POTENTIAL REDUCTION IN LARGE TRUCK AND BUS TRAFFIC FATALITIES AND INJURIES USING LYTX'S DRIVECAM® PROGRAM

Final Report

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

CMV	commercial motor vehicle
FMCSA	Federal Motor Carrier Safety Administration
GES	General Estimates System
LTCCS	Large Truck Crash Causation Study
LCL	lower confidence limit
MVMT	million vehicle-miles traveled
PAR	police accident report
UCL	upper confidence limit

ABSTRACT

This study quantitatively evaluated the potential safety benefits of equipping all United States heavy trucks and buses in the U.S. with Lytx™ Inc.'s DriveCam® program. Heavy trucks and buses include the following vehicle types: single-unit truck (2 axle and greater than 10,000 lbs), single-unit truck (3 or more axles), truck pulling trailer(s), truck tractor/semi-trailer, truck more than 10,000 lbs (cannot classify), bus/large van (seats 9 to 15 occupants including driver), and bus (seats more than 15 occupants including driver). The potential safety benefits of the DriveCam Program were evaluated by comparing the published efficacy of the DriveCam Program (Federal Motor Carrier Safety Administration, 2009; Hickman & Hanowski, 2011) to a large national crash database, the General Estimates System (GES).

The GES database included information about the vehicle, injuries and fatalities, violations, and contributing factors for a sample of crashes during calendar years 2010 to 2012. The GES database was filtered to determine what percentage of heavy-truck and bus crashes resulting in an injury and/or fatality were likely to have been prevented with the DriveCam Program (excluding truck and bus crashes that appeared to be non-fault or the result of weather, road condition, vehicle malfunction, or alcohol/drugs).

The final data set included a total of 10,648 fatal truck and bus crashes (resulting in 11,993 fatalities) and 213,000 injurious truck and bus crashes (resulting in 330,000 injuries). Trucks and buses equipped with the DriveCam Program had the potential to reduce an average of 727 fatal truck and bus crashes (20.5 percent of the total fatal crashes) and save 801 lives (20.0 percent of the total fatalities) each year. Similar results were found for the analysis of injury crashes. Specifically, trucks and buses equipped with the DriveCam Program had the potential to reduce an average of 25,007 truck and bus injury crashes (35.2 percent of the total injury crashes) and save 39,066 injuries (35.5 percent of the total injuries) each year.

1. INTRODUCTION

Motor vehicle crashes are often predictable and preventable. Yet, many drivers choose to behave in ways that put themselves and others at risk for a vehicle crash and/or serious injuries. One of the most significant studies on the factors that contribute to motor vehicle crashes was the Indiana Tri-Level Study (Treat et al., 1979). To provide insight into the factors that contribute to traffic crashes, collision data were collected across three different levels to assess causal factors as being definite, probable, or possible. The study determined that 90.3 percent of the crashes involved some type of human error, such as at-risk driving behavior, inadvertent errors, and impaired states. While the vehicles in Treat et al. (1979) were predominantly passenger vehicles, the same relationship can be found in heavy vehicles. The recently completed Large Truck Crash Causation Study (LTCCS) assessed the causes of, and contributing factors to, crashes involving commercial motor vehicles (CMVs). The LTCCS found that 87.3 percent of the critical reasons assigned to the large-truck driver were driver errors, including decision errors (38 percent; e.g., driver drove too fast for conditions), recognition errors (28.4 percent; e.g., driver did not recognize the situation due to not paying proper attention), non-performance errors (11.6 percent; e.g., driver fell asleep), and performance errors (9.2 percent; e.g., driver exercised poor directional control) (Federal Motor Carrier Safety Administration [FMCSA], 2006).

1.1 ONBOARD SAFETY MONITORING PROGRAMS

If driver behavior is the primary reason for traffic crashes, then approaches that pinpoint and focus on reducing risky driving behavior are likely to be the most effective in reducing crashes and their adverse consequences. Until recently, the primary problem has been getting quality behavioral data on driving behaviors, but technologies are currently available that provide objective measures of driver behavior. These in-vehicle technologies are able to provide measures on a wide variety of driving behaviors previously unavailable to fleet safety managers. The most efficacious onboard safety monitoring systems use in-vehicle video technology to record driver behavior. These video recordings can be used by fleet safety managers, parents, or others to provide feedback on safe and risky driving behaviors and coach drivers to correct risky driving behaviors, thereby reducing future crash risk.

As shown in Figure 1, Lytx's DriveCam Program is a closed-loop behavior modification system with multiple steps to assure positive outcomes. First, risky driving events are captured by the video-based device. The captured events (video and kinematic data) are automatically transmitted from the vehicle to Lytx review centers. Trained analysts review the video and kinematic data and record what the driver was doing during the captured events, then a severity score for each video event is calculated. Reviewed events are made accessible on a password-protected website for captured events, dashboards, and reports. In the setting of a commercial fleet, a supervisor reviews the videos and the report generated by the review analyst with the drivers to pinpoint the risky driving behaviors and coach the drivers on how to avoid future risky behaviors. Lastly, the drivers return to the field with added knowledge and motivation to drive safely.

Figure 1. Illustration. Schematic of the DriveCam® program

In a study sponsored by the FMCSA, Hickman and Hanowski (2011) instrumented 100 tractor-trailers with Lytx video-based devices and collected data for 17 consecutive weeks while the trucks made their normal, revenue-producing deliveries. During the 4-week baseline phase, the device recorded safety-related events; however, the feedback light on the device was disabled and safety managers did not have access to the recorded safety-related events to provide feedback to drivers. During the 13-week intervention phase, the feedback light on the device was activated and safety managers had access to the recorded safety-related events and followed the DriveCam Program coaching protocol with drivers (when necessary). Carrier A significantly reduced the mean rate of recorded risky driving events per 10,000 miles from baseline to intervention by 37 percent ($p = 0.046$), and Carrier B significantly reduced the mean rate of recorded risky driving events per 10,000 miles from baseline to intervention by 52.2 percent ($p = 0.03$). Drivers who received a coaching session at Carrier A reduced their mean rate of severe risky driving events per 10,000 miles from baseline to the intervention phase by 75.5 percent ($p = 0.073$). A "severe" risky driving event was defined as any risky driving event with an Event Score > 3. This usually entailed the driver performing multiple risky driving behaviors and/or a near-crash or crash scenario. The results suggest the combination of onboard safety monitoring

and behavioral coaching provided by the DriveCam Program were responsible for the reduction in risky driving events.

McGehee, Raby, Carney, Lee, and Reyes (2007) used the DriveCam Program with newly licensed teen drivers. This technology provided novice teen drivers, and their parents, with a means of identifying their risky driving behaviors so that feedback and coaching could be provided to reduce future at-risk driving behaviors. McGehee et al. (2007) paired this new technology with parental feedback and coaching in the form of a weekly video review and a graphical report card. The personal vehicle of each teen driver was equipped with an event-triggered video device designed to capture 20-second clips of the forward and cabin views whenever the vehicle exceeded lateral or forward threshold accelerations. Results indicated the combination of video feedback/coaching and a graphical report card significantly decreased the rate of risky driving events in teen drivers. In the first nine weeks of the intervention, the teen drivers reduced their rate of risky driving events from an average of 8.6 risky driving events per 1,000 miles during baseline to 3.6 risky driving events per 1,000 miles (58 percent reduction). The group further reduced the mean rate of risky driving events to 2.1 per 1,000 miles in the following nine weeks (76 percent reduction). The decrease from 8.6 to 2.1 risky driving events per 1,000 miles was statistically significant ($t = 4.15$, $p = 0.0007$).

1.2 OVERVIEW OF THE CURRENT STUDY

As shown above, the results of the DriveCam Program were consistent in truck drivers and teen drivers. Although these results are impressive, to date no published study has shown the potential reduction in fatal and injury crashes using Lytx's DriveCam Program. The current study modeled the potential reduction in fatal and injury crashes (and their associated fatalities and injuries) in large trucks and buses in the United States if all these vehicles were part of the DriveCam Program.

2. METHODS

2.1 GENERAL ESTIMATES SYSTEM (GES) DATABASE

The General Estimates System (GES) database includes information on the vehicle, injuries and fatalities, violations, and contributing factors for a sample of crashes in calendar years 2010 to 2012. The GES database is built from a random sample of police accident reports (PAR) from 400 police agencies in 60 different geographic sites. Data collectors visit the police agencies at least once a month to collect a sample of qualifying crashes. To qualify for inclusion in the GES database, the PAR "must involve at least one motor vehicle traveling on a traffic-way, and must result in property damage, injury, or death" (National Highway Traffic Safety Administration, 2014, p. 10). Table 1 below shows the total number of crashes collected in the GES for years 2010, 2011, and 2012.

Table 1. Number of Crashes in the GES Database in Years 2010 to 2012

Year	Number of Crashes
2012	61,598
2011	55,166
2010	46,391

2.2 PROCEDURES

The GES database was filtered to determine the percentage of heavy truck and bus crashes resulting in an injury and/or fatality that could be prevented or mitigated with Lytx's DriveCam Program (excluding crashes that appeared to be non-fault or the result of weather, road condition, vehicle malfunction, or alcohol/drugs). Heavy trucks and buses include the following vehicle types: single-unit truck (2 axle and greater than 10,000 lbs), single-unit truck (3 or more axles), truck pulling trailer(s), truck tractor/semi-trailer, truck more than 10,000 lbs (cannot classify), bus/large van (seats 9 to 15 occupants including driver), and bus (seats more than 15 occupants including driver). The variables used to filter these crashes are listed in the Appendix A. The goal of the filtering process was to eliminate specific vehicle types (e.g., passenger vehicles), fault (using the accident type variable as a measure of quasi-fault), and contributing factors the DriveCam Program would be unlikely to prevent or mitigate (e.g., vehicle-related contributing factors, such as brake failure). As shown in Appendix A, accident types in which the truck or bus were struck by another vehicle were removed as they were considered non-fault. However, accident types that were coded with no indication of a striking vehicle (e.g., intersect paths, striking from the right) were also removed as there was no reliable way to assign fault.

2.2.1 Fatal and Injury Crashes

For each year, the number of fatal and injury truck and bus crashes (and associated fatalities and injuries) was calculated for the at-fault crashes that could be prevented with the DriveCam Program. The procedures used to calculate the number of fatal and injury crashes that could be

prevented (and the number of associated fatalities and injuries eliminated) are shown below. The same methods were used for both crash types in each year from 2010 to 2012; however, only injury crashes are shown in the methods below. Fatal and injury crashes were not mutually exclusive as a crash could involve a fatality and an injury. The GES database in each calendar year was used to calculate the proportion of truck and bus injury crashes that could be prevented with the DriveCam Program using the following formula:

$$p_{injury\ crashes\ prevented} = \frac{Number\ of\ GES\ injury\ crashes\ that\ could\ be\ prevented \times 0.755}{Number\ of\ GES\ injury\ crashes}$$

As indicated above, an FMCSA (2009) study found that Lytx's DriveCam Program reduced severe safety-related events by 75.5 percent (or a 0.755 reduction rate). This rate was selected as the efficacy rate for the DriveCam Program in modeling the number of injury and fatal crashes that could be prevented. As the GES database contains only a fraction of all the crashes in the United States, the proportion of crashes that could be prevented was extended to national crash counts using FMCSA's *Commercial Motor Vehicle Facts* (2013). *Commercial Motor Vehicle Facts* was used to estimate national counts of truck and bus injury crashes that could be prevented using the following formula:

$$n_{injury\ crashes\ prevented} = p_{injury\ crashes} \times\ Number\ of\ injury\ crashes\ in\ Commercial\ Motor\ Vehicle\ Facts$$

The same method was repeated in each calendar year for both crash types. *Commercial Motor Vehicle Facts* (2013) did not include data for 2012. To estimate the preventable crash counts in 2012, GES 2012 data were used to calculate $p_{injury\ crashes}$ and multiplied by the 2011 crash counts found in *Commercial Motor Vehicle Facts* (FMCSA, 2013). A 95% confidence interval was also calculated for the proportion of injury crashes and fatal crashes that could be prevented.

2.2.2 Fatalities and Injuries

As in the section above, the procedures used to estimate the number of injuries that could be eliminated using the DriveCam Program are shown in detail; the same approach was used to estimate the number of fatalities that could be eliminated. The GES database was filtered for truck and bus crashes with an injury to get the total number of injuries. The number of injuries resulting from crashes that could be prevented was also calculated. A 0.755 reduction in crashes that could be prevented would result, on average, in a 0.755 reduction in injuries. Therefore, the number of injuries from crashes that could be prevented was multiplied by the severe safety-related event reduction rate of 0.755 in the formula for the proportion of injuries eliminated ($p_{injuries}$) below. The GES database in each calendar year was used to calculate the proportion of injuries from crashes that were eliminated with the DriveCam® program using the following formula:

$$p_{injuries\ eliminated} = \frac{Number\ of\ GES\ injuries\ from\ crashes\ that\ could\ be\ prevented \times 0.755}{Number\ of\ GES\ injuries\ from\ crashes}$$

FMCSA's *Commercial Motor Vehicle Facts* (2013) was used to estimate national counts of injuries that could be eliminated using the following formula:

$$n_{injuries\ eliminated} = p_{injuries} \times Number\ of\ injuries\ in\ Commercial\ Motor\ Vehicle\ Facts$$

The same method was repeated in each calendar year for both crash severities. Unlike the injury and fatal crashes, injuries and fatalities were mutually exclusive and could be summed to get the total number of injuries and fatalities eliminated. Similar to the crash counts above, the 2012 preventable injury counts were estimated using 2011 data. A 95% confidence interval was calculated for the proportion of injuries and fatalities that could be eliminated.

3. RESULTS

3.1 NATIONAL CRASH COUNT CALCULATIONS

The estimated mean reductions in total U.S. heavy truck and bus injury crashes using the DriveCam Program are displayed in Table 2. In 2012, the mean reduction in heavy truck and bus injury crashes was estimated to be 34.7 percent, followed by a reduction of 35.3 percent and 35.8 percent in 2011 and 2010, respectively. On average the DriveCam Program would prevent 25,007 injury crashes per year. The injury and fatal crash counts used in the calculations are listed by year in Table 12, Table 13, and Table 14 in Appendix B.

Table 2. Total U.S. Injury Crashes Prevented with the DriveCam® Program

Year	Total Number of Injury Crashes	Mean Injury Crashes Prevented with Lytx System	Mean Injury Crash Reduction Percentage	95% Confidence Interval for the Injury Crash Reduction Percentage
2012	73,000*	25,294	34.7%	34.3% to 35.0%
2011	73,000	25,730	35.3%	34.9% to 35.6%
2010	67,000	23,997	35.8%	35.5% to 36.2%

**2012 data has not yet been published; 2011 crash data and vehicle count data substituted.*

As shown in Table 3, the mean reductions in total U.S. heavy truck and bus fatal crashes using the DriveCam Program were estimated to be 24.1 percent, 20.4 percent, and 17 percent in calendar years 2012, 2011, and 2010, respectively. On average, the DriveCam® program would prevent 727 fatal crashes per year.

Table 3. Total U.S. Fatal Crashes Prevented with the DriveCam® Program

Year	Total Number of Fatal Crashes	Mean Fatal Crashes Prevented with Lytx System	Mean Fatal Crash Reduction Percentage	95% Confidence Interval for the Fatal Crash Reduction Percentage
2012	3,568*	859	24.1%	22.7% to 25.5%
2011	3,568	727	20.4%	19.1% to 21.7%
2010	3,512	595	17.0%	15.7% to 18.2%

**2012 data has not yet been published; 2011 crash data and vehicle count data substituted.*

The estimated mean reductions in total U.S. injuries from heavy truck and bus crashes using the DriveCam Program are displayed in Table 4. The mean percentage of injuries eliminated from heavy truck and bus crashes were 34.5 percent, 35.8 percent, and 36.3 percent in calendar years 2012, 2011, and 2010, respectively. On average, the DriveCam Program would eliminate 39,066

injuries per year from truck and bus crashes. The injury and fatality counts data used in the calculations are listed by year in Table 15, Table 16, and Table 17 in Appendix B.

Table 4. Total U.S. Injuries Eliminated with the DriveCam® Program

Year	Total Number of Injuries	Mean Injuries Eliminated with Lytx System	Mean Injury Reduction Percentage	95% Confidence Interval for the Injury Reduction Percentage
2012	112,000*	38,601	34.5%	34.2% to 34.7%
2011	112,000	40,092	35.8%	35.5% to 36.1%
2010	106,000	38,506	36.3%	36.0% to 36.6%

**2012 data has not yet been published; 2011 crash data and vehicle count data substituted.*

The estimated mean reductions in total U.S. fatalities from heavy truck and bus crashes using the DriveCam Program are shown in Table 5. The mean percentage of fatalities eliminated from heavy truck and bus crashes were 23.7 percent, 19.6 percent, and 16.8 percent in calendar years 2012, 2011, and 2010, respectively. On average, the DriveCam Program would eliminate 801 fatalities per year from truck and bus crashes.

Table 5. Total U.S. Fatalities Prevented with the DriveCam® Program

Year	Total Number of Fatalities	Mean Fatalities Eliminated with Lytx System	Mean Fatality Reduction Percentage	95% Confidence Interval for the Fatal Reduction Percentage
2012	4,018*	953	23.7%	22.4% to 25.0%
2011	4,018	786	19.6%	18.3% to 20.8%
2010	3,957	664	16.8%	15.6% to 17.9%

**2012 data has not yet been published; 2011 crash data and vehicle count data substituted.*

4. DISCUSSION

The current study modeled the potential reduction in fatal and injury crashes (and their associated fatalities and injuries) in large trucks and buses in the United States if these vehicles were part of Lytx's DriveCam Program.

The final data set included a total of 10,648 fatal truck and bus crashes (resulting in 11,993 fatalities) and 213,000 injurious truck and bus crashes (resulting in 330,000 injuries). As shown above, beneficial effects of the DriveCam Program on drivers had the potential to reduce an average of 727 fatal truck and bus crashes (mean 20.5 percent reduction of the total fatal crashes) and save 801 lives (mean 20.0 percent reduction of the total fatalities) each year.

Similar results were found for the analysis of injury crashes. Specifically, driver improvements through the use of the program had the potential to reduce an average of 25,007 truck and bus injury crashes (mean 35.2 percent reduction of the total injury crashes) and save 39,066 injuries (mean 35.5 percent reduction of the total injuries) each year. The results clearly show the benefits of Lytx's DriveCam Program in reducing fatal and injury crashes and their associated injuries and fatalities in large trucks and buses (using only crashes that received a violation).

4.1 CAVEATS

There are several caveats the reader should consider when assessing the validity of the results in the current study. First, the current study used sample crash data and may not be representative of the large truck and bus population. Second, accident types were used as a quasi-measure of fault; this variable may not always be able to determine which crashes were at-fault. For example, the striking vehicle may not always have been at-fault and accident types which did not specify a striking vehicle were removed; thus, more crashes could have been included in the analysis and some of the crashes labeled as at-fault in the current study may have actually been non-fault. Third, 2012 national crash statistics have not been published; thus, 2011 data were modeled as a substitute for 2012. Fourth, the results in the current study are a best case scenario as they assume all truck and bus safety personnel adhere to the training and instructions in the DriveCam Program. Simply installing an event recorder in a truck or bus without following the DriveCam program will not yield the results shown in the current report. Fifth, the authors selected a conservative approach for removing crashes that were not related to driver behavior per se, such as impairment due to drugs or alcohol and weather-related crashes. The DriveCam Program could reduce some of these types of crashes. Lastly, it is possible that some vehicles in the GES database and national counts had Lytx's DriveCam Program. The calculations in this report do not account for these vehicles.

APPENDIX A: LIST OF EXCLUSION/INCLUSION VARIABLES IN GES

Variable: Vehicle Configuration

Keep:

- Single-Unit Truck (2-axle and GVWR more than 10,000 lbs.)
- Single-Unit Truck (3 or more axles)
- Truck Pulling Trailer(s)
- Truck Tractor/Semi-Trailer
- Truck More Than 10,000 lbs., Cannot Classify
- Bus/Large Van (seats for 9-15 occupants, including driver)
- Bus (seats for more than 15 occupants, including driver)

Remove:

- Not Applicable
- Truck Tractor (Bobtail)
- Truck Tractor/Double
- Truck Tractor/Triple
- Vehicle 10,000 pounds or less placarded for hazardous materials
- Not Reported
- Unknown

Variable: Accident Type

Keep:

- Single driver, Right roadside departure, drive off road
- Single driver, Right roadside departure, control/traction loss
- Single driver, Right roadside departure, avoid collision with vehicle, pedestrian, animal
- Single driver, Right roadside departure, specifics other
- Single driver, Right roadside departure, specifics unknown
- Single driver, Left roadside departure, drive off road
- Single driver, Left roadside departure, control/traction loss
- Single driver, Left roadside departure, avoid collision with vehicle, pedestrian, animal
- Single driver, Left roadside departure, specifics other
- Single driver, Left roadside departure, specifics unknown
- Single driver, Forward impact, parked vehicle
- Single driver, Forward impact, stationary object
- Single driver, Forward impact, pedestrian/animal
- Single driver, Forward impact, end departure
- Single driver, Forward impact, specifics other
- Single driver, Forward impact, specifics unknown
- Same trafficway same direction, Rear End, stopped, truck/bus impacted another vehicle
- Same trafficway same direction, Rear End, slower, truck/bus impacted by another vehicle
- Same trafficway same direction, Rear End, decelerating, truck/bus impacted another vehicle
- Same trafficway same direction, Rear End, specifics other
- Same trafficway same direction, Rear End, specifics unknown

- Same trafficway same direction, Forward impact, control/traction loss, truck/bus impacted another vehicle
- Same trafficway same direction, Forward impact, avoid collision with vehicle, truck/bus impacted another vehicle
- Same trafficway same direction, Forward impact, avoid collision with object, truck/bus impacted another vehicle
- Same trafficway same direction, Forward impact, specifics other
- Same trafficway same direction, Forward impact, specifics unknown
- Same trafficway same direction, Angle sideswipe, impacting vehicle moving straight, truck/bus impacted another vehicle
- Same trafficway same direction, Angle sideswipe, impacting vehicle changing lanes, truck/bus impacted another vehicle
- Same trafficway same direction, Angle sideswipe, specifics other
- Same trafficway same direction, Angle sideswipe, specifics unknown
- Same trafficway opposite direction, Head-on, truck/bus impacted another vehicle
- Same trafficway opposite direction, Head-on, specifics other
- Same trafficway opposite direction, Head-on, specifics unknown
- Same trafficway opposite direction, Forward impact, control/traction loss, truck/bus impacted another vehicle
- Same trafficway opposite direction, Forward impact, avoid collision with vehicle, truck/bus impacted another vehicle
- Same trafficway opposite direction, Forward impact, avoid collision with object, truck/bus impacted another vehicle
- Same trafficway opposite direction, Forward impact, specifics other
- Same trafficway opposite direction, Forward impact, specifics unknown
- Same trafficway opposite direction, Angle sideswipe, truck/bus impacted another vehicle
- Same trafficway opposite direction, Angle sideswipe, specifics other
- Same trafficway opposite direction, Angle sideswipe, specifics unknown
- Change trafficway vehicle turning, Turn across path, Initial opposite directions, truck/bus impacted another vehicle
- Change trafficway vehicle turning, Turn across path, Initial same directions, truck/bus impacted another vehicle
- Change trafficway vehicle turning, Turn across path, specifics other
- Change trafficway vehicle turning, Turn across path, specifics unknown
- Change trafficway vehicle turning, Turn into path, turn into same direction, truck/bus impacted another vehicle
- Change trafficway vehicle turning, Turn into path, turn into opposite direction , truck/bus impacted another vehicle
- Change trafficway vehicle turning, Turn into path, specifics other
- Change trafficway vehicle turning, Turn into path, specifics unknown

Remove:

- Same trafficway same direction, Rear End, stopped, truck/bus was impacted by another vehicle

- Same trafficway same direction, Rear End, slower, truck/bus was impacted by another vehicle
- Same trafficway same direction, Rear End, decelerating, truck/bus was impacted by another vehicle
- Same trafficway same direction, Forward impact, control/traction loss, truck/bus was impacted by another vehicle
- Same trafficway same direction, Forward impact, avoid collision with vehicle, truck/bus was impacted by another vehicle
- Same trafficway same direction, Forward impact, avoid collision with object, truck/bus was impacted by another vehicle
- Same trafficway same direction, Angle sideswipe, impacting vehicle moving straight, truck/bus was impacted by another vehicle
- Same trafficway same direction, Angle sideswipe, impacting vehicle changing lanes, truck/bus was impacted by another vehicle
- Same trafficway opposite direction, Head-on, truck/bus was impacted by another vehicle
- Same trafficway opposite direction, Forward impact, control/traction loss, truck/bus was impacted by another vehicle
- Same trafficway opposite direction, Forward impact, avoid collision with vehicle, truck/bus was impacted by another vehicle
- Same trafficway opposite direction, Forward impact, avoid collision with object, truck/bus was impacted by another vehicle
- Same trafficway opposite direction, Angle sideswipe, truck/bus was impacted by another vehicle
- Change trafficway vehicle turning, Turn across path, Initial opposite directions, truck/bus was impacted by another vehicle
- Change trafficway vehicle turning, Turn across path, Initial same directions, truck/bus was impacted by another vehicle
- Change trafficway vehicle turning, Turn into path, turn into same direction, truck/bus was impacted by another vehicle
- Change trafficway vehicle turning, Turn into path, turn into opposite direction, truck/bus was impacted by another vehicle
- Intersect paths, Striking from the right
- Intersect paths, Struck on the right
- Intersect paths, Striking from the left
- Intersect paths, Struck on the left
- Intersect paths, specifics other
- Intersect paths, specifics unknown
- Backing Vehicle, truck/bus was impacted by another vehicle

Variable: Injury Severity

Keep:

- Possible Injury
- Non-incapacitating Injury
- Incapacitating Injury
- Injured, Unknown Injury Severity

- Fatal Injury

Remove:
- No Injury
- Died Prior
- No Person Involved in the Crash
- Unknown if Injured
- Unknown if Injured/Not Reported

Variable: Critical Event- Precrash Event

Keep:
- This vehicle loss of control due to
    - Traveling too fast for conditions
    - Other cause of control loss (specify:)
    - Unknown cause of control loss
- This vehicle traveling
    - Over the lane line on left side of travel lane
    - Over the lane line on right side of travel lane
    - Off the edge of the road on the left side
    - Off the edge of the road on the right side
    - End departure
    - Turning left at junction
    - Turning right at junction
    - Crossing over (passing through) intersection
    - This vehicle decelerating
    - Unknown travel direction
- Other motor vehicle in lane
    - Other vehicle stopped
    - Traveling in same direction with lower or steady speed
    - Traveling in same direction while decelerating
    - Traveling in same direction with higher speed
    - Traveling in opposite direction
    - In crossover
    - Backing
    - Unknown travel direction of the other motor vehicle in lane
- Pedestrian or pedalcyclist or other non-motorist
    - Pedestrian in road
    - Pedestrian approaching road
    - Pedestrian unknown location
    - Pedalcyclist or other non-motorist in road
    - Pedalcyclist or other non-motorist approaching road
    - Pedalcyclist or other non-motorist unknown location

Remove:
- This vehicle loss of control due to

    - Blow out/flat tire
    - Stalled engine
    - Disabling vehicle failure (e.g., wheel fell off) (specify:)
    - Non-disabling vehicle problem (e.g., hood flew up) (specify:)
    - Poor road conditions (puddle, pothole, ice, etc.) (specify:)
- Other motor vehicle encroaching into lane
    - From adjacent lane (same direction) over left lane line
    - From adjacent lane (same direction) over right lane line
    - From opposite direction over left lane line
    - From opposite direction over right lane line
    - From parking lane, median, shoulder, roadside
    - From crossing street, turning into same direction
    - From crossing street, across path
    - From crossing street, turning into opposite direction
    - From crossing street, intended path not known
    - From driveway, turning into same direction
    - From driveway, across path
    - From driveway, turning into opposite direction
    - From driveway, intended path not known
    - From entrance to limited access highway
    - Encroachment by other vehicle - details unknown
- Object or animal
    - Animal in road
    - Animal approaching road
    - Animal - unknown location
    - Object in road
    - Object approaching road
    - Object unknown location
- Other (specify)
    - Other critical precrash event (specify:)
- Unknown
    - Unknown

Variable: Imputed Police-Reported Alcohol Involvement (evaluated for truck/bus driver only)
Keep:

- No *(Alcohol Not Involved)*
- Not Reported
- Unknown *(Police Reported)*

Remove:

- Yes *(Alcohol Involved)*

Variable: Police Reported Drug Involvement (evaluated for truck/bus driver only)
Keep:

- No *(Drugs Not Involved)*
- Not Reported
- Unknown *(Police Reported)*

Remove:
- Yes *(Drugs Involved)*

Variable: Condition (Impairment) at Time of Crash- Driver
Keep:
- None/Apparently Normal
- Asleep or Fatigued
- Walking with a Cane or Crutches
- Paraplegic or Restricted to Wheelchair
- Impaired Due to Previous Injury
- Deaf
- Blind
- Emotional *(Depressed, Angry, Disturbed, etc.)*
- Under the Influence of Alcohol, Drugs or Medication
- Physical Impairment – No Details
- Other Physical Impairment
- Not Reported
- Unknown if Impaired

Remove:
- Ill, Blackout

Variable: Related Factors-Driver Level (2012 Data only)
Keep:
- None
- Aggressive Driving / Road Rage
- Seat Back Not In Normal Upright Position, Seat Back Reclined
- Traveling on Prohibited Trafficways
- Legally Driving on Suspended or Revoked License
- Leaving Vehicle Unattended with Engine Running, Leaving Vehicle Unattended in Roadway
- Following Improperly
- Improper or Erratic Lane Changing
- Failure to Keep in Proper Lane
- Illegal Driving on Road Shoulder, in Ditch, on Sidewalk or on Median
- Making Improper Entry To or Exit From Trafficway
- Starting or Backing Improperly
- Opening Closure into Moving Traffic or While Vehicle is in Motion
- Passing Where Prohibited by Posted Signs, Pavement Markings, Hill or Curve, or
- School Bus Displaying Warning Not to Pass Line

- Passing on Wrong Side
- Passing With Insufficient Distance, or Inadequate Visibility, or Failing to Yield to
- Overtaking Vehicle
- Operating the Vehicle in an Erratic, Reckless or Negligent Manner Operating at
- Erratic or Suddenly Changing Speeds
- Police Pursuing This Driver or Police Officer in Pursuit
- Failure to Yield Right-of-Way
- Failure to Obey Actual Traffic Signs, Traffic Control Devices or Traffic Officers, Failure to Obey Safety Zone Traffic Laws
- Passing Through or Around Barrier
- Failure to Observe Warnings or Instructions on Vehicles Displaying Them
- Failure to Signal Intentions
- Making Right Turn From Left-Turn Lane, Left Turn from Right-Turn Lane
- Making Other Improper Turn
- Driving Wrong Way on One-Way Traffic
- Driving on Wrong Side of Road (Intentional or Unintentional)
- Unfamiliar with Roadway
- Overcorrecting
- Driver Has Not Complied With Learner's Permit or Intermediate Driver License
- Restrictions (GDL Restrictions)
- Driver Has Not Complied With Physical or Other Imposed Restrictions (not
- including GDL Restrictions)
- Pedestrian, Pedal Cyclist, or Other Non-Motorist
- Ice, Snow, Slush, Water, Sand, Dirt, Oil, Wet Leaves on Road
- Trailer Fishtailing or Swaying
- Driver has a Driving Record or Driver's License from More Than One State
- Non-Traffic Violation Charged (manslaughter, homicide, or other assault offense
- committed without malice)
- Other Non-Moving Traffic Violations

Remove:

- Mentally Challenged
- Mother of Dead Fetus/Mother of Infant Born Post Crash
- Reaction to or Failure to Take Drugs/Medication
- Overloading or Improper Loading of Vehicle With Passengers or Cargo
- Towing or Pushing Improperly
- Failure to Dim Lights or to Have Lights on When Required
- Operating Without Required Equipment
- Police or Law Enforcement Officer
- Driving Less Than Posted Minimum
- Operator Inexperience
- Stopped in Roadway (Vehicle Not Abandoned)
- Locked Wheel
- Severe Crosswind

- Wind From Passing Truck
- Slippery or Loose Surface
- Tire Blowout or Flat
- Debris or Objects in Road
- Ruts, Holes, Bumps in Road
- Live Animals in Road
- Vehicle in Road
- Phantom Vehicle
- Getting Off/Out of or On/In to a Vehicle
- Unknown

Variable: Non-Motorist Action/Circumstances at Time of Crash
Keep:

- No Improper Action
- Entering/Exiting Parked/Standing Vehicle
- Inattentive (Talking, Eating, etc.)
- Operating Without Required Equipment

Remove:

- Dart/Dash
- Failure to Yield Right-Of-Way
- Failure to Obey Traffic Signs, Signals or Officer
- In Roadway Improperly (Standing, Lying, Working, Playing)
- Improper Turn/Merge
- Improper Passing
- Wrong-Way Riding or Walking
- Driving on Wrong Side of Road
- Improper Crossing of Roadway or Intersection (Jaywalking)
- Failing to Have Lights on When Required
- Improper or Erratic Lane Changing
- Failure to Keep in Proper Lane or Running Off Road
- Making Improper Entry to or Exit from Trafficway
- Operating the Vehicle in Other Erratic, Reckless, Careless or Negligent Manner
- Not Visible (Dark Clothing, No Lighting, etc.)
- Passing with Insufficient Distance or Inadequate Visibility or Failing to Yield to Overtaking Vehicle
- Other
- Not Reported
- Unknown

Variable: Driver's Vision Obscured By
Keep:

- No Obstruction Noted
- Reflected Glare, Bright Sunlight, Headlights

- Curve, Hill or Other Roadway Design Feature
- Building, Billboard, Other Structure
- Trees, Crops, Vegetation
- In-Transport Motor Vehicle (including load)
- Not In-Transport Motor Vehicle (parked/working)
- Inadequate Defrost or Defog System
- Inadequate Vehicle Lighting System
- Obstruction Interior to the Vehicle
- External Mirrors
- Broken or Improperly Cleaned Windshield
- Obstructing Angles on Vehicle
- No Driver Present / Unknown if Driver Present
- Vision Obscured – No Details
- Other Visual Obstruction
- Unknown

Remove:

- Rain, Snow, Fog, Smoke, Sand, Dust
- Splash or Spray of Passing Vehicle

APPENDIX B: RAW DATA TABLES

Table 6. 2012 GES Crash Calculations

Crash Type	Number of Crashes that could be Prevented	Number of Crashes that could be Prevented with Lytx Reduction Rate	Total Number of Crashes	Crash Reduction Percentage
Injury	1,805*	1,362.78	3,933*	34.7%
Fatality	44*	33.22	138*	24.1%

**2012 data has not yet been published; 2011 crash data and vehicle count data substituted.*

Table 7. 2011 GES Crash Calculations

Crash Type	Number of Crashes that could be Prevented	Number of Crashes that could be Prevented with Lytx Reduction Rate	Total Number of Crashes	Crash Reduction Percentage
Injury	1,598	1,206.49	3,423	35.3%
Fatality	27	20.39	100	20.4%

Table 8. 2010 GES Crash Calculations

Crash Type	Number of Crashes that could be Prevented	Number of Crashes that could be Prevented with Lytx Reduction Rate	Total Number of Crashes	Crash Reduction Percentage
Injury	1,473	1,112.12	3,105	35.8%
Fatality	22	16.61	98	17.0%

Table 9. 2012 GES Injury and Fatality Calculations

Injury Severity	Number of Injuries or Fatalities	Number of Injuries or Fatalities that could be Prevented with Lytx Reduction Rate	Total Number of Injuries or Fatalities	Injury or Fatality Reduction Percentage
Injury	2,728*	2,059.64	5,976*	34.5%
Fatality	49*	37.00	156*	23.7%

**2012 data has not yet been published; 2011 crash data and vehicle count data substituted.*

Table 10. 2011 GES Injury and Fatality Calculations

Injury Severity	Number of Preventable Injuries or Fatalities	Number of Injuries or Fatalities that could be Prevented with Lytx Reduction Rate	Total Number of Injuries or Fatalities	Injury or Fatality Reduction Percentage
Injury	2,419	1,826.35	5,102	35.80%
Fatality	28	21.14	108	19.57%

Table 11. 2010 GES Injury and Fatality Calculations

Injury Severity	Number of Preventable Injuries or Fatalities	Number of Injuries or Fatalities that could be Prevented with Lytx Reduction Rate	Total Number of Injuries or Fatalities	Injury or Fatality Reduction Percentage
Injury	2,258	1,704.79	4,693	36.33%
Fatality	24	18.12	108	16.78%

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