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<tr>
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LIST OF ACRONYMS

ATRI  American Transportation Research Institute
CDL   Commercial Driver’s License
CRI   Crash Rate Index
FHWA  Federal Highway Administration
FMCSA Federal Motor Carrier Safety Administration
GVWR  Gross Vehicle Weight Rating
MCMIS Motor Carrier Management Information System
RAC   Research Advisory Committee
VMT   Vehicle Miles Traveled
SUMMARY

Due to its significant share of freight movement, the trucking industry has long been a principal component of the U.S. economy. Inherent safety risks, however, are associated with travel on U.S. highways and the trucking industry’s exposure to these risks is a major transportation system concern. In 2010, 276,000 large trucks were involved in crashes in the United States, resulting in 3,675 deaths. While these crash statistics generally continue to improve year-over-year, public and private sector safety advocates persistently study truck crash data in order to identify new trends and propose additional safety initiatives.

Previous research has examined safety trends based on a common industry definition of “large trucks” being all trucks with a gross vehicle weight rating (GVWR) greater than 10,000 lbs. However, within the generalized “large truck” category, important operational and functional distinctions exist between class three through six (“Medium Duty trucks”; 10,001 to 26,000 lbs.) and class seven and eight (“Heavy Duty trucks”; 26,001+ lbs.) trucks. For example, drivers of Medium Duty trucks, unlike drivers of Heavy Duty trucks, are often not required to possess a commercial driver’s license (CDL). Distinguishing Heavy Duty trucks from Medium Duty trucks is therefore a critical task in determining factors that influence large truck safety trends and the industry’s overall safety condition. Noting these differences, ATRI’s Research Advisory Committee (RAC) identified this issue as an industry research priority at its annual meeting.

ATRI researchers investigated a decade (2000-2010) of Federal Motor Carrier Safety Administration (FMCSA) Motor Carrier Management Information System (MCMIS) crash data to examine large truck crash trends. The research team developed a methodology to separately examine Medium Duty and Heavy Duty truck crash trends based on a crash rate index (CRI). The CRI, which explored each group’s crash trends compared to a baseline, showed distinct differences among Heavy Duty and Medium Duty truck crash trends. As a result of the distinctions highlighted by ATRI’s CRI analysis, the research team conducted further investigation to determine which crash attributes, such as road configuration or weather, contribute most to the disparities in crash trends for the two groups. The additional examination provides insight for targeting crash mitigation efforts based on truck GVWR.

The trend analysis confirms that overall, large truck crash rates are decreasing; however, the rate of this decline is slowed by contrary trends observed in the Medium

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3 The American Transportation Research Institute (ATRI) Research Advisory Committee (RAC) is comprised of industry stakeholders representing motor carriers, trucking industry suppliers, labor and driver groups, law enforcement, federal government and academia. The RAC is charged with annually recommending a research agenda for the Institute.
Duty truck subgroup. As a result, large truck crash statistics understate the safety improvements realized by the Heavy Duty truck population over the ten-year analysis period. Furthermore, and perhaps more importantly, declines in Medium Duty truck safety are concealed. In summary, increases in Medium Duty truck crash rates are camouflaged by the improvement of overall large truck crash statistics. This, in turn, may result in researchers and policy makers overlooking certain truck populations for crash reduction opportunities. Developing and implementing Medium Duty truck-specific crash mitigation strategies would likely intensify the existing improvements in large truck safety.

Specifically, the analysis revealed that:

- Whereas Heavy Duty trucks have generally experienced a decline in CRI (-24.6% between 2000 and 2010), Medium Duty trucks have seen an increase in the index (38.3% between 2000 and 2010).
- Non-interstate carrier crashes exhibited a steep increase in CRI compared to interstate carriers, particularly among Medium Duty truck crashes.
- An increase in Medium Duty truck crashes on roads with full access control in urban core counties were responsible for much of the increase in Medium Duty truck CRI.
- Adverse weather conditions had somewhat of an equalizing effect, reducing the differences between Medium Duty and Heavy Duty truck CRIs.
- More data, such as driver citations and vehicle speed, is needed to determine the underlying crash causal factors.
1.0 INTRODUCTION

The trucking industry, due to its significant share of U.S. freight tonnage moved, is a principal component of the U.S. economy. \(^4\) Hauling 9.2 billion tons of freight in 2011, this $604 billion industry moved 67 percent of the nation’s freight, by tonnage. \(^5\) However, inherent safety risks are associated with travel on U.S. roadways and the trucking industry’s exposure to these risks is a major transportation system concern. With 276,000 large trucks involved in crashes in 2010\(^6\), continual safety improvement is a primary industry objective.

To fully understand the possible causation of truck crashes, it is important to examine accident trends based on various associated factors. As shown in previous research, it is clear that a variety of large truck crash patterns exist. \(^7\), \(^8\) For example, though the rate of fatal crashes per 100 million vehicle miles traveled (VMT) has steadily decreased over the past 30 years, the total number of fatal crashes has remained relatively stable. \(^9\) While there is a general understanding of crash patterns, there are research opportunities to further explore more nuanced safety trends.

Previous research has produced reports displaying data on large truck crashes. \(^10\), \(^11\) However, various distinctions in trucking industry operations, vehicle configurations and severity of crashes exist between two general types of large trucks:

- Medium Duty Trucks (Class 3-6) 10,001 lbs – 26,000 lbs; and
- Heavy Duty Trucks (Class 7-8) 26,001 lbs +.

The task of distinguishing Heavy Duty trucks from Medium Duty trucks, which are often coupled in safety research, is therefore important in determining the nuances of current large truck safety trends.

This research identifies notable safety trends specific to the Heavy Duty and Medium Duty truck populations. Using a decade of Motor Carrier Management Information System (MCMIS) crash data, the ATRI research team separately evaluated Medium

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\(^4\) In terms of commodity value, trucks move 71.3 percent of all U.S. goods, compared to 13.4 percent by parcel/courier and less than 4 percent by any other mode. Source: *American Trucking Trends: 2012*. American Trucking Associations. Arlington, VA. (2012).


Duty and Heavy Duty truck crash records to better ascertain the nature of safety trends in the trucking industry.

2.0 METHODOLOGY

This research identifies differences in safety trends between Medium Duty and Heavy Duty trucks. The investigation focuses on a comparison of fatal and injury-only records contained in the MCMIS crash file database for the years 2000-2010. MCMIS, maintained by the Federal Motor Carrier Safety Administration (FMCSA), requires all states to report crashes involving a truck or bus, meeting defined severity criteria. There is, however, some degree of underreporting among the states; thus a MCMIS crash file represents all the useable data that has been reported through the requirements of state and federal programs. Each MCMIS crash record contains data elements describing the circumstances of the crash, the motor carrier and the vehicles involved.

As with any database, some degree of refinement was necessary. Duplicate entries were removed from MCMIS crash records and the unique records were categorized into two separate groups for Medium Duty and Heavy Duty trucks. From the master MCMIS crash file, researchers selected trucks for each category based on the record’s gross vehicle weight rating (GVWR) ID. The two GVWR IDs values used were:

- Medium Duty: 10,001 – 26,000 pounds; and
- Heavy Duty: 26,001 pounds and greater.

To account for any GVWR misclassifications, a second attribute, Vehicle Configuration ID, was utilized to ensure that only the appropriate types of vehicles were included in the data analysis. Vehicle configurations such as a passenger car, light truck, or bus were excluded. The remaining vehicle configurations included in the analysis were:

- Single-Unit Truck (2-Axle, 6-Tire)
- Single-Unit Truck (3 or More Axles)
- Truck Tractor (Bobtail)
- Truck/Trailer (trailer has front and rear axles)
- Tractor/Semitrailer (trailer has rear axles only)
- Tractor/Double (tractor pulling two trailers)
- Tractor/Triple (tractor pulling three trailers)
- Unknown Heavy Truck > 10,000 lbs, Cannot Classify.

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12 MCMIS records must include one fatality, one injury requiring treatment away from the scene and/or at least one towed vehicle.
The final study population of Medium Duty truck crashes included those records with a GVWR of 10,001 to 26,000 lbs. and a corresponding truck vehicle configuration. Records with a GVWR of 26,001 lbs. or greater and a corresponding truck vehicle configuration were identified as Heavy Duty truck crashes. Records for each group were further stratified by crash severity (fatal and injury-only). In order to focus on only the most severe incidents, crashes that resulted in property damage only were excluded from the analysis.

Researchers initiated the analysis by examining crash counts and rates across the ten-year period. Although crash counts may identify high-level disparities between Medium Duty and Heavy Duty truck crash trends, crash counts alone do not fully explain crash trends over time. Utilizing crash rates, however, aids understanding of each group’s safety performance relative to changes in exposure (i.e. VMT). To calculate crash rates, ATRI obtained national VMT figures from the Federal Highway Administration (FHWA) using the annual VM-1 table. To establish VMT for Heavy Duty trucks, ATRI used the figures for “combination trucks” while figures for “single-unit trucks” were used for Medium Duty truck VMT. In reality, these are not perfect relationships (e.g. some combination vehicles could weigh less than 26,001 pounds). However, ATRI subsequently used the VMT information to create an index, as described in the next step. By reporting an index, as opposed to reporting actual crash rates, the misclassification effect is minimized.

After establishing national VMT figures, national crash rate figures were calculated for both Medium Duty and Heavy Duty trucks. However, due to the characteristics of the data, basic crash rates were insufficient for the type of comparative analysis ATRI conducted, and it was necessary to add one final step to the methodology. As a result of differences in population size and exposure, Heavy Duty and Medium Duty trucks have different crash rates and direct comparisons can be difficult. Furthermore, the VMT figures did not perfectly align with truck configurations. To account for these issues, the research team developed a crash rate index (CRI) to further clarify differences in trends between the two truck populations. In the ATRI CRI, a separate crash rate for Medium Duty and Heavy Duty trucks was calculated using the total number of crashes in a year divided by the respective VMT for that year. Subsequently, each crash rate was indexed to the year 2000 (which was assigned an index value of 100). This generated the CRI which indicates how the number of crashes changed relative to 2000 while simultaneously adjusting for changes in VMT. For example, a CRI of 50 in 2010 compared to a CRI of 100 in 2000 means that there were half as many crashes in 2010 compared to in 2000 after taking into account changes in VMT during that period. In this way, the CRI allows for a clearer comparison of Medium Duty and Heavy Duty truck crash trends since both types of crashes begin at the same index value (100) in 2000. Any divergences between Medium Duty and Heavy Duty CRIs are then easily illustrated.

In addition to the general CRI calculations described above, the research team conducted further investigation to determine which crash attributes contribute most to any disparities in CRI trends. As a first step, crash attributes were grouped into similar descriptive categories, as shown in Table 1. Categorization of the attributes facilitated investigation of the trends, permitting researchers to consider what types of vehicles were involved, the type of road where the crash took place, when the crash occurred, environmental conditions and the condition of the roadway at the time of the crash.

<table>
<thead>
<tr>
<th>Category</th>
<th>MCMIS Attributes</th>
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<td>Vehicle</td>
<td>Carrier Type, Vehicle Configuration, Cargo Body Type</td>
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<tr>
<td>Roadway</td>
<td>Traffic Way, Access Control, Location</td>
</tr>
<tr>
<td>Environmental</td>
<td>Weather Condition, Light Condition, Road Surface Condition</td>
</tr>
<tr>
<td>Temporal</td>
<td>Day of Week, Time of Day</td>
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For each attribute, Medium Duty and Heavy Duty crash data was aggregated and the CRI for each attribute was calculated. It should be noted that in most cases the CRI was based on the same national VMT figures described previously. Unfortunately, VMT data on a national scale was generally not available by attribute (e.g. Medium Duty truck VMT in rainy conditions, Heavy Duty truck VMT on Tuesdays, etc.). By utilizing the CRI, ATRI mitigated some of the concerns associated with using the national VMT data instead of attribute-specific VMT data. The CRI methodology reasonably assumes that VMT for a particular subset of Medium Duty or Heavy Duty trucks mimics the overall trends for Medium Duty or Heavy Duty trucks (e.g. change in VMT for Heavy Duty trucks on Tuesday will be similar on a percentage basis to the change in Heavy Duty truck VMT for all days of the week combined). The subsequent analyses note cases where more refined VMT data was available that better matched the attributes being analyzed.

### 3.0 RESULTS

This section discusses the crash trends identified by ATRI’s crash index methodology and highlights the significant outcomes from the crash attribute analyses.

#### 3.1 Crash Trends

When considering all large trucks, the rate of fatal crashes per 100 million VMT has steadily decreased over the past 30 years though the total number of fatal crashes has remained relatively stable. However, within the large truck classification, the numerous operational differences between Heavy Duty trucks and Medium Duty trucks

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create unique differences in crash risks and data trends. To further investigate these trends, researchers aggregated Medium Duty and Heavy Duty truck crash counts and rates for a ten-year period using MCMIS data. After performing the MCMIS data refinement steps previously described in Section 2, ATRI calculated overall large truck crash rate trends to determine if the MCMIS data showed similar trends as found in other studies. As expected, the MCMIS data indicated that while the total frequency of large truck crashes has remained nearly steady with only a slight increase over the past decade, the crash rate per 100 million VMT has generally declined. Figures 1 and 2 illustrate these findings. Please note that the analysis only included crashes with an injury or fatality.

**Figure 1. Frequency of Large Truck Crashes (Fatal and Injury-only)**

![Graph showing the frequency of large truck crashes (Fatal and Injury-only) from 2000 to 2010. The number of crashes remains nearly steady with only a slight increase over the past decade.](image1)

**Figure 2. Rate of Large Truck Crashes (Fatal and Injury-only) per 100 Million VMT**

![Graph showing the rate of large truck crashes (Fatal and Injury-only) per 100 Million VMT from 2000 to 2010. The crash rate per 100 million VMT has generally declined.](image2)
However, within the large truck classification the two main categories of trucks, Medium Duty and Heavy Duty, express different operational characteristics and crash experiences. ATRI isolated crashes for Medium Duty and Heavy Duty trucks within the MCMIS data to disaggregate differences in crash trends. Several high-level disparities were identified. For example, the Heavy Duty truck crash counts appeared to increase at a much slower rate than that of Medium Duty truck crash counts (Figure 3). A linear regression on the data confirms this observation, with the slope of the Heavy Duty truck crash trend line increasing at only 172.5 crashes per year, compared to 628.5 crashes per year for Medium Duty truck crashes. When considering crash severity, fatal crash counts across the ten-year period held steady for Heavy Duty trucks though increased for Medium Duty trucks (Figure 4, Heavy Duty slope: 1.9 crashes per year, Medium Duty slope: 27.5 crashes per year). Additionally, the number of injury crashes grew for both classifications; yet again, the increase was greater for Medium Duty trucks (Figure 5, Heavy Duty slope: 170.6 crashes per year, Medium Duty slope: 601.0 crashes per year).

Figure 3. Frequency of Crashes by Truck type (Fatal and Injury-only)
However, normalizing the crash counts by change in VMT and analyzing crash rates using the CRI developed by ATRI offered a more meaningful measure of crash trends and further highlighted significant disparities between the two groups. Figure 6 presents a separate overall CRI for Medium Duty and Heavy Duty trucks from 2000 to 2010 along with a CRI of combined Medium Duty and Heavy Duty truck crashes. As with the truck crash count analysis, the CRI analysis reveals an increase in the crash rate for Medium Duty trucks relative to the change in Medium Duty truck VMT. Conversely, the
Heavy Duty truck CRI displays a decrease in the crash rate relative to Heavy Duty truck VMT. By 2010, the CRIs for Medium Duty and Heavy Duty trucks had diverged enough that the differential between the two indices was 62.9 points (relative to the index baseline of 100). Given that there are significantly more Heavy Duty truck crashes compared to Medium Duty truck crashes within the study dataset (77.2% versus 22.8%)\(^\text{16}\), changes in Medium Duty truck crash rates can be masked when grouping all large trucks together. This is illustrated in Figure 6 by the CRI line for Medium Duty and Heavy Duty trucks combined (i.e. all large trucks) which closely follows the more prevalent behavior of Heavy Duty trucks.

### Figure 6. Overall CRI for Large Trucks, by Truck Type

ATRI also separated injury-only crashes from crashes where a fatality was involved. Given that injury-only crashes constituted 92.0 percent of the crashes analyzed, there were no considerable differences between the injury-only CRIs and the overall CRIs (Figure 7). Interestingly, as shown in Figure 8, the CRI trends for Medium Duty and Heavy Duty truck crashes that involved a fatality were less divergent than the overall trend for all large trucks combined. In 2010, the comparative Medium Duty-Heavy Duty fatal CRI differential was only 18.2 points and both indices were well below the year 2000 baseline. This indicates that both types of vehicles have seen improvement in fatal crash rates relative to VMT changes since 2000.

\(^{16}\) MCMIS data from 2000-2010
3.2 Crash Attribute Trends

The research team conducted additional analyses to determine which crash attributes contributed most to the disparities in CRI trends between the Heavy Duty and Medium Duty truck groups. Crash attributes were grouped into similar descriptive categories: vehicle type, roadway configuration and location, environmental conditions, and time-of-day. Trends were examined within each category to explore the effect of these trends on the overall crash rates for each group. In situations where CRI trends for Heavy
Duty and Medium Duty trucks behaved similarly to the overall CRI trends presented in Figure 6, it was determined that there were likely no significant factors for that specific situation contributing to the overall differences in CRI trends (or that any contributing factors were masked by other variables). Conversely, if the CRI trends for a particular combination of attributes diverged from overall trends, this situation was flagged as a possible explanation for crash rate trend differences.

Vehicle Characteristics

As previously noted, within the Medium Duty and Heavy Duty truck classifications there exists a wide array of vehicle configurations and cargo body types. ATRI hypothesized that there could be variations in crash rate trends for specific vehicle configurations due to the different operational characteristics of each vehicle type. To test this hypothesis, the Medium Duty and Heavy Duty crash data was aggregated across numerous types of vehicles and the CRI for each type was calculated.

ATRI first analyzed vehicles involved in crashes based on whether they were interstate or intrastate motor carriers. ATRI hypothesized there could be differences in the CRI trends between interstate and intrastate carriers given the different regulatory environment within which each carrier type must operate. The MCMIS data indicates whether the truck involved in the crash was part of an interstate carrier, an intrastate carrier, or was a non-motor carrier (e.g. state/local government vehicle, leased vehicle, etc.). ATRI grouped intrastate and non-motor carriers together for the purposes of this analysis, which yielded two groups: interstate carriers and non-interstate carriers.

The analysis revealed that the CRI for non-interstate carriers was generally higher than the CRI for interstate carriers. This pattern was particularly noticeable for Medium Duty trucks. As Figure 9 illustrates, the interstate carrier CRI for Heavy Duty trucks was lower than the non-interstate (Heavy Duty truck) carrier CRI in seven out of the 11 years studied. By 2010, the CRI differential was up at 22.1 points. The differences in CRI trends were more pronounced for Medium Duty trucks. Figure 10 plots the CRI for interstate and non-interstate carriers for Medium Duty trucks, revealing a widely divergent pattern. In 2010, the differential between the interstate CRI and non-interstate CRI had grown to 89.8 points. This indicates that crashes among non-interstate Medium Duty carriers are a key contributing factor to the overall increase in the Medium Duty truck CRI.

The number of crashes involving non-interstate motor carriers appears to be steadily increasing, particularly among the Medium Duty truck population. Whereas non-interstate carrier crashes only constituted 35.6 percent of all Medium Duty truck crashes in 2000, that figure rose to 50.5 percent by 2010. Conversely, non-interstate carrier crashes only accounted for between 10-15 percent of all Heavy Duty truck crashes during the study period, with the peak in 2006.
The disparities between interstate and non-interstate carriers appear to warrant further investigation, particularly within the Medium Duty truck population. There are numerous differences between the regulations that govern interstate motor carriers versus intrastate carriers and non-motor carriers. A separate study to understand these differences is likely needed. An interesting trend within the data is the emergence of large truck crashes classified as “non-motor carrier” in the database.\(^{17}\) In 2000, these

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\(^{17}\) Examples of “non-motor carrier” trucks include public sector fleets and truck rental companies.
crash types only accounted for 0.01 percent of all large truck crashes studied in this analysis. By 2010, non-motor carrier crashes constituted 4.9 percent of crashes. Further investigation into the cause of this sharp rise will be necessary.

In addition to carrier type, ATRI also studied vehicle types. Researchers found divergences in CRI trends for certain vehicle configurations, particularly among Medium Duty trucks. Figure 11 plots the CRI for the three most common configurations of Medium Duty trucks involved in crashes. Single-unit trucks (with 2 or 3 axles) generally had a much higher CRI than Tractor/Semitrailer or Truck/Trailer vehicle configurations. Single-unit vehicles also made up the majority (70.9%) of Medium Duty truck crashes.

Tractor/Semitrailer and Truck/Trailer vehicles exhibited different trend patterns compared to single-unit vehicles; while there were some years that exhibited higher CRIs in the first half of the decade, the general trend has been downward since then. Taken together, this analysis provides evidence that an increase in the single-unit CRI was a key driver of the overall increase in the Medium Duty truck CRI. If it were not for improvements in the CRI for other types of Medium Duty trucks, the overall CRI would have been even higher.

**Figure 11. Medium Duty Truck CRI by Vehicle Configuration**

![Figure 11](image)

Figure 12 presents the same vehicle configuration analysis for the three most common types of vehicles involved in Heavy Duty truck crashes. Tractor/semitrailer vehicles constituted 79.7 percent of Heavy Duty truck crashes yet consistently exhibited the lowest CRI of the three vehicle configurations in Figure 12. It appears that an improvement in the CRI for tractor/semitrailer vehicles is the primary driver behind decreases in the overall Heavy Duty truck CRI.
ATRI similarly investigated cargo body type to determine if there were any variations within Medium Duty and Heavy Duty truck classes. There was little variation in CRI among cargo body types for Heavy Duty truck crashes. However, there were some noticeable divergences for Medium Duty trucks. Figure 13 presents the CRIs for the four most common cargo body types involved in Medium Duty truck crashes (van, flatbed, dump, tanker – respectively). As is evident, vehicles with a flatbed or van cargo body type generally had the highest CRI. Dump trucks generally had the lowest CRI. Given that Van and Flatbed are the most common cargo body types and also generally have the highest indices, it can be concluded that those cargo body types are responsible for a significant portion of the upward pressure on the Medium Duty truck CRI.
Roadway Characteristics

Previous examinations of large truck crash trends have found that the majority of large truck fatalities occur on non-divided two-lane roadways.\textsuperscript{18,19} The share of crashes across various road configurations is largely influenced by exposure, meaning road types with higher truck volumes are generally more likely to experience truck crashes. However, an analysis of Heavy Duty and Medium Duty truck crash trends on specific road configurations yields insights into factors beyond exposure that could be influencing crashes. The ATRI research team investigated the MCMIS data to determine if variations in crash rate trends existed between Medium Duty and Heavy Duty truck classes for specific road configuration attributes. The combination of crash attributes investigated in the Roadway category included the following traffic way configurations and degrees of access control:

Traffic Way:
- Two-way, not divided
- Two-way, divided, unprotected median
- Two-way, divided, positive median barrier
- One-way, not divided

Access Control:
- Full Access Control
- Partial Access Control
- No Access Control

As shown in Table 2, crashes that occurred on two-way, not divided roadways with no access control (e.g. secondary streets) were the most frequent attribute combination for all types of large truck crashes (24.8%). Two-way roadways divided by a positive median barrier with full access control (e.g. urban Interstate highways) were the second largest source for large truck crashes (19.4%). Not far behind with 14.8 percent of crashes were two-way roadways divided by an unprotected median with full access control (e.g. rural Interstate highways).

Table 2. Distribution of Large Truck Crashes by Road Configuration

<table>
<thead>
<tr>
<th>TRAFFIC WAY</th>
<th>ACCESS CONTROL</th>
<th></th>
<th></th>
<th></th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full Control</td>
<td>Partial Control</td>
<td>No Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One-way, not divided</td>
<td>2.6%</td>
<td>1.3%</td>
<td>1.0%</td>
<td></td>
<td>5.0%</td>
</tr>
<tr>
<td>Two-way, divided, positive median barrier</td>
<td>19.4%</td>
<td>4.3%</td>
<td>2.9%</td>
<td></td>
<td>26.6%</td>
</tr>
<tr>
<td>Two-way, divided, unprotected median</td>
<td>14.8%</td>
<td>4.0%</td>
<td>7.6%</td>
<td></td>
<td>26.3%</td>
</tr>
<tr>
<td>Two-way, not divided</td>
<td>8.6%</td>
<td>8.7%</td>
<td>24.8%</td>
<td></td>
<td>42.1%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>45.3%</td>
<td>18.4%</td>
<td>36.3%</td>
<td></td>
<td>100.0%</td>
</tr>
</tbody>
</table>

This crash distribution is heavily influenced by exposure, meaning that road configurations with higher truck activity will likely see more crashes. However, an analysis of the CRIs for each configuration type can provide further insight into the differences between the Medium Duty and Heavy Duty truck CRIs. Each of the twelve configurations presented in Table 2 is characterized by different operational environments and may therefore be experiencing different crash trends. ATRI analyzed the CRIs for each configuration combination along with an analysis of each individual access control type and traffic way scenario.

First, ATRI analyzed the three types of access control. As Table 2 illustrated, the majority of large truck crashes occurred on either a Full Access Control road (45.3% of crashes) or a No Access Control road (36.3% of crashes). Figures 14 and 15 present the CRIs for these two access control scenarios. Figure 14 reveals a surge in the Medium Duty truck CRI for roads with full access control. While the Medium Duty truck CRI for full access control roads has been trending down since 2005, the 2010 value still remains significantly higher than the Heavy Duty truck index (64.7 point differential). Interestingly, the trend for full access control stands in stark contrast to the trends presented in Figure 15 for roads with no access control. Roads without access control have consistently seen CRIs below 100 for the past decade for both Medium Duty and Heavy Duty truck crashes. This indicates that crashes on roads with full access control are an important factor influencing the overall increase in the Medium Duty truck CRI.
An analysis of traffic way configurations also yielded interesting findings. Figure 16 presents the three types of two-way roads reported in the MCMIS data. All three types of roads exhibited higher Medium Duty truck CRIIs; however, the index for roads with a positive median barrier had the greatest Medium Duty-Heavy Duty index differential.
Figure 16. Two Way Roads (Not Divided, Divided with No Barrier, Divided with Barrier) – CRI by Truck Type
Taken together, there appears to be a significant amount of evidence that a key explanation for the increases in Medium Duty truck CRI lies on roads with access control, particularly those with a positive median barrier. ATRI hypothesized that roads with full access control and positive median barriers are more prevalent in urbanized areas and that crashes in urban areas may be responsible for much of the increase in the Medium Duty truck CRI. This hypothesis could provide further insight into the reasons why Medium Duty trucks had a much larger CRI, as roadway type alone does not explain the differences in CRI compared to Heavy Duty trucks.

To validate this hypothesis, ATRI determined the urban/rural nature of each crash using the county information within each record along with census data associated with each county. This resulted in six types of crash locations:

- Large Metro (Core) – Central counties of metropolitan areas with regional populations over 1 million
- Large Metro (Suburb) – Fringe counties of metropolitan areas with regional populations over 1 million
- Medium Metro - Counties within metropolitan areas of 250,000-999,999 population
- Small Metro - Counties within metropolitan areas of 50,000-249,999 population
- Micropolitan - Counties in micropolitan statistical areas
- Rural - Counties not within a micropolitan or metropolitan region

A CRI was then calculated for each type of location. It should be noted that for this exercise ATRI was able to segment VMT by urban versus rural areas to account for changes in travel patterns over the study decade. ATRI utilized the urban VMT figures for the first four location types and the rural VMT data for the last two location types. As Figure 17 demonstrates, ATRI’s hypothesis appears to be validated by the crash data. The Medium Duty truck CRI for accidents that occurred in the core county of large metropolitan areas is significantly larger than all other types of crash location. These core counties account for only 63 of the 3,147 counties in the crash database (2.0%) but are responsible for 26.0 percent of all Medium Duty truck crashes over the study period.

The same analysis was performed on Heavy Duty truck crashes. The results, shown in Figure 18, reveal no major differences in CRIs for the various location types.

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Taken together, there appears to be strong evidence that much of the increase in the Medium Duty truck CRI was the result of a disproportionate increase in Medium Duty truck crashes in urban areas, particularly on roads with full access control and positive median barriers (i.e. urban freeways). The next two sections on Environmental Conditions and Temporal Characteristics attempt to further explain the differences between the Medium Duty and Heavy Duty truck CRIs.
Environmental Conditions

Previous work has estimated that the majority (80-90%) of large truck crashes occur on dry roads with no adverse weather conditions. Nevertheless, weather can hamper visibility and increase stopping distances and should be addressed as a risk factor. Furthermore, environmental conditions can have different impacts on Medium Duty trucks compared to Heavy Duty trucks and those impacts can vary regionally due to climatic differences.

In order to analyze if any environmental factors may explain the difference between Heavy Duty and Medium Duty truck crash trends, ATRI investigated the Road Surface Condition, Weather Condition, and Light Condition information within the MCMIS database. First, ATRI isolated adverse weather conditions by studying the CRIs for accidents with clear weather and compared them to crashes with any type of adverse weather. Figure 19 shows the CRI for Medium Duty and Heavy Duty trucks in the “clear” conditions, while Figure 20 shows the indices for “adverse” conditions. Interestingly, there was a greater difference between the Medium Duty and Heavy Duty CRIs in clear conditions. In 2010 the Medium Duty truck CRI for clear conditions was 147.3 compared to only 81.6 for Heavy Duty trucks, a difference of 65.7 points. This was somewhat larger than the overall Heavy Duty-Medium Duty gap in 2010 of 62.9 points. For adverse conditions, the indices were much closer over the course of the decade. In 2010, the Medium Duty truck CRI was only 43.3 points higher than the Heavy Duty truck index.

One hypothesis to explain why the CRI for Medium Duty trucks behaved more similarly to the Heavy Duty truck CRI in adverse weather conditions is vehicle speed. In many cases, drivers will reduce speed and drive more cautiously in adverse weather conditions. Despite the fact that the roadway conditions are less than ideal, the change in driver behavior may be resulting in a lower Medium Duty truck CRI in adverse weather.

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To further test the impact of weather and speed on the CRI, ATRI analyzed how adverse weather conditions affected the CRI for crashes on roads with full access control, which were shown in the previous section to have one of the largest Medium Duty-Heavy Duty differentials. As Figure 21 illustrates, adverse weather had a strong dampening effect on the CRI for both types of vehicles, however the effect was more pronounced for Medium Duty trucks. This finding may reveal a critical causal factor for accidents that is not recorded in the MCMIS data: speed. Since roads with full access
control are generally characterized by higher travel speeds, crashes on those roads are likely more severe. Adverse weather conditions often cause drivers to slow their travel speed and drive more cautiously.

Another potential explanation that cannot be tested with the MCMIS data is that adverse weather causes certain types of Medium Duty vehicles to cancel trips (e.g. landscaping flatbed trucks). If for some reason the vehicles that cancel their trips also tend to be at a higher risk for crashes, this would explain the lower CRI in adverse weather conditions.

**Figure 21. Full Access Control Roads – CRI for Clear vs. Adverse Conditions**

Daylight can also play a factor in crash propensity. The MCMIS data contains several attributes for ambient light, including: daylight, dawn, dusk, dark (with street lights), and dark (no street lighting). ATRI compared the Medium Duty and Heavy Duty CRIs for daylight crashes with those in dark conditions (with and without street lighting). The CRI for incidents that occurred in daylight is very similar in trend to the overall CRI (Figure 22). The 2010 index differential between Medium Duty and Heavy Duty trucks is 62.5, which is nearly identical to the overall differential of 62.9. However, there are a number of interesting differences between trends for crashes in dark conditions. As Figure 23 illustrates, there is a large difference in CRI trends for Medium Duty and Heavy Duty trucks when analyzing crashes that occurred in dark conditions with street lighting. The 2010 differential between the Medium Duty and Heavy Duty index is 88.7, much larger than the overall differential. Interestingly, the opposite is true for crashes in dark conditions without street lighting. As Figure 24 shows, the difference between Medium Duty and Heavy Duty CRIs for dark conditions without street lighting is much smaller. In
2010 the Medium Duty-Heavy Duty index differential was only 49.5, which is noticeably less than the overall differential.

**Figure 22. Daylight Conditions – CRI by Truck Type**

![CRI for Daylight Conditions](image)

**Figure 23. Dark Conditions (with Street Lighting) – CRI by Truck Type**

![CRI for Dark Conditions (with Street Lighting)](image)
These findings at first may appear somewhat counterintuitive because they suggest that Medium Duty trucks are experiencing an increase in the number of crashes in locations where street lights are in operation compared to areas that are completely unlit. This should not be interpreted as concluding that street lighting is a hindrance to safety. Rather, the more logical explanation lies in attributes outside of those considered in this environmental conditions analysis, namely road configuration and context. Street lighting is far more likely to be present in urbanized areas. As discussed in the roadway configuration analysis, roads in urban areas with full access control and positive median barriers (e.g. urban interstates) exhibit a higher CRI for Medium Duty trucks compared to the overall average. This provides further evidence that such a scenario is indeed occurring.

The higher CRI in dark conditions with street lighting suggests that there may be some value to conducting an analysis on crash time of day. The next section will address the degree to which crash time of day plays a role in the differences between Medium Duty and Heavy Duty truck CRIs.

**Temporal Characteristics**

FARS data indicates that 2010 large truck crashes resulting in a fatality occurred most often during morning and daylight hours (6 a.m. to 3 p.m.) on a Weekday.\(^{24}\) Additionally, daytime crashes are about 19 percent more likely among single-unit trucks.
than combination trucks. However, much of these differences are due to the different operational characteristics of Medium Duty and Heavy Duty trucks. The ATRI research team investigated the MCMIS data to further explore these trends within the Medium Duty and Heavy Duty truck classes.

Two temporal attributes were considered; day-of-week and time-of-day. The date provided in MCMIS was used to determine the day of the week on which the crash occurred. The time associated with the crash record was used to assign the record to one of eight three-hour time bins, the first of which began at midnight and continued to 2:59 a.m.

In terms of day-of-week, the distribution of crashes among weekdays was mostly uniform for both groups (Figure 25). When considering weekends, Heavy Duty truck crashes were slightly more frequent on Sundays than Medium Duty truck crashes, but again, these differences are likely explained by exposure.

As shown in Figure 26, when examining crashes by time of day, crash frequencies increased for both groups during business hours. A greater proportion, however, of Medium Duty truck crashes occurred during peak business hours. Heavy Duty truck crashes were more likely than Medium Duty truck crashes to occur during off-peak hours. These differences are explained almost entirely by exposure as Medium Duty trucks tend to operate more during normal business hours, thus are involved in more crashes during that time.

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Although exposure appears to explain much of the difference between the time when Heavy Duty and Medium Duty trucks most frequently experience crashes, ATRI generated a CRI for each time bin to identify any more subtle trends during the decade. Figure 27 presents the CRI by time of crash for Medium Duty trucks. Generally, each time bin is following the trajectory of the overall Medium Duty truck CRI. However, there are several time periods that experienced somewhat higher indices, particularly in the middle part of the decade. The time bins between 9:00 PM and 9:00 AM generally experienced the highest CRIs. This indicates a more rapid increase in the number of Medium Duty truck crashes during off-peak hours than VMT alone would explain. As Figure 28 illustrates, there was little of note in the Heavy Duty truck time of day CRI analysis.
Figure 27. Medium Duty Truck CRI by Time of Crash

Figure 28. Heavy Duty Truck CRI by Time of Crash
Unfortunately there is no way to determine how VMT changed by time of day for Medium Duty and Heavy Duty trucks over the study period. It is unlikely that travel during non-business hours became more risky for Medium Duty trucks over the course of the study period. Rather, the more likely explanation is that there was a shift in VMT for Medium Duty trucks to off-peak hour operations. The increase in the Medium Duty truck crash rate during off-hours was most pronounced between 2003 and 2006 when the economy was strong. An increase in business may have required longer work days or increased night shifts for certain types of Medium Duty trucks.

4.0 CONCLUSION

The past few sections have provided a significant amount of analysis on the various attributes of Medium Duty and Heavy Duty truck crashes in an effort to understand differences in the CRI trends between the two subgroups of large trucks. A detailed analysis of the MCMIS data revealed several interesting distinctions between Medium Duty and Heavy Duty truck crash trends:

- Whereas Heavy Duty trucks have generally experienced a decline in CRI (-24.6% between 2000 and 2010), Medium Duty trucks have seen an increase in the index (38.3% between 2000 and 2010).
- Non-interstate carrier crashes exhibited a steep increase in CRI compared to interstate carriers, particularly among Medium Duty truck crashes.
- Two and three-axle single-unit trucks experienced the greatest increase in CRI for Medium Duty trucks.
- An increase in Medium Duty truck crashes on roads with full access control in urban core counties were responsible for much of the increase in Medium Duty truck CRI.
- Adverse weather conditions had somewhat of an equalizing effect, reducing the differences between Medium Duty and Heavy Duty truck CRIs.
- There was a larger increase in the Medium Duty truck CRI during off-peak hours compared to normal business hours, particularly from 2003 to 2006.

4.1 Discussion

The trend analysis confirms that overall, large truck crash rates are decreasing. However, the rate of this decline is slowed by contrary trends observed in the Medium Duty truck group. As a result, large truck crash statistics understate safety improvements gained by the Heavy Duty truck population over the ten-year analysis period. Furthermore, and perhaps more importantly, increases in crash rates by Medium Duty trucks are masked by the greater influence of Heavy Duty truck crash statistics. Given that many in the public and private sector are concerned with reducing the number of crashes, this may cause researchers and policy makers to overlook an important opportunity to improve safety.
The MCMIS data analysis revealed some interesting trends in large truck crashes, particularly when isolating specific crash attributes. It appears that there was a significant increase in the number of Medium Duty truck crashes in urban areas that was not commensurate with changes in Medium Duty truck urban VMT. Conversely, the frequency of Medium Duty truck crashes in other areas, from suburbs to rural areas, was more in line with changes in Medium Duty truck VMT. Specifically, the increase in crashes appears to have occurred mostly on roads with full access control, particularly those with positive median barriers. Interestingly, there was very little increase in Medium Duty truck crashes in urban areas on roads with no access control. Therefore, some factor associated with Medium Duty truck travel on roads with full access control was likely contributing to the increase in crashes. The most obvious difference between travel on roads with full access control compared to no access control is vehicle speed. As a result of simple physics, crashes that occur at higher speeds tend to be more severe.

The highest CRI for Medium Duty trucks occurred at the height of the last period of economic expansion, 2006. It is no surprise that a good economy would result in more trucks (both Heavy Duty and Medium Duty) on urban freeways. However, by disaggregating urban VMT data, ATRI was able to account for increased urban VMT, meaning the high CRI was due to factors beyond increased exposure. There is evidence from the MCMIS data that driver behavior may be a factor in the increase in Medium Duty truck crashes. ATRI discovered that the CRI on roads with full access control dropped sharply when adverse weather was reported compared to when conditions were clear. The most likely explanation is that when faced with adverse weather conditions, drivers tended to slow down and drove more cautiously, thus reducing the number of severe accidents compared to clear conditions.

There is also evidence that there may have been an increase in the number of Medium Duty trucks operating during off-peak hours, particularly at the height of the economic expansion. The MCMIS data revealed higher Medium Duty truck CRIs from 9:00 PM to 9:00 AM compared to daytime hours. Also, the Medium Duty truck CRI in dark conditions (with street lighting) was greater than the CRI for daytime conditions, suggesting an increase in Medium Duty truck crashes during non-business hours in urban areas (where street lighting is more common). Drivers of Medium Duty trucks are in many cases more accustomed to operating during normal business hours and a large portion of those drivers is not subject to federal Hours-of-Service regulations. Unfortunately the public MCMIS data does not contain adequate information on the condition of the driver during the accident (e.g. fatigued) nor does it report whether the truck driver was cited for a traffic violation.

One speculative consideration for the increase in Medium Duty truck crashes rests with driver quality. Given that the largest CRI for Medium Duty trucks was recorded at the height of economic expansion, it is plausible to assume there was a shortage of


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qualified drivers. In fact, ATRI reported in its 2006 annual survey of critical trucking industry issues that a driver shortage was the issue of most concern for the industry.\(^{27}\) Many Medium Duty truck drivers are not required to obtain a CDL to operate their vehicle.\(^{28}\) Furthermore, many are also not subject to federal Hours-of-Service regulations. One piece of evidence from the MCMIS data that supports this hypothesis is the increase in CRI for non-interstate carriers. In many cases, drivers of trucks belonging to non-interstate carriers are subjected to fewer requirements than drivers with interstate carriers.

4.2 Next Steps

While the MCMIS data has been thoroughly parsed, it does not explicitly reveal much information about the cause of the accident. More data on the condition of the driver(s) involved in the crash, along with any citation information, would be very useful for further understanding these trends. Additional data on the contributing factors for the crash would also be helpful, particularly vehicle speed.

The issue of interstate versus non-interstate carriers is a complicated one and warrants further investigation. Recognizing this research need, the ATRI RAC and Board of Directors prioritized a proposed study in 2013-14 on the differences between interstate and intrastate motor carriers. This proposed research will help address many of the questions raised in the analysis of MCMIS data.

Beyond the intrastate carrier issue, much of the attempt to explain the trends discovered in this analysis rests on the assumption that an increase in economic activity may have reduced the quality of the Medium Duty truck driver population. Unfortunately it is impossible to conclude with certainty from the public MCMIS data that this was indeed the case. Additional research will be necessary to confirm whether or not this was indeed a causal factor for the increase in the Medium Duty truck CRI. Finally, as the economy begins to expand again, it will be important to continue to monitor the safety trends for all types of vehicles to determine if past trends are being repeated.

In all cases, increased accuracy in MCMIS reporting by the states will increase the rigor with which researchers can draw conclusions from the crash dataset. The trucking industry is always concerned with safe operations and maintaining a workforce of the highest quality. This analysis shows that safety improvements continue to be made among our heaviest trucks as crash rates have moved downward. However, the improvements are not uniform across all types of trucks. If a goal of zero crashes is to ever be realized, gains in safety must be universal across the industry.

