiable information. All staff with access to the data were certified under the Program for Education and Evaluation in Responsible Research and Scholarship at the University of Michigan, which is a program to ensure the ethical conduct of research.

Six carriers agreed to supply crash files. Of necessity, they were large carriers, since an initial requirement was a sufficient number of crashes. However, they also represented a good mix of the attributes sought. Three were large, for-hire carriers that operated both single-unit trucks (SUTs) and tractor-semitrailers, as well as some tractor-double-trailer combinations. One was a regional for-hire carrier that operated primarily tractor-combination trucks. Two were private carriers, one of which operated primarily SUTs, the other operated both SUTs and some tractor-semitrailers. Their crashes occurred in every State of the Union (except Hawaii) and the District of Columbia.

It should be noted that the carriers were not a random sample. The carriers that supplied crash data were a sample of convenience. The carriers were those who were willing to share their data, under certain restrictions, and who met the other above-mentioned requirements. They were not a random sample of all carriers, or even a random sample of carriers big enough to have a reasonable number of crashes, since their participation was voluntary. Accordingly, caution is required in drawing conclusions about the MCMIS crash file as a whole. However, the carriers participating constituted a reasonable mix of trucks and types of operations that covers most for-hire trucking in the United States.

It also should be noted that intrastate-only non-hazardous materials carriers could not be part of the sample. Intrastate-only non-hazardous materials carriers are not required by the USDOT to register and obtain a USDOT number, although some States do require such registration. None of these intrastate carriers with USDOT numbers had a sufficient number of crashes to be useful in this study.

The sampled carriers supplied a total of 58,333 crash records, 8,392 of which were identified as having met the MCMIS crash reporting criteria.

5.2 MCMIS FILES

The MCMIS crash files for 2012–14 were used in the project. The data were extracted on April 9, 2015.[vii] States are required to upload crash records within 90 days of the crash occurring, so the crash file used more than likely contained most of the crash records for 2012, 2013, and 2014. Working with FMCSA, UMTRI extracted 4,777 crash records for analysis.

Information about the carriers, including types of trucks operated and whether private or for-hire, was obtained from the MCMIS census file, which contains descriptive information on all active carriers registered with the USDOT.

5.3 STATE CRASH DATA

Crash data for 15 states over three years (2012-2014) were obtained. The states consisted of Florida, Georgia, Idaho, Louisiana, Maryland, Michigan, Missouri, Nebraska, New Jersey, New Mexico, New York, Ohio, Oregon, Utah, and Washington. The complete crash file was obtained for each State, not just the crashes of commercial vehicles. Obtaining the complete crash file was important to account for the possibility that vehicles may have been misclassified as light vehicles or something other than a vehicle that met the MCMIS file vehicle type criterion.

[vii] The crash file used would not contain any records for crashes that occurred within the timeframe of the study but were uploaded after the file extraction date.

6. METHOD

The objectives of the project were met through two sets of data linkages. In the first, carrier crash records were linked to the corresponding records in the MCMIS crash file. This process identified several sets of crashes of interest:

1. Carrier-identified MCMIS-reportable crashes in the MCMIS file. (A)
2. Crashes identified as reportable by carriers, but not found in the MCMIS file. (B)
3. Crashes not identified by carriers as reportable, but in the MCMIS file. (C)
4. Crashes in the MCMIS crash file but not in the carriers' files. (D)

Table 4. Critical categories from the intersection of carrier and MCMIS crash files for evaluation.

Carrier file	Present in MCMIS file	Not present in MCMIS file
Reportable	A	B
Not reportable	C	
Not present	D	

After the initial carrier-file/MCMIS-file link, UMTRI searched in State files for crashes not found in the MCMIS file. If found in State files, UMTRI then determined whether the crashes (as coded in the State data files) met the MCMIS reporting criteria.

Finally, this study reviewed individual carrier records that were not found in MCMIS or State crash data systems, but which the carriers believed met the MCMIS reporting thresholds. The purpose of this review was to judge whether the crashes qualified as MCMIS-reportable.

Crash files were linked using probabilistic methods. Hard links, such as police report numbers, were not available in a usable form in the MCMIS crash file, or typically at all in the carrier crash data. Accordingly, it was necessary to use a method of selecting variables common between two files that had a high probability of uniquely identifying a specific vehicle in a specific crash. Generally speaking, the method linked records using fields or sets of fields that uniquely identify crashes in time and space (crash date, time, and geographic location) and specific vehicles in the crashes (vehicle identification number [VIN], driver's license number, vehicle plate number). Details of the matching methods are provided in the discussions for each set of matches.

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7. MATCHING CARRIER CRASH RECORDS

7.1 MCMIS CRASH FILE MATCHING

Carrier crash records were matched to the MCMIS crash file. For four of the six carriers, the carriers supplied a complete crash file that included not only the crashes they had identified as reportable to the MCMIS file, but also other crash records and events. In fact, some records of events could not be reasonably termed traffic crashes, such as instances of vandalism or damaging an external mirror at a loading dock. The two other carriers supplied only records of crashes they had determined to be MCMIS-reportable.

There were no hard links between carrier and MCMIS data and no common set of unique crash identification numbers. For example, carriers did not typically include the police report number of crashes in their file; the MCMIS crash file also does not include the police report number.

Therefore, as described above, probabilistic methods were used to link data records. A match was made by finding records for crashes that occurred at the same time, in the same place, and involving the same vehicles. In other words, crashes were linked if there was a high probability that they matched in space, time, and vehicles. In practice, however, a reasonable allowance was made within the dimensions of time and location. For example, with respect to time, crashes were matched if their times were within a reasonable window, such as within an hour. Places were matched if crashes were within reasonable proximity, typically the same road and town. Vehicles were matched on VIN, if available, or make and model year, or driver name. Records had to agree on each of the three dimensions (time, place, and vehicle) to be accepted as a match.

Separate matching algorithms were developed for each of the six carriers' data. Each carrier supplied data that differed in the detail provided. The data for each carrier were processed into a common format with the data in the MCMIS. Matching proceeded in steps, from the most rigorous match using the most exacting and specific criteria, then relaxing a matching requirement if a match was not made. For example, the matching algorithm might use year, month, day, hour, and minute for the time dimension in the first step, and then drop "minute" for the second step. Matches were validated by comparing information from fields not used in the matching, such as vehicle make.

After all computer matches were completed, remaining unmatched cases were processed manually. The same requirement of matching on time, place, and vehicle/driver was enforced here, but manual matching allowed for cases to still be matched when the matching variables had slight differences in spelling or punctuation (e.g., Smith-Jones rather than Smith Jones).

The matching process for each of the carriers used the following steps:

1. Identify and extract crash records for a carrier from the MCMIS crash file.
2. Import carrier and MCMIS crash records into the matching software.
3. Reformat fields according to a common format.
4. Identify fields for the most rigorous matching.

5. Identify and eliminate records that are duplicates on the set of match variables.
6. Match remaining, non-duplicative records.
7. Validate matches by comparing fields not used in the match step.
8. Relax or eliminate one of the matching fields (while still matching on time, place, and vehicle/driver information).
9. Repeat process until all cases are exhausted or all combinations of matching fields have been used.
10. Individually match remaining cases by manually comparing carriers' records with MCMIS cases that remain unmatched.

7.1.1 Results of MCMIS/Carrier Crash File Matching

The MCMIS crash file for 2012–14 contained 4,777 crash records for the participating carriers. The carriers, on the other hand, identified 8,392 crash records that they believed met the vehicle-type and crash-severity thresholds for reporting to the MCMIS crash file. If the carrier records correctly identified MCMIS-reportable crashes, and all the MCMIS-reported records were also found in the carrier file, that implies underreporting of about 45 percent. However, the results of matching carrier and MCMIS records, searching for unmatched carrier records in State crash records, and the analysis of the carrier records themselves found a considerably more complex result. Figure 3 shows a schematic of the outcome.

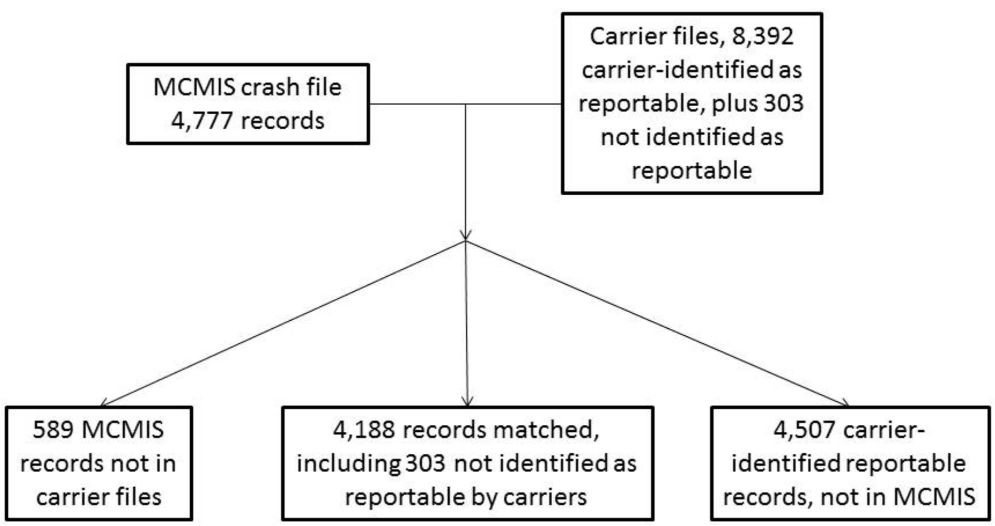

Figure 3. Schematic. Outcome of matching carrier records to MCMIS crash file.

The matching process found over 300 records in the MCMIS crash file that had not been classified by carriers as meeting the MCMIS crash file reporting threshold. These records were in the carriers' data but had not been recognized as reportable by the carriers. Thus, 6.3 percent of MCMIS crash file records were not identified by carriers as reportable.[viii]

In addition, 12.3 percent (589) of the MCMIS crash records could not be matched to any record in the carrier files. These were crashes assigned in MCMIS to study carriers but with no corresponding record in the carrier's files, at least in the data that were supplied for this project. Overall, matching crashes that carriers identified as reportable with crashes actually reported to the MCMIS crash file showed that about 54 percent (4,507 out of 8,392) of the crashes carriers identified as reportable were not in the MCMIS file.

The goal of the current project was not to test the completeness of carrier crash records but to assess the extent of underreporting to the MCMIS file that could be demonstrated by finding MCMIS-reportable crashes in carrier files that were not in the MCMIS file. Nevertheless, it was unexpected to find so many crashes in the MCMIS file that were not in carrier files. Even making allowances for errors in matching, 589 of the 4,777 records in MCMIS for these carriers is a substantial number. Carriers have an incentive to ensure that only crashes attributable to them are in the MCMIS file.

Possible explanations for this finding are:

- *Insufficient information in carrier files to link the records to the correct crashes in MCMIS*. This would simply be a lack of precise-enough information in the carrier records about times, places, and vehicles to find the right crash in MCMIS. Some of the non-matches were no doubt attributable to this cause, particularly where carriers did not supply detailed information about crash location. But, the matching process was exhaustive, culminating with a manual scan of all available records. In the great majority of cases where a crash reported to MCMIS could not be found in the carrier's file, there was no crash with the same date, State, and driver information in the carrier's records.
- *Incorrect information in either the MCMIS file or carrier files as to times, places, and vehicles.* This possibility raises the issue of ground-truth. Was the error in the MCMIS file (which was ultimately derived from police reports) or in the carriers' files? Ultimately, the question of ground-truth cannot be resolved between the two sources because there is no independent standard against which to compare. An independent investigation of each crash to determine ground-truth was not feasible. However, it is reasonable to assume that the MCMIS data, derived as they were from police reports, are sufficiently accurate as to times and places—particularly places. In doing manual matches, we found a few records that matched on date, time, driver name, and vehicle description but which occurred in an adjoining State, rather than the one indicated in the carrier's record. Such cases were most likely errors in carrier data. Other cases of mismatches included different days, particularly when a crash occurred near midnight.

[viii] Two carriers supplied records only for crashes they identified as reportable, so the rate of false-negatives (MCMIS-reportable crashes considered not reportable by carriers) is higher. Restricting the denominator to the four carriers that supplied records of all crashes, 11.2 percent of the crashes reported to MCMIS were not flagged as MCMIS-reportable by the carriers.

One can easily see how there might be a disagreement as to the day of the crash, but we also found crashes that matched on time of day, driver name, location, and vehicle description but were separated by 2 or 3 days. These were most likely clerical or data-entry errors in the carrier data. Errors in more than one field used in linking in one of the files could have prevented finding a matching record in the other file.

- *Crashes erroneously attributed to a carrier.* In performing matches with State crash records, we found several instances in which the carrier's name or USDOT number was entered incorrectly into the State database. Sometimes the USDOT number was missing a digit or digits were transposed. In other cases, a USDOT number used by a different line of the carrier's business was used. These could be errors on the part of the reporting police officer, which, if uploaded to the MCMIS crash file and not corrected, would attribute a crash to the wrong carrier. Errors could also occur if the carrier itself mixed crashes from different lines of business. Some carriers have diverse operations and have different USDOT numbers for different operations. UMTRI requested that the carriers supply crash records for a specific USDOT number, and if the carrier itself assigned a crash to a different DOT number from that specified, it would not be among the data supplied for this project.

After the match with the MCMIS file, there were still approximately 4,500 crash records in the carriers' files that were marked as meeting the MCMIS reporting threshold but which could not be found in MCMIS, either using computer matching or by an individual, manual search. These were *potentially* underreported crashes, depending on whether they met the MCMIS reporting criteria. The next step was to search for these records in State crash files to determine whether they were present in the State crash data and, if so, whether they met the MCMIS crash file reporting criteria.

7.2 MATCHING CARRIER RECORDS NOT IN MCMIS TO STATE CRASH DATA

The 4,507 carrier records of allegedly MCMIS-reportable crashes not in MCMIS were distributed across 3 years and 49 States (excluding Hawaii) and the District of Columbia. Searching for all the carrier records would have required obtaining State crash data from each State for each of the years, from 2012 to 2014—potentially 150 crash files. It was infeasible to obtain and search crash data from all of the States represented in the carrier data.

Accordingly, a subset of 15 States was identified that accounted for about a third of the crash records at issue. The States were broadly representative of the country and represented all of the geographic regions (see Table **5** for the list). UMTRI maintains a library of crash data for many States and years, but for all the selected States it was necessary to obtain at least the most recent year of data (2014), and for some States it was necessary to obtain data for all three years for this project. In total, 33 annual crash files were acquired for this project from the 15 States. Each file was cleaned, evaluated, and built into a database suitable for matching with the carrier records.

Table **5** lists the 15 States whose data were searched for crash records carriers identified as MCMIS-reportable that were not reported to the MCMIS crash file. The number of carrier crash records in each State is shown in the "Total" column, along with the result of the matching effort. In total, 1,462 carrier records of crashes that the carriers identified as reportable to the

MCMIS crash file were searched for in the records of these 15 States. As the table shows, 564 carrier records were successfully located in the State data; 710 carrier crash events could not be found; and the data for 188 records (primarily from one State) were too inadequate to support a legitimate search. In this State, the information on drivers and vehicles was, for the most part, too generic to be usable. These 188 carrier crashes were excluded from further consideration in the analysis of the matching results.

Table 5. Results of matching carrier crash records to State crash data for crashes carriers identified as MCMIS-reportable not found in MCMIS.

State	Carrier Records Matched	Carrier Records Not Matched	Carrier Records with Insufficient Information (could not match)	Total Carrier Records
Florida	73	126	1	200
Georgia	89	91	2	182
Idaho	6	6	0	12
Louisiana	25	55	0	80
Maryland	39	35	0	74
Michigan	56	33	3	92
Missouri	50	65	0	115
Nebraska	13	22	0	35
New Jersey	72	41	0	113
New Mexico	16	16	0	32
New York	15	8	182	205
Ohio	71	121	0	192
Oregon	9	26	0	35
Utah	13	21	0	34
Washington	17	44	0	61
Total	**564**	**710**	**188**	**1,462**

7.2.1 Process of State Matching

A computer-match was not a realistic approach for matching carrier records with State data. The data for each State and carrier were recorded in different formats, so it would have been necessary to develop different matching programs for each combination of State and carrier (or about 90 separate computer matching programs). Instead, an effective, albeit tedious, manual method of searching and matching was developed and implemented.

The same fundamental matching requirements were used as in the computer-match with the MCMIS crash file: crash records had to match on place, time, and either vehicle or driver. A match was assigned if records matched on the location of the crash, the date and time, and the vehicle/driver, with a reasonable allowance for differences between the different data systems. Once a match was made, data relevant to determining if the crash and vehicle met the MCMIS reporting threshold were recorded, along with other information relevant to the reporting process.

The match process for each combination of State and carrier data consisted of the following steps:

1. Carrier crash records were listed for each State, including all information that could be used in matching.
2. State crash data were built into usable formats, with all location, time, and vehicle/driver information available.
3. Each carrier crash record was manually searched for in the State crash data.
4. If a matching record was found, information about how the case was coded in the State file was collected, with particular attention to fields that would determine if the vehicle and crash would qualify for the MCMIS crash file. Data collected included:
    a. Most severe injury in the crash.
    b. Whether any injured person was transported for immediate medical attention.
    c. Whether any vehicle was towed due to disabling damage.
    d. Vehicle type and configuration of the matched vehicle.
    e. Cargo body type of the matched vehicle.
    f. Whether the vehicle was placarded to transport hazardous materials.
    g. Reporting agency type (state police, police department, sheriff department, or other).
    h. Whether the USDOT number of the matched vehicle was recorded and if it was accurate.
    i. State of registration (as indicated by the vehicle license plate).
    j. State crash and vehicle identification variables.

Microsoft Excel® 2013 was used to facilitate the search process. Excel has data filtering and searching capabilities that were used to speed the process, reducing the number of possible cases to match. For many of the States, 1,000 to 3,000 police-reported crashes occurred per day; for example, New Jersey averaged about 1,500 vehicles in crashes per day, on the relevant days. It was important to eliminate crashes from a specific search that occurred on different days or, to the extent possible, in different places. For example, the data filtering tools were set to show all the crashes and vehicles involved for a particular date and city, to reduce the search space. Matching was facilitated if the driver's name or the vehicle's VIN were available; however, the requirement that the crashes match on time and place was still enforced.

Some States geo-located crashes and included latitude and longitude in crash records. If a carrier provided an address or intersection as the location, mapping tools were used to determine if the point was nearby. Online search tools were used to resolve differences in geographic conventions. For example, some States identified crash locations outside of large urban areas by the township. Others used State route numbers in preference to road names. The carriers, in contrast, usually reported location by identifying the closest town or village, and used road names and route numbers interchangeably. Online search tools were used to match townships with towns or villages. Mapping tools were used to reconcile differences in route designations.

The matching was done by four individuals, two with very extensive experience in police-reported crash data and two staff members specially trained for the project. Ambiguous matches were discussed and resolved within the team. All matches were spot-checked by the more experienced staff members. The requirement was maintained that the crashes had to match on time, space, and vehicle/driver. No matches were accepted without all three of the elements.

7.2.2 State Match Results

The search in the 15 State databases for the subset of 1,274 carrier crash records not found in MCMIS (after excluding the 188 records with insufficient information, as shown in Table 5) resulted in matching 44.3 percent of them; 55.7 percent of the records could not be matched (see Figure 4). It is certainly possible that some portion of the records not found were actually in the State files but were missed due to insufficient or inaccurate information in the carrier data. Crashes assigned the wrong date or State—both of which were observed occasionally in matching with the MCMIS file—would not be found in the match to State data. It was not possible to search all States for a record, and the numbers of records within a particular State for a specific day were so great that searching multiple days was infeasible. (We did, however, search across days for crashes that occurred within an hour of midnight.) Moreover, the matching standard used was inherently conservative to reduce the probability of incorrect matches. However, in the State matching process, we were able to search all crashes in a State on a particular date and location. In most of the failed matches, there was simply no possible truck involved in a crash at the relevant time and place.

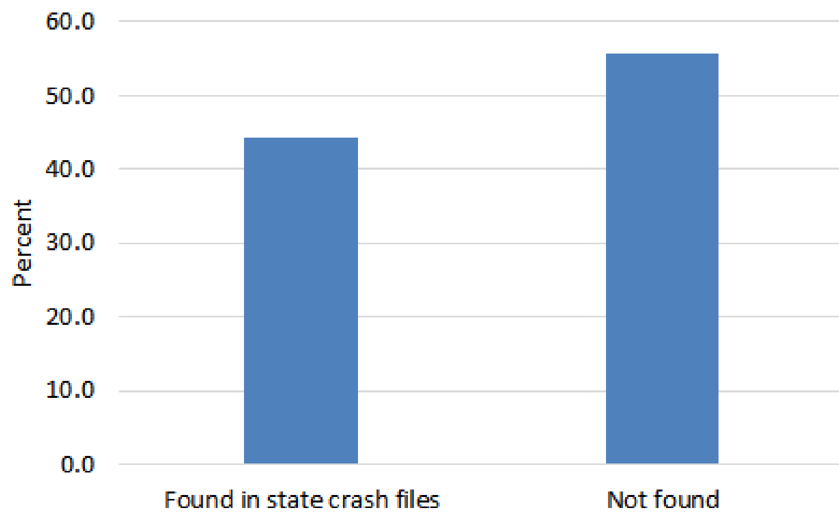

Figure 4. Bar chart. Result of search in State crash files for crashes carriers identified as MCMIS-reportable not found in MCMIS.

For each of the crashes found in State files, data were collected on the factors used in determining if a crash is reportable to the MCMIS crash file, including crash severity and vehicle type. Other data collected included whether the USDOT number was recorded and correct, and the type of police agency responsible for the report.

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8. ANALYSIS OF CRASHES CARRIERS IDENTIFIED AS MCMIS-REPORTABLE NOT FOUND IN MCMIS

Table 6 shows the distribution of crash severity, classified in relation to the MCMIS crash reporting threshold (see Table 2 for a description) for those crashes in the study carriers' files marked as MCMIS-reportable, not found in MCMIS, but still identified in State databases. Fatal crashes, crashes in which an injured person was transported for immediate medical attention, and crashes in which a vehicle was towed due to disabling damage, all should have been reported if they involved a qualifying vehicle (that is, the carrier's vehicle was classified as meeting the vehicle-type criterion). (Note that there were eight fatal-crash involvements that carriers identified as reportable but which were not in the MCMIS crash file for those carriers. The outcome of the fatal involvements is discussed below.) A total of 36.2 percent (summing table percentages is subject to rounding error) of these crashes should have been reported (see first three rows of table), if they involved a reportable vehicle. In another 16.3 percent of the crashes, it was known in the State data that at least one vehicle was towed, but the data did not indicate whether the tow was due to disabling damage. (All of the State data indicated whether vehicles were towed or not, but five did not include information on whether the towed vehicle was also disabled.) In 21.1 percent of the records, no tow was indicated, and these crashes likely did not involve towing. The final 26.4 percent had no injuries or vehicles towed. Thus, between 36 percent and 53 percent of the crashes appeared to meet at least the MCMIS crash severity criteria, while about half clearly did not.

Table 6. Crash severity in State files for crashes carriers identified as MCMIS-reportable not found in MCMIS but matched to crash records in 15-State sample.

Crash severity	Number	Percent
Fatal	8	1.4%
Injury/transported	135	23.9%
Towed/disabled	61	10.8%
Towed/unknown if disabled	92	16.3%
Unknown if towed	119	21.1%
None (no injury, no towing)	149	26.4%
Total	**564**	**100.0%**

Table 7 shows the distribution of vehicle configurations as classified in the State crash files for these crashes. Implicitly, by classifying as MCMIS-reportable, the carriers identified all as meeting the MCMIS vehicle type standard. However, many were classified differently in the State data. Typically, for police-reported data, vehicle type classification was made by reporting officers at the scene, so this classification represented the officers' coding. Passenger cars, light trucks, and other light vehicles do not qualify unless carrying amounts of hazardous materials (hazmat) requiring a placard. As identified in the State data, about 28 percent of the cases identified by carriers as reportable were classified as light vehicles, and thus, based on this classification, would not be reportable. Recognizing trucks that are on the border between reportable and not-reportable accounted for a substantial portion of the problem of identifying vehicles in crashes that meet the MCMIS reporting threshold.

Table 7. Vehicle type in State files for crashes carriers identified as MCMIS-reportable not found in MCMIS but matched to crash records in 15-State sample.

Vehicle type	Number	Percent
Passenger car	8	1.4%
Light truck/van	88	15.6%
Other light vehicle	63	11.2%
Bus 9-15	1	0.2%
SUT 2xl	132	23.4%
SUT 3xl	9	1.6%
SUT /trailer	25	4.4%
Bobtail tractor	10	1.8%
Tractor-semitrailer (TS)	136	24.1%
Tractor, 2 trailers	39	6.9%
Tractor, 3 trailers	1	0.2%
TS/SUT with trailer	14	2.5%
Tractor 2/3 trailers	2	0.4%
Unknown truck	34	6.0%
Unknown vehicle type	2	0.4%
Total	**564**	**100.0%**

However, the carrier data for these crashes included several other data items that were used to determine if the vehicles met the MCMIS vehicle type threshold. Some carriers included the VIN, make/model, or the actual gross vehicle weight rating (GVWR) of the vehicles. All vehicles classified in State data as light vehicles or unknown vehicle types were reviewed, either by decoding the VIN to extract the GVWR or by checking the carriers' data on the vehicle's GVWR. The review showed that the classification of light vehicles in the State data was incorrect in 86 percent of the records. In most of these instances, the reporting officers incorrectly classified two-axle SUTs as light vans, pickups, and in some cases, passenger vehicles.

Table 8 provides a summary classification of the vehicles belonging to study carriers with respect to the MCMIS vehicle type criteria, (after correcting for the misclassification of light vehicles in the State data) for crashes carriers identified as MCMIS-reportable that could not be matched to MCMIS, but were matched to the State crash records from the 15-State sample.. Of these cases, 2.7 percent were light vehicles and so would not qualify for reporting to MCMIS. However, almost a quarter of the vehicles were misclassified in State data. The misclassification of trucks as light vehicles would cause States to fail to identify the crashes as MCMIS-reportable, even if the crashes otherwise met the severity threshold.

Table 8. Vehicle type based on carrier data for crashes carriers identified as MCMIS-reportable not found in MCMIS, but matched to crash records in 15-State sample.

Vehicle type	Number	Percent
Light vehicle	15	2.7%
Light vehicle with hazmat in placardable amounts	6	1.1%
Truck	402	71.3%
Truck misclassified as light	139	24.6%
Unknown	2	0.4%
Total	**564**	**100.0%**

Finally, Table 9 shows the cross-classification of crashes identified by carriers as MCMIS-reportable with how they were identified in State crash data. This table essentially shows the cross-classification of Table 6 and Table 8 above. This table can be used to classify 1) crashes in which the States had the data needed to determine if a crash met the MCMIS threshold, 2) crashes where the State data was likely incorrect, and 3) crashes where the States had insufficient or ambiguous data.

The 140 records in the shaded cells (upper left portion of the table) certainly qualified as reportable, based on how they were recorded in the State crash files. In addition, the 57 trucks misclassified as light vehicles in the top 3 rows also should have been reported, but presumably they were not because they were misclassified. The status of the 79 crashes with a qualifying truck and a vehicle towed, where it was unknown whether the towed vehicle was disabled, was ambiguous. Some portion of these likely qualified as towed/disabled. The remainder of the 564 crashes, 61.1 percent (excluding a case in which vehicle type was unknown but the crash met the MCMIS severity threshold), did not meet the reporting threshold, as classified in State data. The 76 cases involving a State-identified truck, where it was unknown whether a vehicle was towed or not, were most likely not towed, with the officer responsible for completing the report leaving that particular field blank.

Table 9. Classification of crashes carriers identified as MCMIS-reportable not found in MCMIS, but matched to crash records in 15-State sample, by crash severity and study carrier vehicle type.

MCMIS Crash Severity	Truck	Light Vehicle w/Hazmat	Truck, Misclassified as Light	Light Vehicle	Unknown Type	Total
Fatal	6	1	0	1	0	**8**
Injury/transported	90	2	38	4	1	**135**
Towed/disabled	40	1	19	1	0	**61**
Towed/unknown if disabled	79	0	12	1	0	**92**
Unknown if towed	76	0	39	4	0	**119**
None	111	2	31	4	1	**149**
Total	**402**	**6**	**139**	**15**	**2**	**564**

Table 10 summarizes the main results from Table 9. Almost 25 percent of the records should have been reported to the MCMIS crash file, based solely on how they were coded in State data.

The records met both the vehicle type and crash severity criteria to qualify for reporting and should have been extracted for MCMIS. An additional 10.1 percent could have been reported had they not been misclassified as light vehicle collisions (carrier information confirmed that they involved qualifying trucks). They were likely missed in the State extraction process because the vehicle type was coded incorrectly. The records labeled “possible,” may have been reportable, but that could not be determined with certainty. The data for these crashes in the State files indicated that at least one vehicle in the crash was towed, but the data did not show whether the towed vehicle(s) was disabled or not. Seventy-nine of the “possibles” were correctly identified as trucks, while 12 were misclassified as light vehicles. Finally, almost 49 percent of the crashes in State data that carriers had identified as reportable did not qualify for reporting, primarily because they did not meet the MCMIS crash severity threshold.

Table 10. Classification of carrier crashes relative to MCMIS reporting criteria, for crashes carriers identified as MCMIS-reportable not found in MCMIS but matched to crash records in 15-State sample.

Met MCMIS Reporting Criteria?	Number	Percent
Yes: Vehicle type correctly classified	140	24.8%
Yes: Misclassified as light	57	10.1%
Possible: Towed/unknown if disabled	79	14.0%
Possible: Towed/unknown if disabled; misclassified as light	12	2.1%
No	276	48.9%
Total	**564**	**100.0%**

Whether the “possibles” actually qualified for reporting to the MCMIS crash file depends on whether one of the towed vehicles in these crashes had been disabled in the crash. A reasonable estimate of that proportion can be formed using GES data. Data for trucks in crashes (for the 3-year study time frame—2012–14), were analyzed to estimate the proportion of towed vehicles that were also coded as disabled. This proportion was calculated for crashes where there was no fatality and no injured person transported for immediate medical attention (i.e., the crash would not have otherwise met the MCMIS crash severity). In the GES data, 84 percent of vehicles towed in crashes with no fatalities and no injuries were coded as disabled. Applying this proportion to the 14.0 percent of cases in the “towed/unknowd disabled” category suggests that about 11.8 percentage points of that 14 percent likely represents vehicles towed due to disabling damage; similarly, 1.8 percentage points of the trucks misclassified as light vehicles would also have qualified as towed due to disabling damage.

Based on these calculations, UMTRI estimated the percentage of the 564 carrier-identified, MCMIS-reportable crashes in State crash files that should have been reported to MCMIS. Just using the records as they appeared in the State files (including the States’ classification of vehicle type), 36.6 percent of the records should have been reported. This included the 24.8 percent that were correctly classified as trucks and in crashes that clearly met the MCMIS crash severity criterion, plus the 11.8 percent estimated to be in towed/disabled crashes. However, there was also a substantial number of trucks misclassified as light vehicles. Including these cases added another 11.9 percent (10.1 percent plus 1.8 percent) to those that should have been reported. States misclassified the vehicles, but the carriers correctly identified them as reportable. Thus 48.5 percent (0.336 + 0.119) of these 564 crashes should have been reported by the States to the MCMIS crash file. The remaining crashes, 51.5 percent of the 564 carrier-identified, MCMIS-reportable crashes identified in State crash files, did not meet the MCMIS crash reporting criteria.

8.1 EVALUATION OF UNDERREPORTING OF REPORTABLE CRASHES IN STATE FILES

The records of crashes in State files that met the MCMIS reporting threshold and were not reported to the MCMIS file were further analyzed to identify possible reasons for the omissions. Based on the data in the State crash files, these crashes should have been reported by the States and uploaded to the MCMIS file, but they were not. The question is, why?

One primary reason for underreporting from State crash files was that officers misclassified trucks (mostly two-axle SUTs) as light vehicles. As shown in Table 9, trucks misclassified as light vehicles accounted for almost a quarter (24.5 percent) of the missed cases in the State data. Vehicles miscoded at the scene in the crash report would not be recognized as meeting the MCMIS vehicle type criterion.

Some of the States included USDOT numbers in the data provided to UMTRI. As part of the data collection on matched cases, coders recorded whether the USDOT number for the record was correct, incorrect, or missing. Of the 564 “matched” records, 168 should have been reported to the MCMIS file (i.e., the vehicle type was correct and the crash severity met the requirement). In 48.2 percent of these records, the USDOT number was correct. However, in 16.1 percent, the USDOT number was incorrect, and in 35.7 percent, the USDOT number was missing altogether.

For cases that were reportable and that had correct USDOT numbers, the failure to identify, extract, and upload to the MCMIS file must have occurred elsewhere in the process. The evidence was that the reporting officer recorded data that met the MCMIS reporting threshold and also correctly identified the carrier of record. The failure occurred sometime after that point.

In the cases that qualified for reporting where the USDOT number was left blank, the most plausible explanation is that the reporting officer simply failed to complete the report. The vehicle was operated by a motor carrier and met the reporting threshold, but somehow the officer failed to recognize the case properly and complete all the data needed. Supporting this interpretation, in almost half (45 percent) of the cases with missing USDOT numbers, the vehicle was coded as a two-axle SUT. Two-axle SUTs accounted for only about 18 percent of the MCMIS-reported crashes for these carriers, so it is clear that trucks at the borderline of the range of qualifying vehicles were more likely not to be reported to MCMIS by the State. Thus, State crash records with missing USDOT numbers may represent cases where the reporting officers did not recognize that the trucks were large enough to meet the MCMIS threshold.

In an additional 28 percent of the cases with missing USDOT numbers, the vehicles were coded as unknown trucks. The most straightforward interpretation is that the reporting officers did not recognize the vehicles as meeting the MCMIS standard. Most police officers only rarely cover truck crashes, so it is not surprising that they sometimes miss important details about the vehicles.

In cases where the USDOT number was incorrect, some appear to have been typographical or transcription errors. The State-recorded USDOT numbers were similar to the correct USDOT numbers, but they differed by a digit, a digit was left off, or two digits were reversed. In other cases, the USDOT numbers were not obvious transcription errors. Incorrect USDOT numbers could account for some level of underreporting. These cases may have been uploaded to the MCMIS file but credited to a different carrier. According to the managers of the carriers' data, the cases would be unreported because they would not be among those attributed to the carriers.

However, another explanation might be confusion over operating authority for the trucks at the time of the crashes. Some carriers contract with owner-operators to haul loads. The owner-operators may have their own authority (i.e., their own USDOT numbers), but when contracted to another carrier, they use the operating authority of the carrier responsible for the load. Thus, at the time of the crashes, there could be confusion as to the correct operating authority. For the purpose of the MCMIS crash file, crashes are attributed to the USDOT number of the entity responsible for the particular loads. The reporting officers may have simply chosen the wrong one at the scene of the crashes.

It should be noted that crashes covered by police departments or county sheriffs had significantly higher rates of missing and incorrect USDOT numbers. Of the unreported cases, State police had the correct USDOT numbers in 62 percent of the cases they covered (as shown in Figure 5). County sheriffs had the highest rate of missing USDOT numbers, at 78 percent, with police departments missing 45 percent.

Differences may be related to differences in the level of training and enforcement focus. State police often patrol highways and focus more on traffic safety and enforcement. Therefore, they may deal more often with truck crashes. Local police departments and sheriffs may have more general law enforcement responsibilities and work with fewer truck crashes, thus they may be less familiar with trucks and truck operations.

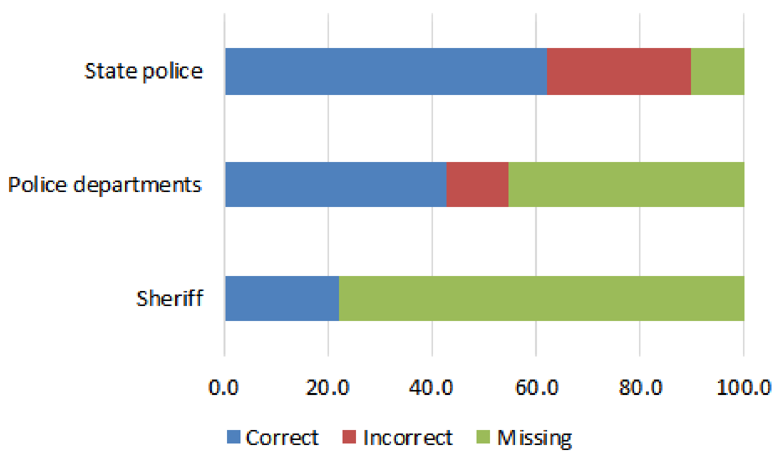

Figure 5. Bar chart. Status of USDOT number in State data on MCMIS-reportable crashes not reported to MCMIS, by enforcement agency.

In total, it was estimated that about half of the reportable crash involvements identified in State files that were not found in MCMIS were likely either not reported or incorrectly reported because of missing or incorrect USDOT numbers in the crash reports.

8.2 FATAL CRASHES NOT REPORTED

The eight fatal crash involvements identified in the carrier data but not found in the MCMIS crash file are of particular interest because of their seriousness. All eight were found in a search of State crash records. Since the crashes included a fatality, it was expected that they would have received greater attention at the State level, so it was particularly unexpected that they apparently had not been reported to the MCMIS crash file.

One of the eight fatal crashes did not involve any vehicles meeting the MCMIS vehicle type criteria. However, the other seven all involved qualifying trucks and so should have been reported to the MCMIS crash file.

In three of the seven, the USDOT number was missing. In another three, an incorrect USDOT number was entered, or at least the USDOT numbers entered did not match the USDOT numbers of the carriers who supplied the data to us. For these six cases, the most likely explanation is that errors in recording the USDOT number on State crash reports accounted for the crash not being found in MCMIS.

However, in the final case the USDOT number in the State file matched the USDOT number of the carrier that supplied the data, so the record should have been among the MCMIS crashes for that carrier. All MCMIS crash records (i.e., not just those having the carrier's USDOT number) were searched in an effort to find this case, and it was located in the MCMIS crash file. In fact, it appears that the case had been uploaded by the State with the correct USDOT number, but the number had been subsequently changed so that it was on the record of another carrier. The MCMIS crash file includes a variable for UPLOAD_DOT_NUMBER, which records the USDOT number when uploaded. In this case, the number in that variable matches the carrier's USDOT number. However, uploaded records go through a process of census search (to determine whether other crash records from the same carrier are located in the file), and it is likely that the USDOT number was changed at this point and the crash attributed to another carrier. There may have been some mismatch between the number and carrier name or some other discrepancy that caused the number to be changed.

In any case, all eight fatal involvements were accounted for: one was a light vehicle, six had missing or incorrect USDOT numbers, and in the final case, the USDOT number was changed after being uploaded to the MCMIS file.

8.3 CRASHES CARRIERS IDENTIFIED AS MCMIS-REPORTABLE BUT NOT FOUND IN STATE FILES

For a crash record to appear in the MCMIS crash file, it must first be appropriately reported in a State crash file. The previous section analyzed the set of crashes that met three criteria: 1) they had been identified by the participating carriers as meeting the MCMIS reporting requirements;

2) they appeared in State files, and 3) they did not appear in the MCMIS file. This section reviews available data on those crashes identified by study carriers as MCMIS-reportable that could not be found in either MCMIS or State crash records.

The search process described in Section 7.2.1 identified 710 carrier-identified MCMIS-recordable crashes not found in MCMIS that could also not be found among the State crash data. These records had all been classified by carriers as meeting the MCMIS reporting threshold, and therefore they should also have met all the requirements for a police-reported crash. However, a careful search of State crash data failed to find matching records. It is of course possible that some actually were present in the State dataset but were not found because of data entry errors. For example, if dates were recorded incorrectly, (which happened in a small number of cases in the MCMIS match), a match would be impossible. However, the greatest likelihood is that the matching process failed because no police crash reports were filed for the unmatched carrier records. While the matching process could have included errors, UMTRI assumed these unmatched cases to be instances where no police report was filed.

All available information in the carrier records was reviewed to help determine whether the unreported crashes met the MCMIS reporting criteria. The amount of information varied between carriers but generally included counts of injuries (there were no crashes with fatalities in this group), whether a vehicle was towed (though generally not whether it was disabled), crash location, GVWR of the carrier's vehicle, and unstructured text descriptions of the crashes. Carriers' descriptions of crashes were particularly useful because they often included pertinent details, such as injured persons transported for medical attention or specific details about crash locations. The data supplied by several of the carriers included a field for "towed," but such fields did not indicate whether the tow was due to disabling damage or for some other reason. Similar ambiguities were present for fields that recorded counts of injuries. Crash narratives sometimes clarified whether vehicles were disabled or injuries were transported for treatment.

The review showed that these crashes were a mixture of widely differing situations. Accordingly, the cases were sorted into different groups that reflected the realities of crash reporting. Crashes were classified as either clearly reportable, likely reportable, possibly reportable if a towed vehicle had been disabled, likely not reportable, and clearly not reportable.

Crashes classified as clearly reportable ("Yes") included cases where it was stated that an injured person was transported for immediate medical attention or a vehicle was towed because it had been disabled. These events were clearly traffic crashes, involved a truck, and met the MCMIS severity threshold.

Crashes were classified as likely reportable ("Likely yes") if the description suggested a high probability of serious injury or vehicle damage, such as head-on collisions or vehicles out of control colliding with the truck.

Crashes classified as possibly MCMIS-reportable ("Maybe, if towed") appeared to be relatively minor, with no recorded injuries but with a towed vehicle. Disabling damage was not indicated, but the record was classified as possible because if the towed vehicle were disabled, the crash would meet the MCMIS threshold.

Likely not reportable crashes ("Likely no") appeared to be minor crashes with no indication that any vehicle was towed. These included crashes at locations such as customer lots, parking lots, fuel stops, and locations where the description of the crash suggested it was minor (backed into pole) or in situations where the location (such as a customer's lot or other parking lot) may not have qualified the event as a police-reported crash.

The "No" category included a number of events that were deemed not to be traffic crashes, such as trailer drops, engine or other fires while parked, or a hit and run crash in a parking lot.

In addition to these categories, it was useful to call out other circumstances that might technically qualify crashes as MCMIS-reportable but would realistically reduce the probability that they would be reported. These events largely comprised single-vehicle crashes in which trucks hit road debris or animals and suffered damage that rendered the trucks undrivable. Most of these crashes involved animal strikes with radiator leaks, punctured fuel tanks, or damage to the steering mechanisms. In such circumstances, particularly since they did not involve another vehicle, police may not have been called, or if the police were notified, they may not have filed crash reports.

Table 11 shows the result of the carrier data review. About one out of six (16.3 percent) of the crashes reviewed were classified as reportable or likely reportable. These were cases that clearly seemed to meet the MCMIS reporting threshold, should have appeared in the State crash data, and should have been reported to the MCMIS file. An additional 36.8 percent may have been reportable, if a vehicle towed had suffered disabling damage. About 30 percent of the crash records were judged either not reportable or likely not reportable. Most of these cases were minor incidents where no vehicles were towed and no injuries were reported, or they were non-crashes such as dropped trailers or engine fires while parked. Some occurred in areas typically not subject to police crash reports, such as customer loading docks or operational centers of the carriers. An additional 3.4 percent of the records did not qualify because the vehicles were not qualifying trucks (i.e., the carriers' records indicated that the vehicles' GVWRs were under 10,001 pounds, and there was no indication that they were transporting hazmat).

Table 11. Classification of crashes identified by carriers as MCMIS-reportable but not found in MCMIS or State data, according to MCMIS reporting criteria.

Met MCMIS Reporting Criteria?	Number	Percent
Yes	28	3.9%
Likely yes	88	12.4%
Maybe, if towed	261	36.8%
Likely no	109	15.4%
No	104	14.6%
No, light duty	24	3.4%
Road debris, damage	18	2.5%
Deer/animal – minor	71	10.0%
Unknown	7	1.0%
Total	**710**	**100.0%**

Finally, 12.5 percent of the records reviewed here were for crashes that involved colliding with wildlife or road debris, resulting in damage to the trucks that made them undrivable. In most cases, the damage was described as a leaking radiator. It is entirely plausible that in many of these “crashes,” no police report was filed. However, such cases technically qualified as MCMIS-reportable because such incidents were traffic crashes and involved vehicles towed due to disabling damage.

In sum, about a third of the crashes identified in carrier files as MCMIS-reportable and not found in either the MCMIS file or a State crash file were likely not MCMIS-reportable crashes. Some were not traffic crashes at all.

However, it also appears that at least 29 percent (those classified by UMTRI in Table 11 as yes, likely yes, road debris, and deer/animal strikes) in all likelihood met the threshold for a MCMIS-reportable crash. In addition, some portion of the 36.8 percent of crashes in which a vehicle was towed also qualified. As discussed in Section 8, analysis of GES data showed that about 84 percent of towed vehicles in truck-involved crashes were disabled, so we can estimate that an additional 31 percent (0.84 x 0.368) of these crashes should have been in the State files and reported to MCMIS.

Accordingly, it is reasonable to estimate that about 60 percent of the crashes identified by carriers as MCMIS-reportable but not found in MCMIS and not found in State crash files probably should have been in the State crash files and reported to the MCMIS crash file. That percentage could be as high as 65 percent if vehicles were disabled in all the crashes with towed vehicles. However, about 33 percent of records likely did not qualify and were identified incorrectly by the carriers as MCMIS-reportable.

9. SYNTHESIS OF THE RESULTS: MCMIS-REPORTABLE CRASHES IN THE MCMIS FILE, STATE CRASH FILES, AND CARRIER RECORDS

This section presents an estimate of the number of MCMIS-reportable crashes in the carrier files. The evaluations that led to the estimates required several distinct and complex activities. The steps included: 1) matching carrier files to the MCMIS crash file, 2) matching records not found in the MCMIS file to many State files, and 3) reviewing records not found in either the MCMIS file or the State files.

This section synthesizes the results of these activities in an attempt to answer three questions:

1. How many additional MCMIS-reportable crashes were in carrier records?
2. How reliable was carrier identification of MCMIS-reportable crashes?
3. What is the implied level of underreporting to the MCMIS crash file, based on the carrier files?

Matching crash records carriers identified as MCMIS-reportable with the MCMIS crash file left a substantial number of records that were not in the MCMIS crash file. Referring to Figure 3, 4,507 candidate records from carrier files were not found in the MCMIS crash file.

9.1 MATCHING CARRIER-IDENTIFIED RECORDS NOT FOUND IN MCMIS TO STATE CRASH FILES

A protocol was developed to search for these 4,507 records in State crash data. It was not feasible to search for all 4,507 crashes in the 49 States (study carriers had no crashes in Hawaii) and the District of Columbia represented by the crashes, so a subset of crashes that occurred in 15 States was used. These 1,462 crashes served as a reasonably representative sample of the 4,507 crashes not found in MCMIS.

The search of State data found 44.3 percent of the 1,462 records, while 55.7 percent apparently existed only in the carrier records (Figure 4). Applying these percentages to the overall number of candidate carrier records (4,507) estimates that 1,995 (0.443 x 4,507) were in State data files and 2,512 (0.557 x 4,507) were in the carrier files only.

Evaluation of the carrier-identified reportable records not in MCMIS, but found in state files, suggests that 48.5 percent met the MCMIS reporting criteria for vehicle type and crash severity. Details for this estimate can be found in Section 8.1. Applying this percentage to the estimated 1,995 carrier-identified reportable crashes in State data files but not in MCMIS estimates that 967 (0.485 x 1,995) additional crashes from the study carriers should have been reported to MCMIS from State crash files.

9.2 REVIEWING RECORDS NOT FOUND IN EITHER THE MCMIS FILE OR STATE FILES

Evaluation of the candidate records found only in carrier records estimated that about 60 percent met the MCMIS reporting criteria for vehicle type and crash severity. Details for this estimate can be found in Section 8.3. Applying this percentage to the 2,512 records found only in the carriers' files but not in State files estimates that 1,501 additional crashes for the carriers should have been reported to the MCMIS crash file.

The total additional MCMIS-reportable crashes found among the carrier-identified reportable crashes is 2,468 (967 +1,501). These additional MCMIS-reportable crashes amount to about 29 percent of the carrier-identified reportable crashes in the carrier's files (see Table 12.) In total, about 76 percent of the crashes identified by the carriers as reportable to the MCMIS crash file were determined to actually be reportable, while about 24 percent were classified as most likely not meeting the threshold for the file.

Table 12. Disposition of crashes carriers identified as MCMIS-reportable.

Status	Number	Percent
In MCMIS crash file	3,885	46.3%
Estimated reportable crashes not in MCMIS	2,468	29.4%
Estimated crashes incorrectly identified as reportable	2,039	24.3%
Total crashes carriers identified as MCMIS-reportable	**8,392**	**100.0%**

In addition to the 8,392 records that carriers identified as reportable, the MCMIS crash file contained 303 records that were in carriers' files but not identified as reportable by the carriers themselves, as well as 589 records that were (likely) not in the carriers' records at all. Thus, while carrier records included a substantial number of crashes that met the MCMIS crash reporting threshold but were unreported, carriers were also involved in a significant number of reportable crashes that they did not identify as reportable (as shown in Table 13). Carriers correctly identified as reportable 3,885 of the crashes already in the MCMIS crash file, plus an estimated 2,468 crashes in State records or their own, to total 6,353 estimated crash involvements correctly identified as reportable. But carrier files also contained 303 crash records incorrectly identified as not reportable, plus an estimated 2,039 records identified as reportable that were determined to be not reportable. In addition, carrier records missed 589 crashes that were reported to the MCMIS file. Thus, considering the total number of crashes carriers identified as reportable, plus the crashes they either misclassified as not reportable or missed altogether, carriers identified about 68 percent correctly, 25 percent incorrectly, and missed 6 percent altogether.

Table 13. Disposition of crashes carriers identified as MCMIS-reportable by accuracy of identification.

Status	Number	Percent
Correctly identified by carriers as reportable	6,353	68.4%
Incorrectly identified by carriers as reportable*	2,039	22.0%
Incorrectly identified by carriers as not reportable	303	3.3%
Missed altogether	589	6.3%
Total	**9,284**	**100.0%**

*Counts in this row are estimated.

From the perspective of crashes that should have been reported to the MCMIS crash file, we estimate, from review of the MCMIS file, carrier crash records, and State data files, that 7,245 crashes should have been reported (as shown in Table 14). Of these, almost 70 percent actually were reported, while about 31 percent of the crashes that should have been reported to the MCMIS crash file were missed.

Table 14. Net MCMIS-reportable crashes associated with study carriers from review of carrier crash records and State files.

Status	Number	Percent
Both in MCMIS & carrier files	3,885	53.6%
Incorrectly identified in carrier files as not reportable but in MCMIS	303	4.2%
Not in carrier files but in MCMIS	589	8.1%
Additional reportable crashes not in MCMIS but in carrier files	2,468	34.1%
Total	**7,245**	**100.0%**

Accordingly, the answers to the questions proposed at the beginning of this section are as follows:

1. How many additional MCMIS-reportable crashes were in carrier records?

The best estimate is that about 2,468 additional records identified by the study carriers should have been reported to the MCMIS crash file but were not. For the carriers studied, 4,777 crashes were reported to MCMIS. An additional 2,468 should have been reported.

2. How reliable was carrier identification of MCMIS-reportable crashes?

Overall, the reliability of the carrier's identification of MCMIS-reportable crashes in carrier files was similar to that of the MCMIS file. In other words, the study carriers' success rate was similar to the success rate of States in reporting to the MCMIS file for those carriers. Summarized in Table 12 and Table 13, carriers correctly identified about two-thirds of the crashes as MCMIS-reportable. They identified about 25 percent of their crashes as reportable when they were not, and they missed about 6 percent of their reportable crashes.

3. What is the implied level of underreporting to the MCMIS crash file, based on the carrier files?

It appears that the MCMIS crash file contained about 66 percent of the reportable crashes for the study carriers. Based on the results of the review, underreporting was estimated to be about 34 percent.

10. SOURCES OF UNDERREPORTING

For crashes to be submitted to the MCMIS crash file, they must first be reported to State crash databases (that is, a police report must be filed on them). The search in State crash databases for those carrier-identified reportable crashes not in the MCMIS crash file showed that about 56 percent very likely did not have a police report filed. Regardless of whether these crashes met the criteria for the MCMIS crash file, they could not be found in State data and likely did not have a police report filed. Therefore, one major initial source of underreporting was that no police report was filed on the crashes in the first place.

The only information available about carrier crashes not found in either the MCMIS crash file or State data comes from the carriers' data. The carriers' data were reviewed to characterize the nature of the crashes, particularly in terms of their severity. Not surprisingly, it appears that these events for which no crash report appears to have been filed tended to be minor. About 83 percent were crashes in which the most severe event was that a vehicle was towed. Many of those crashes were single-vehicle events in which trucks struck deer, other animals, or road debris and suffered serious enough damage that a tow was required. These crashes technically qualified for reporting to the MCMIS file and were counted as such in estimating underreporting to the MCMIS file in this study. But they may not have had crash reports filed because the carriers did not notify the police or because the police declined to file crash reports.

In the remainder of these crashes, there was an indication of an injury transported for immediate medical attention. It is surprising that no police report may have been filed in such cases. In fact, there may have been a crash report in some cases, but the matching record was not found. It is possible that crash times and locations in carrier and State files were too different to identify a match, or there may have been some other break in the process or error in the police report. Nevertheless, it seems reasonably clear that most of the crashes not reported in State files were relatively minor.

The remaining 44 percent of the crashes were found in the State files, but they had not been reported by the States to the MCMIS file. Section 8.1 discusses the crash records found in State files more fully, but the major findings are summarized here. One major source of underreporting was the misclassification of trucks as light vehicles. Almost 25 percent of the crash vehicles in State files were coded as light vehicles. Review of their VINs and carrier data on the vehicles' GVWRs showed that they were in fact qualifying trucks. Since the vehicles were not correctly identified on police reports, they would not have been identified as candidates for the MCMIS crash file when the states extracted the data for upload to the MCMIS file.

Other sources for errors at the State level included missing and incorrect USDOT numbers. In over half of the cases in State files that should have been (but were not) found in MCMIS, USDOT numbers were missing or wrong. Missing numbers may have been due to police officers not recognizing that the crashes met the MCMIS reporting criteria and not completing all the needed information. These omissions could have resulted from inadequate training, competing priorities, or for other reasons. It is noteworthy that crash reports completed by State police agencies tended to have higher rates of reporting USDOT numbers accurately. There were also transcription errors in recording USDOT numbers. Both incorrect and missing USDOT numbers, would be obstacles to complete reporting and assigning crashes to the correct carriers.

The literature evaluating State reporting to the MCMIS crash file suggested two other factors in State underreporting. One factor was that crashes only involving in-State trucks were less likely to be recognized as meeting the requirements for reporting. Figure 6 compares the distribution of State-of-license (in-State vs. out-of-State) for trucks involved in crashes correctly reported to the MCMIS file and for trucks involved in crashes that should have been reported to MCMIS, but were not recognized as such by State personnel. For crashes uploaded to MCMIS involving the carriers in this study, over 70 percent involved trucks licensed outside the States where the crashes occurred. These crashes were recognized as fitting the Federal reporting requirements. However, for the carriers' crashes that were not recognized as reportable in the State crash files, the split of in-State/out-of-State licensing was closer to 50-50. About 47 percent were in-State licensed trucks and 51 percent were trucks licensed out of the State of the crash. Among crashes meeting the MCMIS reporting criteria, trucks in MCMIS-reportable crashes with out-of-State license plates were more likely to be reported than in-State trucks. Note that these are records for crashes that had all the information needed to be identified as reportable and should have been extracted and uploaded to the MCMIS crash file.

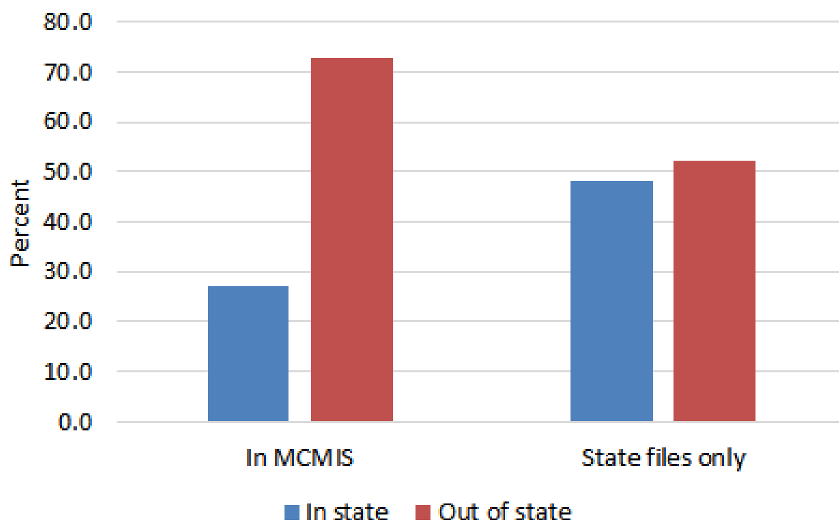

Figure 6. Bar chart. Distribution of truck license state of MCMIS-reportable carrier crashes in MCMIS and MCMIS-reportable carrier crashes in state files only

Similarly, common—indeed, stereotypical—heavy-truck configurations like tractor-semitrailers and doubles were more likely to be recognized as meeting the requirements of the Federal truck crash database than medium-duty trucks. The trucks in the cases that were properly reported to the MCMIS crash file were predominantly tractor-semitrailers and doubles (see Figure 7). In contrast, the trucks from the same carriers in the State files that were not reported were much more likely to be two-axle SUTs, which is the smallest vehicle that meets the MCMIS vehicle type threshold (save for light vehicles placarded for hazmat). About 32 percent of the study carriers' unreported crashes involved vehicles that were two-axle SUTs, and only 18 percent of these carriers' crashes reported to MCMIS had this same configuration. Similarly, 66.6 percent of trucks reported to MCMIS for the study carriers were tractor-semitrailers or doubles, compared with 44.7 percent of the trucks that should have been reported, but were missed. Again, these are cases where the State data has the information needed to identify the crashes as reportable to the MCMIS file. Somehow, at the stage where cases were extracted to be uploaded, they were not recognized as meeting the reporting requirements.

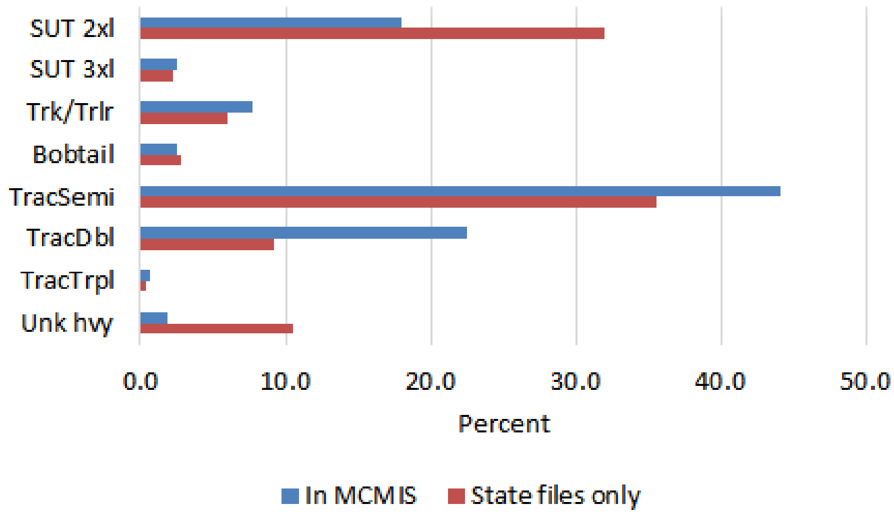

Figure 7. Bar chart. Distribution of truck configuration in MCMIS-reportable carrier crashes found in MCMIS and MCMIS-reportable carrier crashes found in State files only.

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11. DISCUSSION

Ultimately, the MCMIS crash file is compiled from State crash data files. Thus, in some sense, the data collectors for the file are law enforcement officers who may be called upon to cover a crash involving a truck. Bureau of Labor Statistics data estimates that there were 653,740 police and sheriff's patrol officers in the United States in 2015.[ix] These are the men and women who completed the crash reports on which the MCMIS crash file is based. On average, over the 3-year study time frame (2012–14), about 370,000 trucks were involved in reported traffic crashes per year. Considering only crashes reportable to the MCMIS file, it is estimated there were 136,000 trucks involved annually from 2012 to 2014 (see Table 3). That means if the crash reporting load were distributed evenly among all police officers in the United States, each one would see a truck in a crash about every 1.8 years and a truck in a MCMIS-reportable crash about every 5 years.

This study estimated a significant amount of underreporting to the MCMIS crash file, at least for the carriers who cooperated in the study. For those carriers, it appears that the MCMIS file contained about 66 percent of all reportable crashes.

Several sources of underreporting were identified. Arranging them in chronological order, moving from crash event to State crash file to the MCMIS crash file, highlights the weak links in the reporting process.

1. About 56 percent of the missing crashes apparently had no police report filed. They were in the carriers' crash data, but were not found in State crash data. If no crash report is filed, the case cannot appear in the MCMIS crash file.

   Many of these crashes could be considered minor, in that they met the towed/disabled criterion only. It is impossible to know now why the police were not called or why a crash report was not filed, but this observation is consistent with the general level of underreporting of traffic crashes. Many of the unreported crashes were deer or other animal strikes, with radiator leaks or punctured fuel tanks, which effectively disabled the vehicles. That crash reports were not filed for such incidents is not surprising, even if they technically qualified for the MCMIS crash file.

2. Among crashes reported to State crash files, several factors may have contributed to some not being uploaded or not being found in the MCMIS crash file. Some were most likely attributable to errors and omissions by the officers completing the crash reports:

   a. In about half of the cases of crashes in State files not found in MCMIS, the USDOT number was either missing or incorrect. These were most likely cases where the reporting police office either failed to recognize the need to capture

[ix] Bureau of Labor Statistics, Occupational Employment and Wages, estimate for May 2015. At http://www.bls.gov/oes/current/oes333051.htm.

that information, was unable to identify the correct number, or simply transcribed the information incorrectly.

b. About 24 percent of the records missed were medium- and heavy-duty trucks that were misclassified as light vehicles.

c. Two-axle SUTs were overrepresented among reportable crashes that were missed. Many of the trucks in cases identified by carriers as MCMIS-reportable were misclassified as light vehicles by the reporting officers. This points to a problem in determining the vehicle's GVWR correctly, which is one of the fundamental reporting criteria for MCMIS.

d. Similarly, MCMIS-reportable crashes involving only trucks with in-State plates were unreported at a higher rate than those involving a truck with out-of-State plates. This finding was consistent with the notion that officers often do not recognize that such vehicles meet the MCMIS vehicle type threshold.

e. Finally, in about half of the MCMIS-reportable cases in State files that were not reported, the crash severity as coded met the MCMIS severity threshold and the vehicles met the MCMIS vehicle criteria. Allowing for some errors in matching, this points to problems within State systems in identifying crashes in their data that meet the MCMIS standard and uploading those crashes to the file.

In terms of minor crashes going unreported by the police, that has been a problem common to all traffic crashes and is not unique to truck and bus crashes. The parties may not have notified the police, or the police may have had higher priorities or simply not filled out a report for some other reason. However, the tendency for this to occur is more common for minor crashes. The current study of large truck and MCMIS crashes, prior evaluations of State reporting to MCMIS, and the recent national study of all traffic crashes have all shown that crash reporting is more complete for more severe crashes. Thus, one possible means of addressing underreporting related to crash severity would be simply to increase the severity threshold for reporting crashes to MCMIS.

Underreporting problems in general are more acute at the margins. In this study, crashes involving large vehicles obviously identifiable as trucks were reported at a higher rate than were those involving vehicles closer to MCMIS's vehicle-type threshold. Reporting officers apparently had greater difficulty recognizing medium-duty trucks as meeting the commercial vehicle definition than they had with larger trucks. MCMIS-reportable crashes involving tractor-semitrailers were reported at a higher rate than those involving two-axle SUTs. The GVWR threshold is in principle a clear line between reportable and not, but many officers had trouble applying it accurately.

Because police officers at the scene are so critical to the present process, this suggests moving to a system where it is not necessary for the reporting officer to identify vehicles meeting the inclusion threshold, instead using a process that makes the identification of reportable vehicles by automatic means not subject so directly to human error. This could be accomplished through linkage with other systems, through automated data collection from the vehicles at the crash sites, or by implementing automated checks by State data analysts responsible for extracting crash data from State systems for uploading to MCMIS via SAFETYNET.

There were also problems in cleanly applying the severity thresholds related to transported injuries and vehicles towed due to disabling damage. Both were clearly implicated in the tendency for carriers to over-identify reportable crashes. Both may also contribute to underreporting of crash reports.

With respect to the carriers, several included in their own crash data files coded fields for the number of injuries in crashes and yes/no fields recording whether a vehicle was towed. However, these data often did not indicate whether the injured person was transported for medical attention. This critical fact was only occasionally captured in text descriptions of the crashes. Similarly, whether vehicles were disabled or not was also often not captured in their data. Both omissions would lead carriers to over-identify MCMIS-reportable crashes.

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12. LIMITATIONS

The primary limitation of this study is that the carriers whose data were used were not representative in the sense of being a randomly selected sample of the population of carriers with crashes in the MCMIS crash file. Thus, it is not statistically valid to make inferences about the accuracy of the results from the limited sample of convenience.

Since the study was based on a convenience sample of carriers that were willing to cooperate and share sensitive crash data, there may be biasing effects. The study carriers may be more focused on safety and may have tended to over-identify MCMIS reportable crashes, or may have more detailed crash data to work with.

Similarly, the State crash data used in the study were also a sample of convenience, as it included all States that were willing to provide their data in time for the study. The evaluations of State reporting showed that States vary in the completeness of their reporting, so the set of States may have been biased toward or against full reporting.

In addition, there were likely errors and omissions at the different stages of record-matching performed by UMTRI. Records in carrier files may actually have been present in the MCMIS file, but not found because of errors in key variables in the MCMIS or carrier records, or errors on the part of the match team, or differences in the variables used for matching. If the errors were systematic (e.g., dates were more likely to be wrong for certain vehicle types or certain carriers), such systematic errors would contribute bias to the results. However, it is unlikely that there was a systematic bias in the distribution of errors in the variables used to match records that would affect the main results.

Moreover, it is noteworthy that the primary findings in this study are similar to those from the evaluations of State reporting to the MCMIS crash file, reported in Section 4. Evaluations of individual States fairly consistently found that reporting rates were lower for medium trucks than heavy trucks, for less severe crashes than more severe, and for in-State carriers than out-of-State. Those evaluations were based entirely on State crash data. Even though the sample of carriers in the present study was not representative in a statistical sense and the starting point was carrier crash data rather than State crash data, the findings are consistent with the findings from individual State evaluations.

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13. RECOMMENDATIONS

It should be recognized at the outset that perfect crash reporting in MCMIS has never been achieved, though it remains the goal. Traffic crashes are inherently chaotic events and resist being classified into neat binary categories. The goal in data collection is always to strive to increase reporting rates and improve the accuracy of the data in order to continue improving the tools used to identify unsafe carriers and increase highway safety. Crash databases, including the MCMIS crash file, are indispensable tools in addressing the problems of highway safety. Even though imperfect, there is no reasonable alternative.

The following recommendations are meant to reduce the burden of data collection on law enforcement officers, to increase reporting rates, and to reduce errors in the data. This study uncovered no single error or source of mistakes that was the key to major improvement. Data collection is unavoidably tedious and painstaking. However, there are steps that can be taken to increase the comprehensiveness of reporting and improve the accuracy and usefulness of the data.

The following are a set of suggestions to address several of the problems observed. They do not all need to be adopted at once and, in fact, some of the suggestions are mutually exclusive. For example, one suggestion is to raise the crash severity threshold to reduce the probability of underreporting, while another proposes simplifying reporting criteria by accepting all tow-away crashes, not just towed, disabled crashes. Competing interests will need to be balanced, such as accuracy versus comprehensiveness. The suggestions are intended to offer reasonable ways to address different, specific problems. Depending on how the different problems are valued, different suggestions could be adopted.

- **Simplify the MCMIS crash reporting criteria.** A large share of the underreporting problem occurred at the boundary between reportable and non-reportable crashes. This was true for both carriers and States in identifying reportable cases.

  The MCMIS crash severity threshold is, in principle, an astute means of identifying a crash severity consistently across States. It is known that States vary in classifying injury severity. Adding the qualification that the injured be transported for medical attention presumably produces more consistency. However, it also produces more errors of omission, as the current and other studies have shown. As a general rule, the more qualifiers associated with a variable, the higher the error rate. In addition, determining if a case qualified as MCMIS-reportable often required looking at multiple variables in the data, first to see if a person was injured and then to determine if the person was transported. Some States coded transportation for treatment directly, but in others it was necessary to infer from EMS run codes or hospital codes. Every additional qualifier adds to the error rate.

  The same principle holds for the MCMIS towed/disabled reporting criterion. Some States code “towed due to disabling damage” directly; in other States, whether a vehicle is disabled is embedded in “vehicle damage” severity fields. As a general rule, each field in a crash report should collect only one type of information. And, as with the "injury/transported" problem, adding qualifiers adds to the error rate. Based on these considerations, FMCSA should consider dropping the requirement for disabling damage.

- **Consider raising the crash severity threshold to qualify for reporting crashes to MCMIS.** This study and others have found that the problem of underreporting is more severe for minor crashes. The completeness of reporting increases with crash severity.
- **Encourage all States to collect the same crash data for all vehicles.** One consistent finding was that problems occurred when collecting the data depended on officers recognizing that vehicles or crashes met the MCMIS reporting criteria. By collecting the same information on all vehicles in all crashes, officers would be relieved of some of the burden of assuming the role of data collectors in addition to being law enforcement officers.
- **Automate data collection as much as possible.** Transcription errors and errors of omission could be significantly reduced if, for example, carrier and vehicle information were collected by scanning bar codes rather than manually entering the data. This would significantly reduce the number of records missed due to missing or inaccurate USDOT numbers.
- **Use data linkage as much as possible to bring in data from other sources and reduce the burden on officers who complete crash reports.** For example, vehicle and carrier information could be extracted from registration and carrier census files. Injury information could be linked in from hospital and EMS records.
- **Encourage all States to adopt the Model Minimum Uniform Crash Criteria (MMUCC).** The 4th edition of the MMUCC contains the data elements needed to identify virtually all reportable crashes, and all the data required for the MCMIS crash file. If all States used the MMUCC, the correct crash records could be extracted using a computer program, which would reduce the opportunity for human error.

  In addition, if the MMUCC were in widespread use, a much richer data set would be available than the current MCMIS crash file. It would be necessary to modify MCMIS and SAFETYNET to accept the additional fields, of course. However, information on driver errors and condition, crash conditions and events, and many other data items could be extracted for the file, significantly enhancing FMCSA's understanding of motor carrier crashes.
- **Develop a standardized computer algorithm to extract the State crash data and upload it to MCMIS.** FMCSA should develop data extraction software for each of the States, if necessary. Coupled with widespread adoption of the MMUCC, this would obviate any State-level misunderstandings or misinterpretations and would increase FMCSA's control over the data collection process.

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