

Research Report  
KTC-99-20

**HEAVY TRUCK INVOLVEMENT IN TRAFFIC ACCIDENTS  
AND RELATED COUNTERMEASURES**  
(KYSPR-98-181)

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and

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<b>16. Abstract</b> <p>The objectives of this research study were to conduct a detailed analysis of truck accidents and recommend countermeasures to reduce the number and severity of this type of accident. Police reports for fatal accidents in which a truck was involved were reviewed for the period 1994 through 1997. Each accident report was reviewed and classified into types of accidents and causative factor categories. The most common accident involved another vehicle crossing the centerline into the path of a truck. The primary causative factor was related to the actions of the other driver, rather than the truck driver, in nearly two-thirds of the accidents. Countermeasures were recommended to reduce specific types of accidents. Locations were identified with the highest number of specific types of accidents and case studies were conducted to offer recommended solutions.</p> <p>Data from a weigh-in-motion site on US 23 in Lawrence County was analyzed and summarized to show the pattern of loads being carried by coal trucks in eastern Kentucky. Results were used to offer data which could support revisions to the current weight limits for the Extended-Weight Coal Haul Road System for combination trucks and to develop an enforcement mechanism which could improve compliance. Data summarized by the Transportation Cabinet's Division of Vehicle Enforcement was also collected and summarized to show the results of commercial vehicle inspections and the adjudication process for citations issued.</p> <p>Recommendations were made to reduce the number and severity of truck accidents. They included countermeasures relating to the vehicle, roadway, and driver.</p>					
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## EXECUTIVE SUMMARY

Traffic accidents involving heavy trucks are more severe and represent higher percentages of fatal accidents than collisions involving other types of vehicles. The primary objectives of this report were to conduct a detailed analysis of truck accidents and recommend countermeasures to reduce the number and severity of this type of accident.

Police reports for fatal accidents in which a truck was involved were reviewed for the four-year period of 1994 through 1997. Each accident was classified into one of several categories. The most common accident involved the other vehicle crossing the centerline into the path of the truck. The primary causative factor was related to the actions of the other driver, rather than the truck driver, in about two-thirds of the accidents. The circumstances which resulted in some of the most common types of accidents were described with potential countermeasures given. An analysis was performed of specific types of accidents, such as angle collisions at intersections and rear-end collisions in which both vehicles moving, resulting in identification of locations with the highest number of a specific accident type. Case studies were conducted at several locations with a summary of the types of accidents presented.

Data from the weigh-in-motion (WIM) site on US 23 in Lawrence County was analyzed, summarized, and presented. Data summarized by the Transportation Cabinet's Division of Vehicle Enforcement was also collected and summarized to show the results of annual commercial vehicle inspections.

Recommendations to reduce the number and severity of truck accidents were made. They included countermeasures relating to the vehicle, roadway, and driver. The potential for a revision to the current weight limit for the Extended-Weight Coal Haul Road System is discussed.

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## **1.0 INTRODUCTION**

Traffic accidents involving heavy trucks are more severe and represent higher percentages of fatal accidents than collisions involving other types of vehicles. In Kentucky, trucks are involved in about 7 percent of all accidents but are involved in approximately 13 percent of fatal accidents (1). In a previous study, truck braking characteristics and accidents involving trucks were investigated (2). The primary objectives of this report were to conduct a detailed analysis of truck accidents and recommend countermeasures to reduce the number and severity of this type of accident.

Truck accidents involved both single unit and combination trucks. A general summary of this type of accident is given in the annual problem identification report prepared by the Transportation Center. The most recent report gave the following summary related to truck accidents (1). Counties having the highest rates (accidents per 10,000 population) in each county population category were Gallatin, Webster, Grant, Perry, and Boone. Gallatin, Grant, and Boone Counties have at least one interstate highway. Webster and Perry Counties do not have an interstate highway within their borders, but there is a large amount of coal truck traffic in those counties. Pike County is another county which does not have an interstate but had a high rate due to the large amount of coal truck traffic.

The trend analysis showed there was a decrease in the number of truck accidents in 1997 (12.3 percent) compared to the previous four-year average (1). The number of truck accidents over the five years ranged from a high of 9,975 in 1996 to a low of 8,249 in 1997. The number of injury accidents decreased by 12.6 percent while the number of fatal accidents increased by 9.4 percent in 1997 compared to the 1993 through 1996 average. The number of injury accidents ranged from 1,852 in 1997 to 2,292 in 1996 while the number of fatal accidents ranged from 95 in 1996 to 108 in 1997.

## **2.0 PROCEDURE**

### **2.1 Trends in Truck Accidents and Traffic Volume**

The number of accidents involving trucks on all roads and on various types of roads (interstates, parkway, other state maintained, non-state maintained) were summarized for the years of 1992 through 1997. All accidents, fatal accidents and fatalities, and injury accidents and injuries were summarized. The trends in truck volumes over the past several years were also investigated. Data from a previous study were used to compare the increase in truck volumes with the increase in total traffic volume (2).

## **2.2 Analysis of Fatal Truck Accidents**

The computer file was used to obtain the case numbers of all fatal accidents involving a heavy truck. Copies of the uniform police report were obtained for these accidents for the four-year period of 1994 through 1997. The accident report was analyzed in detail with information from the report placed into a data base. Information obtained from the review included accident type, vehicle type, type of load, and primary fault. The accident type was a description of the type of collision such as "the other vehicle crossed the centerline into the path of the truck" or "the other vehicle ran into the rear of a slow moving truck." While many contributing factors may combine to result in a collision, the primary fault was assigned to either the truck driver or other driver, based on the review of the available information.

## **2.3 Analysis of Specific Types of Accidents**

The analysis of all truck accidents, as well as only fatal truck accidents, conducted in the previous report identified several common types of accidents (2). These accidents were investigated in more detail to determine where they were occurring as well as the contributing factors. A data base containing all truck accidents for the four-year period of 1994 through 1997 was used. The directional analysis (angle, head-on, opposite direction sideswipe, overturned, pedestrian, rear end, etc.) coded in the computer file was used to identify specific types of accidents.

## **2.4 Case Studies of Specific Locations**

The previous report produced lists of locations having high accident rates or a high number of a specific type of accident. Some of these locations were investigated in more detail. Also, some locations suggested by the Division of Traffic of the Transportation Cabinet were investigated. The investigation consisted of a site visit and analysis of the accidents at the site.

## **2.5 Truck Weight Analysis**

Weigh-in-motion (WIM) equipment has been installed at approximately 100 sites throughout the state and is used to collect vehicle weight data by the Transportation Cabinet's Division of Transportation Planning. The equipment is used to obtain weights of trucks, primarily for the development of equivalent single load axle (ESAL) estimates used for pavement design. Detection and monitoring equipment is used to obtain axle weights and total weights as trucks travel at highway speeds. Data from this equipment were used to estimate the distribution of weights for loaded trucks on specific types of highways.

## **2.6 Vehicle Enforcement Data**

Records for citations issued related to violations involving motor vehicles in Kentucky are maintained by the Administrative Office of the Courts (AOC). Data were obtained from AOC for overweight citations. The data were for one fiscal year (July 1996 through June 1997) and was summarized by county. The number of citations and the percent dismissed were summarized.

Another source of enforcement data is the Division of Vehicle Enforcement within the Department of Vehicle Regulation of the Transportation Cabinet. Data concerning vehicle inspections were obtained and summarized.

## **2.7 Field Testing**

The field testing involved an attempt to evaluate a vehicle stability system developed by VESCO Engineering. This is an on-board system that measures vehicle stability by means of three dimensional center of gravity monitoring and displays real-time information to the driver.

In addition, a roller brake tester was demonstrated at the I-75 Kenton County weigh/enforcement station. This equipment has the capability of measuring the brake rolling resistance, brake threshold pressure, service brake force, parking brake force, and ABS operation.

## **3.0 RESULTS**

### **3.1 Trends in Truck Accidents and Volumes**

As previously noted, the total number of truck accidents decreased in 1997 compared to the previous several years. To further investigate this trend, the number of truck accidents in 1997 were compared to the previous five-year average (1992 through 1996) for various types of highways (interstates and parkways, US and KY routes, and other roadways). This comparison was made for all, fatal, and injury accidents as well as for number of fatalities and injuries.

The total number of truck accidents decreased by 14 percent in 1997 compared to an average of the previous five years (1992 through 1996). This reduction in 1997 was the result of a lower number of accidents on US and KY routes (14 percent) and non-state maintained routes (28 percent). The number on interstates and parkways increased slightly (eight percent). The total number of injury accidents decreased by 11 percent in 1997 while there was a one percent increase on interstates and parkways. The number of injuries decreased by 14 percent with a decrease on all road types (ranging from 7 percent on interstates and



parkways to 16 percent on US and KY numbered routes). The number of fatal accidents increased by 12 percent in 1997 with an 8 percent increase on interstates and parkways. Fatalities increased by 14 percent with a 20 percent increase on interstates and parkways and a 5 percent increase on US and KY routes.

There has been a continuing increase in total traffic volume over the years. This increase in total traffic was compared to the increase in truck volume. An analysis of heavy truck vehicle-miles of travel (VMT) for the period 1988 through 1996 indicated that statewide truck VMT increased throughout the time period, but at a lesser rate than did total VMT. For the period 1988 through 1996, the overall increase for statewide traffic was 34.8 percent. This compares to an increase of 28.8 percent for heavy truck traffic during the same time period. This means there are more trucks on most roadways each year for the time period analyzed; however, the increase in total statewide traffic was generally greater than statewide truck traffic.

### 3.2 Analysis of Fatal Truck Accidents

An attempt was made to obtain copies of the police report and investigation for all fatal accidents in which a truck was involved (as indicated by the computer records). For the four-year period of 1994 through 1997, police reports were located for 383 of the case numbers located on the computer file in which truck involvement was verified. Each report was reviewed and accidents were classified into one of several categories describing the type of accident. When information was available, the load type was noted. Accident locations were summarized by county and route.

Following is a frequency listing of the most common accident descriptions (350 of the 383 accidents) resulting from review of the report and investigation.

<u>Accident Description</u>	<u>Number</u>
Other vehicle crossed centerline into path of truck	87
Other vehicle pulled or turned into travel path of truck	57
Single vehicle	41
Other vehicle ran into rear of slow moving truck	29
Pedestrian/bicycle	24
Other vehicle crossed median into path of travel of truck	21
Truck crossed centerline into path of other vehicle	18
Truck ran into rear of vehicle(s) on road	17
Other vehicle ran into rear of truck stopped on road	16
Vehicle hit side of truck trailer while truck making turn	14
Other vehicle ran into truck stopped off road	12
Truck disregarded traffic signal	8
Other vehicle disregarded traffic signal	6

From a review of the police accident reports, the primary contributing factor in two-thirds of the accidents was action by the other driver, rather than the truck driver. Other factors may also have contributed. For example, a vehicle may have pulled from a side road into the path of the truck but the truck driver may not have made the appropriate accident avoidance maneuver. In this example, the primary action was related to the action (failure to yield the right of way) of the other driver.

There were 43 accidents in which the determination was made that either a loaded (25 accidents) or unloaded (18 accidents) coal truck was involved. Other loaded trucks may have been coal trucks; however, insufficient information was available to make that conclusion. The highest numbers of these accidents were 10 in Pike County followed by 7 in Floyd County, 5 in Perry County, and 3 in Lawrence and Letcher Counties. All of these counties are in southeastern Kentucky. All but seven of the accidents occurred on a dry pavement. Fifteen accidents occurred during non-daylight hours. Sixteen accidents occurred on a grade with four at a hillcrest. The most common accident type (with 16 collisions) involved the other vehicle crossing the centerline into the path of the truck. This type was followed by nine collisions where the other vehicle ran into the rear of a slow moving truck and eight where the other vehicle pulled into the path of the truck. Considering the 16 accidents involving a vehicle crossing the centerline into the path of the truck: 5 were in Pike County (2 on US 460 and 2 on KY 194) with 2 on US 421 in Leslie County; 10 were on a curve; only 2 were not on dry pavement; and 6 were during non-daylight hours. Considering the nine rear-end collisions with a slow moving truck: three were in Floyd County (all on US 23) with two in Pike County; eight of nine were on a grade or hillcrest; four were during non-daylight hours; six involved a single unit truck; and all but one of the trucks were loaded. Considering the eight accidents where the other vehicle pulled into the path of the truck: three were in Floyd County with two in Martin County at the intersection of KY 645 and KY 40; only two were during non-daylight hours; and only one was not on a dry pavement.

For trucks where a determination could be made, the majority (66 percent) were loaded. A wide variety of loads were listed and, in several cases, the type of load could not be identified. Following is a list of the most common loads for trucks in which the type of load could be identified, along with the percent of all accidents.

<u>Type of Load</u>	<u>Number</u>	<u>Percent</u>
Coal	25	6.5
Food Products	21	5.5
Gravel/Sand	15	3.9
Steel	15	3.9
Liquid (fuel, etc.)	14	3.7
Timber, Logs	14	3.7
Equipment Parts	11	2.9

Seven of the 14 accidents involving a liquid were single vehicle. This suggests that a shifting load may have been a contributing factor.

The counties with the highest numbers of fatal truck accidents were Jefferson County with 30 followed by 16 in Pike County, 11 in Floyd County, and 10 in Madison County. Twelve of the accidents in Jefferson County were on an interstate. The most common accident type in Jefferson County involved six occurrences of a collision between a truck and a pedestrian, with only one of those on an interstate. Of the 16 fatal accidents in Pike County, 10 involved a coal truck, and 5 were unloaded. The most common accident was seven involving the other vehicle crossing the centerline into the path of the truck. Of the 11 fatal accidents in Floyd County, 7 involved a coal truck and 3 were unloaded. The most common accident was seven in which a vehicle pulled into the path of a truck. Of the 10 accidents in Madison County, 5 were on an interstate.

The county and route having the largest number of fatal accidents in the four-year period was US 23 in Floyd County, with six accidents. All six of these accidents involved a coal truck, including three rear-end collisions of another vehicle into a slow moving truck. Counties and routes having five accidents were I 65 in Bullitt County, KY 80 in Floyd County, I 65 in Hardin County, US 41 in Henderson County, and US 23 in Lawrence County. All five of the accidents on KY 80 in Floyd County involved a vehicle pulling into the path of the truck. Counties and routes with four accidents were I 65 in Barren County, KY 9 in Campbell County, US 60 in Daviess County, I 64 in Jefferson County, KY 9 in Mason County, KY 194 and US 460 in Pike County, and I 65 in Warren County. All four of the accidents on KY 194 in Pike County involved a vehicle crossing the centerline into the path of the truck.

Following are analyses of the circumstances which resulted in some of the most common types of accidents.

#### Other Vehicle Crossed Centerline into Path of Truck

Pike County had the largest number of this type of collision with seven followed by five in Leslie County and three in Letcher and Jefferson Counties. Four of the collisions in Pike County occurred on KY 194 with all of these occurring on a curve. Statewide, about 40 percent of this type of collision were coded as occurring on a curve.

In many instances, no reason could be found to explain why the vehicle crossed the centerline. In some cases the driver lost control due to overcorrecting after dropping off the pavement or lost control due to a high speed in a curve. However, the typical collision involved a driver drifting across the centerline.

Explanations included falling asleep, fatigue, or a distraction.

A potential countermeasure for this type of collision could involve a method of warning drivers that they were crossing the centerline into the opposing lane. The use of centerline rumble strips, similar to the shoulder rumble strips currently used, could provide this type of warning. A review of practices in other states has found one state (Maryland) which indicated a use of centerline rumble strips on two lane roads. They noted the rumble strips had been effective in reducing the risk of head-on crashes.

### Other Vehicle Pulled or Turned into Travel Path of Truck

Floyd County had the largest number of this type of collision with seven followed by several counties with two (Hancock, Martin, Pulaski, and Trigg Counties). Five of the seven accidents in Floyd County were on KY 80 with no occurrence of two at the same intersection. Five were at intersections with another state maintained road with two at a private entrance. The only location with more than one accident of this type was the intersection of KY 645 and KY 40 in Martin County. The accidents typically occurred at rural, high speed intersections with the speed limit 55 mph in 72 percent of the accidents. Countermeasures for this type of accident could include increased public awareness of the increased stopping distance required for a large truck, removing obstacles to increase sight distance, and warning signs for intersections with lower speed advisories.

### Single Vehicle

About 69 percent of the trucks were loaded in this type of accident compared to 63 percent for all fatal accidents. Seven of these accidents (18 percent) were loaded with a liquid such as fuel or solvent compared to four percent for all fatal accidents. Twenty-two of the accidents (55 percent) involved a single unit truck compared to 38 percent for all fatal accidents. All of the accidents involving a liquid load were single unit trucks. Sixteen of the accidents were on an interstate or parkway and five of these involved the driver falling asleep. In 45 percent of the accidents, the driver lost control on a curve. In a few instances, the accident occurred on a ramp. A common accident involved a driver allowing his vehicle to drop off the pavement onto the shoulder and then overcorrecting. Driver training would appear to provide a potential countermeasure for this type of accident. For example, drivers of trucks hauling a liquid load must be aware of the potential and consequences of load shifting and drive at a speed which will not result in a shifting of the center of gravity which could cause loss of control. A stability measuring device could be used to provide additional information to the driver and increase their level of awareness of the inherent instability of many vehicles. Development is underway of devices which could be used to measure and display stability. A

cooperative effort between the Transportation Center and VESCO Engineering was initiated but not yet completed to develop and test one type of device to measure and display stability. Warning signs should be placed in advance of sharp curves, specifically on exit ramp curves where accidents involving overturning trucks have occurred.

#### Other Vehicle Ran into Rear of Slow Moving Truck

The truck was loaded in 26 of the 29 accidents. In eight accidents the truck was loaded with coal. In 13 accidents the collision occurred on a grade with the truck loaded. Nineteen of the accidents occurred during non-daylight hours with a lighting defect noted in two accidents. Eighteen collisions involved a combination truck with 11 involving a single unit. Thirteen of the accidents occurred on an interstate with 11 of those involving a combination truck.

Jefferson County had the largest number of this type of collision with four and all occurred on an interstate. Both Pike and Floyd Counties had three collisions of this type with all three of the Floyd County accidents occurring on US 23. All of the six accidents in Pike and Floyd Counties involved a coal truck with the truck loaded in five instances.

Countermeasures for this type of collision could involve the vehicle, driver, and roadway. Vehicle measures would involve providing proper underride protection as well as adequate lighting and reflectivity. All trucks, both single unit and combination, should be equipped with rear impact guards that meet the requirements of Federal Motor Vehicle Safety Standards (FMVSS) 223 and 224. Trucks should also be equipped with appropriate FMVSS lighting and reflectivity devices. Truck drivers should use the truck's emergency flashers when driving at a speed substantially slower than the prevailing traffic speed. Warning signs should be posted at steep grades to alert motorists of the presence of slow moving trucks. Truck climbing lanes should be constructed at locations with steep grades and high truck volumes. The truck volume should be considered when determining the maximum grade in the roadway design process.

#### Pedestrian/Bicycle

Eight of the 24 accidents occurred on an interstate. Jefferson County had the highest number of this type of accident with six followed by three in Pike County. The most common action involved a pedestrian walking into the road into the path of the truck (not at an intersection). A few occurred at an intersection when the truck driver did not observe the pedestrian. A countermeasure for the intersection accidents would be to assure the truck had adequate mirrors to allow the driver to observe around the truck and for the pedestrian to be aware of the blind spots

adjacent to a truck which should be avoided.

#### Other Vehicle Crossed Median into Path of Truck

All but six of these 21 accidents occurred on an interstate. The only county and route with more than one accident of this type was US 23 in Lawrence County. In nine accidents, the pavement was not dry and five occurred during non-daylight hours. There is no obvious countermeasure for this type of accident which would relate to the truck.

#### Truck Crossed Centerline into Path of Other Vehicle

The most common sequence of events in this type of collision involved the truck dropping its wheels onto the shoulder and the driver overcorrecting and crossing into the opposing lane. The only counties with more than one accident of this type were three in Fayette County (two on US 27) and two in Butler County. Eight of the 18 accidents occurred in a curve. Only two were on a wet pavement with five occurring during non-daylight hours. Eleven of the accidents involved a single unit truck. Use of a 102-inch trailer on a road limited to eight feet maximum width was noted in one accident. A countermeasure for this type of accident would involve driver training relating to the handling characteristics of trucks with emphasis on the proper procedure after dropping tires onto the shoulder. The problems of offtracking must also be emphasized to truck drivers.

#### Truck Ran into Rear of Vehicle(s) in Road

Nine of the 17 accidents occurred on an interstate with two on I 75 in Madison County and two on I 65 in Bullitt County. The truck was loaded in 16 accidents. Six were during non-daylight hours. In two accidents defective brakes were noted and slippery surface was noted in two accidents. Countermeasures would relate to truck driver training. Specifically, the training should emphasize the increased distance required to stop, the limited handling characteristics of a truck, and the need to avoid driving for an excessive number of hours.

#### Other Vehicle Ran into Rear of Truck Stopped on Road

Only three of these 16 collisions occurred during non-daylight hours with a lighting defect noted in one accident. The trucks were stopped for a variety of reasons with the most common that the truck driver was preparing to turn left. Only two of the accidents occurred on an interstate. Seven of the trucks were single unit. None of the accidents involved a view obstruction. A countermeasure for reducing the severity of this type of collision would be to provide proper underride protection.

### Other Vehicle Ran into Rear of Truck Stopped off Road

Eight of these 12 collisions occurred on an interstate. Six occurred during non-daylight hours. A problem in this area is truck drivers who stop on the shoulder for a non-emergency purpose. Drivers should be trained to not stop their vehicle on the shoulder unless an emergency exists. Signs should be posted at locations where this problem has been identified prohibiting stopping unless an emergency exists. KRS 189.450 specifies that no vehicle registered at a gross weight of over 44,000 pounds be allowed to stand on the shoulders of any state-maintained highway except for an emergency or in response to a peace officer's signal. An example of a location where parking prohibition signs should be posted is adjacent to rest areas on interstate highways. Providing additional areas to park would be another countermeasure in this area.

### Vehicle Hit Side of Truck Trailer while Truck Making Turn

Twelve of the 14 accidents were during non-daylight hours with a lighting defect noted in three accidents. All but one involved a combination truck. The only county with more than one of this type of collision was Henderson County with two on US 41. In the typical collision, the truck was attempting to pull onto the road from a side road or business when a vehicle on the main road ran under the side of the trailer. Eleven of the collisions occurred in a straight section of road. While the trailer typically had the required lighting, the countermeasure for this type of collision would be increased reflectorization along the sides of trailers, including the use of reflective tape. This use of reflective tape is required on the sides of new trailers, and it should be added to existing trailers.

## **3.3 Analysis of Specific Types of Accidents**

Following is a discussion of an analysis of various types of accidents involving trucks. This analysis refers to the four-year period of 1994 through 1997. The file contained 36,161 accidents involving a truck of which 8,534 involved an injury and 404 a fatality.

### Angle Collision at Intersection

There were 3,839 angle collisions at intersections. Of those collisions, 1,176 involved an injury while 56 involved a fatality. Slightly over one-half of the collisions involved a combination truck. Only 14 percent occurred during non-daylight hours. Jefferson County had the highest number of this type of collision with 1,154 followed by 304 in Fayette County, 166 in Daviess County, 129 in Kenton County, 121 in Warren County, and 110 in McCracken County. Following is a list of locations with the highest number of angle collisions at intersections.

<u>County</u>	<u>Route</u>	<u>Milepoint</u>	<u>Intersection</u>	<u>Accidents</u>
Daviess	US 60	13.364	US 231 (Lewis St.)	5
Jefferson	KY 1020	12.802	US 31E	5
Jefferson	KY 1703	2.261	I 264	5
Jefferson	I 264	14.646	KY 1703	5
Knott	KY 80	8.042	KY 160	5
Logan	US 431	14.318	KY 79	5
Kenton	KY 8	0.859	I 471	4
Daviess	US 60	11.553	Ewing Road	4
Daviess	US 60	13.616	US 231 (Triplett St.)	4
Fayette	US 68	3.110	KY 4	4
Hardin	US 68	18.056	Poplar Street	4
Jefferson	US 150	1.650	12 <sup>th</sup> Street	4
Jefferson	KY 1631	7.583	Hiawatha Avenue	4
Jessamine	US 27	9.552	KY 169	4
Kenton	KY 8	6.869	US 25	4
Logan	US 68	8.604	KY 178	4
Marshall	US 62	7.618	Purchase Pkwy.	4
Martin	KY 645	4.682	KY 40	4
Mercer	US 127	4.402	US 68	4
Warren	US 231	8.917	KY 2158	4

Head-on (non-intersection)

There were 277 collisions of this type in the four-year period with 157 injury and 56 fatal. Only 19 percent occurred during non-daylight hours but 47 percent occurred when the roadway surface was not dry.

The county with the highest number of this type of accident was Pike County with 25 followed by 24 in Jefferson County and 12 in Letcher County. The routes with the highest numbers in each of these counties were four on US 119 in Pike County, four on I 65 in Jefferson County, and three on KY 1862 in Letcher County.

Opposite Direction Sideswipe (non-intersection)

There were 1,087 collisions coded as "opposite direction sideswipe" and involving an injury or fatality in the four years. Sixty five of the collisions involved a fatality. Only 17 percent occurred during non-daylight conditions but 36 percent occurred when the roadway surface was not dry. Most of the trucks involved (59 percent) were combination.

Pike County had the highest number of this type of collision with 118



followed by 65 in Jefferson County, 42 in Floyd County, and 33 in Letcher and Perry Counties. Routes with the highest number of collisions in these counties were 24 on US 119 in Pike County, 4 on I 65 in Jefferson County, 10 on KY 122 in Floyd County, 9 on US 119 in Letcher County, and 5 on KY 15 in Perry County.

Overturnd

All injury or fatal accidents in which a truck was coded as overturning were identified. There were 1,348 accidents identified including 75 fatal accidents. A review of these accidents by type of highway show that 325 occurred on an interstate or parkway and 164 were on a non-state maintained road with the majority (64 percent) occurring on a state maintained road (non-interstate or parkway). Most of the accidents (80 percent) were single vehicle. Only 10 percent occurred at an intersection. The most common type was a single vehicle accident in which the truck overturned in the road (30 percent) followed by "single vehicle run off road" (26 percent) and collision with a fixed object (18 percent).

Spots having the highest number of this type of accident were identified. Following is a list of 0.3-mile spots which had at least three accidents in the four-year period involving an overturning truck.

<u>County</u>	<u>Route</u>	<u>Beginning Milepoint</u>	<u>Ending Milepoint</u>	<u>Accidents</u>
Boone	I 75	175.360	175.383	3
Boone	I 75	182.400	182.500	3
Daviess	US 60	7.200	7.319	3
Daviess	Natcher Pkwy.	70.000	70.222	3
Fayette	US 27	15.000	15.200	4
Hardin	I 65	90.950	91.000	3
Hardin	I 65	91.430	91.500	3
Jefferson	KY 841	10.000	10.269	4
Kenton	I 75	187.700	187.721	4
Lawrence	US 23	18.410	18.410	3
Trigg	I 24	68.800	68.900	4
Warren	Natcher Pkwy.	0.000	0.300	6

Pedestrian

There were 117 accidents involving a pedestrian in which 93 involved a fatality. The majority (78 percent) were not at an intersection. Slightly over one-half involved a single unit truck rather than a combination. About two-thirds occurring during non-daylight hours. About 18 percent occurred on an interstate or parkway with 38 percent on a non-state maintained road. As would be expected,

the highest number occurred in the urban counties with 39 in Jefferson County followed by 8 in Fayette County.

### Ramp Related

All accidents which were coded as occurring on a ramp and involving a truck were identified. A total of 1,436 accidents were identified with 321 involving an injury and 7 involving a fatality. A large number (22 percent) were single vehicle.

Almost one-half (47 percent) were at the intersection of the ramp and side road. Of those accidents, the most common were rear end (38 percent) followed by same direction sideswipe (23 percent) and angle (18 percent).

The most common accident not at the intersection was 28 percent involving a rear end collision. In the majority of the rear end collisions, one vehicle was stopped which could occur if a driver stopped on the ramp while attempting to merge. The second most common type was 23 percent involving a same direction sideswipe. This type of collision would typically involve a merging maneuver. There were numerous single vehicle accidents with 13 percent in which a fixed object was hit and 11 percent in which the truck overturned. About seven percent of the collisions involved a truck parked on the ramp.

### Rear End in Traffic Lanes with Both Vehicles Moving

All injury or fatal rear end collisions occurring in the travel lanes with both vehicles moving and involving a truck were identified. A total of 975 collisions of this type were identified in the four-year period with 41 involving a fatality. Almost half (48 percent) of these collisions occurred on an interstate.

The counties and routes with the highest number of this type of accident typically involved an interstate. The highest numbers were 38 on I 65 in Jefferson County followed by 29 on I 75 in Boone County, 28 on I 75 in Kenton County, 25 on I 65 in Warren County, and 20 on I 75 in Madison County. The highest numbers on non-interstate routes were 12 on US 23 in Pike County, 12 on US 27 in Pulaski County, 11 on KY 15 in Perry County, and 9 on US 19 in Pike County.

### Truck Parked out of Travel Lane

A summary was prepared of injury or fatality collisions with a truck which was parked out of the travel lane. There were 253 of these collisions in the four year period, and 13 were fatal accidents. Of these, 51 were on an interstate or parkway and 91 were not on a state-maintained highway. Approximately 36 percent occurred during non-daylight hours. Counties with the highest number of

this type of accident follow:

<u>County</u>	<u>Total Number (Injury &amp; Fatal)</u>	<u>Fatal</u>
Jefferson	57	2
Fayette	17	0
Pike	15	1
Kenton	13	0
Campbell	8	1
Daviess	7	0
Madison	7	0
Warren	7	2
Boone	6	0
Floyd	6	0

Of the 13 fatal accidents, 5 occurred on an interstate or parkway.

### **3.4 Case Studies of Specific Locations**

In order to give examples of specific locations where accidents involving heavy trucks were a potential issue, input was obtained from the Transportation Cabinet. Also, information from the previous report was used (2). Following is a summary of the types of collisions which have occurred at a variety of locations across the state. Some locations have several accidents involving trucks while others do not. Data were obtained for either the five-year period of 1993 through 1997 or for the four years of 1994 through 1997.

#### Boone County, Interstate 75 interchange with KY 338, MP 175.364

This is a diamond interchange between I 75 and KY 338 in Boone County. There were 32 accidents on the ramps at this interchange in the four year period of 1994 through 1997. There are truck stops at this interchange which generate a large amount of truck traffic. One half of the accidents occurred at the intersections between the ramp and cross road. Considering all accidents, the most common accident was a rear end type. Seven of the accidents involved an injury with two of these involving a rollover. Only seven of the accidents were single vehicle.

#### Breathitt County, KY 15 at intersection with KY 1098 and KY 1812, MP 14.629

This is an intersection of two lane, rural roadways. KY 15 has the right of way with stop signs on the two side road approaches. There were 12 accidents in the five years with none involving a truck. There are signs warning of the truck crossing with an advisory speed sign.

Breathitt County, KY 15 at intersection with KY 541 and Hoover Bridge Rd.;  
MP 23.253-23.363

This site includes two adjacent intersections of KY 15 and two side roads. KY 15 has the right of way with stop signs on the side road approaches. There were 12 accidents in the five years with one involving a truck. There are side road warning signs with flashers.

Floyd County, US 23, Milepoints 13.0-15.0

This is a four-lane, rural highway with a flush median. The speed limit is 55 mph. There is significant coal truck traffic. There are steep grades over this section of road which results in slow moving trucks on the upgrade. There were 39 accidents in the five-year period of 1993 through 1997 with 11 involving a heavy truck. The most common collision involved a rear end in the traffic lane with both vehicles moving. There were 12 of these collisions with 4 involving a truck. There were two fatal collisions with both involving a truck. One involved a rear end impact into the rear of a slow moving truck, which occurred during daylight conditions, and the other involved the truck crossing the centerline into the opposing lanes. There is a warning sign for trucks to use a lower gear on the downgrade. Truck drivers typically activate the truck's flashers when moving at a slow speed up the grade.

Floyd County, US 23, Milepoints 17.5-20.5

This is a four-lane, rural highway with a flush median. The speed limit is 55 mph. There is significant coal truck traffic. There are steep grades which result in slow moving trucks. There are also intersections with state routes. There were 74 accidents in the five-year period with 8 involving a truck. Approximately one-half of the accidents were at intersections. Twenty four accidents occurred at one intersection with KY 1428 (MP 17.805) but only one involved a truck. A traffic signal was added at this intersection. The intersection is on a steep grade and an advanced warning flasher was installed to provide additional warning when the signal is changing from green to red.

Hardin County, I 65, Milepoints 95.3-98.5

This is a rural interstate with a median and a speed limit of 65 mph. This section of interstate has six lanes except in the area where there are four lanes for southbound traffic. The additional lane for southbound traffic is a truck climbing lane because of a long upgrade. There were 81 total accidents with 26 involving a truck. The most common type of accidents, considering total accidents and truck accidents, were same-direction sideswipe collisions followed by a rear end collision

with both vehicles moving. Five of the rear end collisions, and four of those involving a truck, were at MP 96.0 and all involved southbound vehicles. This was near the end of the long upgrade for southbound traffic and involved a slow moving truck. Signs stating "trucks use right 2 lanes" are provided. Fifteen of the truck accidents occurred during daylight conditions. Of the 26 truck accidents, 11 were same direction sideswipes, 6 were a rear end collisions with both vehicles moving, and 5 involved a parked vehicle (in 2 of these the truck was the parked vehicle).

#### Martin County, KY 645 at intersection with KY 40, Milepoint 4.682

This intersection is in a rural area. Right of way is controlled by stop signs on the KY 40 approaches. The speed limit on KY 645 is 55 mph but there are intersection warning signs with 45 mph advisory speeds. An intersection warning beacon has been installed. Sight distance is not limited. The approaches are straight with a downgrade. Of 12 accidents during the five-year period, 5 involved a truck. In four of the five truck accidents, a vehicle from KY 40 pulled into the path of the truck which was on KY 645. Two of these collisions resulted in a fatality with injuries in the other two.

#### Powell County, Mountain Parkway, Milepoints 34.0-36.0

This is a rural parkway with a depressed median. The speed limit is 65 mph. There is a steep upgrade for eastbound traffic over most of this section. There were 14 accidents in this section with two involving a truck. There is a hill warning sign which warns of slow moving trucks. None of the accidents involved a rear end impact with a slow moving vehicle.

#### Warren County, Natcher Parkway at I 65, Milepoints 0.0-0.3

The Natcher Parkway is a four lane, divided parkway which ends at I 65 at milepoint 0.0. Of 27 accidents at this location, 16 involved a truck. Of the 16 truck accidents, 9 involved the truck overturning in the road with all but 2 of the others a single vehicle accident. Of the 16 truck accidents, only 2 occurred during non-daylight hours with only 3 when the road was not dry. The single vehicle accidents are occurring on the long ramp from the Natcher Parkway to proceed northbound on I 65. Curve warning signs with a 40 mph advisory speed, chevrons, and truck rollover warning signs with a flasher are provided.

### **3.5 Truck Weight Analysis**

Weigh-in-motion (WIM) data are collected at a series of locations across the state by means of sensing devices installed in the pavement. The data include type of truck (single unit or combination and number of axles) along with axle and total

weight. Data from one of the WIM sites were used to estimate the distribution of weights for coal trucks. The WIM site was on US 23 in Lawrence County in southeastern Kentucky. This road has a high volume of coal truck traffic. The equipment was calibrated prior to data collection by the Transportation Cabinet's Division of Transportation Planning. The analysis considered only six axle trucks which had a minimum weight of 80,000 pounds so that only loaded coal trucks were included in the analysis. The assumption was that a loaded coal truck would have a minimum weight of 80,000 pounds since this WIM site was on the Extended Weight Coal Haul Road System. A sample of over 19,000 trucks was obtained for a time period in late 1998. The average weight of the sample was approximately 158,000 pounds with a median of about 157,000 pounds. The maximum weight was 220,600 pounds. The distribution of weights showed that about 88 percent of the trucks were hauling a load over the current extended weight limit (including tolerance) of 126,000 pounds. About 15 percent of the trucks had a weight over 180,000 pounds, with 60 percent over 150,000 pounds.

As a comparison, WIM data were summarized at an interstate site. Data taken at the station on I 24 in Lyon County were analyzed. This site is close to the weigh-enforcement station on I 24. In 1997, data were obtained for almost 47,000 five axle trucks with a weight over 40,000 pounds. Such a small number of the five axle trucks were over the 80,000 weight limit that the cumulative percentage showed 100 percent having a weight of 80,000 or less. Approximately 27 percent of these trucks had a weight between 70,000 and 80,000 pounds. Different results were obtained when weights for a small sample of six axle trucks was analyzed. Weights for 724 six axle trucks weighing 40,000 pounds or more showed that about 42 percent were over 80,000 pounds with 22 percent over 100,000 pounds and five percent over 120,000 pounds. The maximum weight of a six axle truck at the I 24 site was 138,700 pounds.

### 3.6 Vehicle Enforcement Data

Information was obtained from the Administrative Office of the Courts (AOC) concerning the number of overweight citations in their records. Data were obtained for a one-year period (July 1996 through June 1997). The data gave the number of citations and their disposition. A total of 2,313 citations were recorded with only 6.1 percent dismissed. Following is a summary of the 10 counties with the highest number of citations issued.

<u>County</u>	<u>Number</u>	<u>Percent Dismissed</u>
Lyon	780	0.3
Kenton	361	2.8
Henderson	282	1.1

<u>County</u>	<u>Number</u>	<u>Percent Dismissed</u>
Pike	161	16.8
Simpson	90	3.3
Floyd	84	3.6
Boyd	56	1.8
Mason	40	7.5
Warren	34	26.5
Lawrence	32	15.6

Counties with the highest number of citations (Lyon and Kenton) have weigh-enforcement stations on an interstate highway while Henderson County has a weigh-enforcement station on US 41.

Summaries of the results of vehicle inspections are reported by the Division of Vehicle Enforcement. The number of inspections and the results are given. There are five levels of inspection. Level I is the standard inspection of the vehicle and driver. Level II is a walk-around driver and vehicle inspection. Level III is a driver-only inspection. Level IV is a special inspection. Level V is a vehicle-only inspection. There are very few Level IV or V inspections. A summary of the total number of inspections for the last few years follows. The 1998 data are for January through September while the 1997 data are for 12 months.

<u>Year</u>	<u>Level I</u>	<u>Level II</u>	<u>Level III</u>	<u>Level IV</u>	<u>Level V</u>	<u>Total</u>
1998	25,513	8,310	21,667	17	127	55,634
1997	30,813	8,990	22,980	207	168	63,158

About 91 percent of the inspections were for trucks not carrying a hazardous material, 7 percent for trucks carrying hazardous materials and 2 percent for busses.

Considering Level 1 inspections, 20 percent resulted in an out-of-service violation for the vehicle. The percentage was the same for 1997 and 1998. This percentage varied from 21 percent for a truck not carrying a hazardous material to 17 percent for a truck carrying a hazardous material to 5 percent for buses. The Level 1 inspections resulted in an out-of-service violation for 5.3 percent of the drivers. This varied from 5.5 percent for a driver of a truck not carrying a hazardous material to 3.5 percent for a driver of a truck hauling a hazardous material to 0.9 percent for a bus driver. The Level II inspections resulted in out-of-service violations for 23 percent of the vehicles and 7 percent of the drivers. The Level III driver inspections resulted in 12 percent with out-of-service violations.

The types of violations were also summarized. Almost 40 percent of all vehicle violations involved a brake problem with 17 percent for the brakes being out of adjustment. Following is a summary of the percentage of the various types of violations related to the vehicle considering all violations and out-of-service violations. The combination of violations related to brakes, lighting, and tires accounted for about three-fourths of the violations.

<u>Vehicle Violation Type</u>	<u>Percent of All Violations</u>	<u>Percent of Out-of-Service Violations</u>
Brakes, all other	21.7	20.4
Brakes, out of adjustment	17.2	16.0
Lighting	24.1	27.7
Tires	10.9	13.3
Suspension	3.7	7.7
Emergency equipment	3.7	0.1
Frames	2.3	2.7
Steering mechanism	2.0	2.7
Wheels, studs, clamps	1.9	2.9
Windshield	1.9	0.1
Exhaust discharge	1.7	0.2
Fuel systems	1.1	1.8
Load securement	0.9	2.6
Coupling devices	0.6	0.9

About 41 percent of total driver violations and 49 percent of out-of-service violations related to a problem with the log book. Hours-of-service violations accounted for about 7 percent of all violations and 27 percent of out-of-service violations. Following is a summary of the percentage of the various types of violations related to the driver considering all violations and out-of-service violations. The combination of violations related to the log book and hours of service accounted for 48 percent of all violations and 76 percent of out-of-service violations.

<u>Driver Violation Type</u>	<u>Percent of All Violations</u>	<u>Percent of Out-of-Service Violations</u>
Log book	40.7	49.0
Hours of service	7.0	26.9
Traffic enforcement	19.5	1.2
Medical certificate	10.3	0.3
Seat belt	1.6	0.0
Radar detectors	1.5	0.0



<u>Driver Violation Type</u>	<u>Percent of All Violations</u>	<u>Percent of Out-of -Service Violations</u>
Drugs	1.1	4.3
Disqualified driver	0.6	2.4
Alcohol	0.5	2.3

### **3.7 Field Testing**

An attempt was made to install and evaluate the VESCO vehicle stability system on a tractor trailer and then place a load on the truck and collect data. The system is based on the theory that the stability of a vehicle can be measured by determining the lateral acceleration required for a vehicle to rollover, regardless of payload. Stability is calculated as the ratio of the weight differences between the sides of a truck by measuring the pressure in the air springs, which is proportional to the weight. The system was placed on a combination truck provided by the Kentucky Transportation Cabinet (KyTC). The system was calibrated by VESCO Engineering with a load provided and the truck weighed by KyTC. A driver provided by KyTC then drove the truck while VESCO Engineering personnel monitored the system. The objective was to operate the truck over a range of conditions so that a various levels of lateral and longitudinal acceleration could be measured. However, the load placed on the low-boy trailer did not produce the desired range of acceleration levels which would have been necessary to adequate assess the system's capability of measuring the onset of rollover . It was concluded that additional data must be collected to evaluate the vehicle stability system.

A roller brake tester was demonstrated and evaluated for potential application by the research team and other members of the Study Advisory Committee. The system incorporates electronics and controls to measure brake forces at each wheel with strain-gage type transducers. Additional sensors measure air pressure, pedal force, and axle weight. The equipment has the capability of measuring the brake rolling resistance, brake threshold pressure, service brake force, parking brake force, and anti-lock braking system operation. Representatives from the Division of Vehicle Enforcement expressed interest in additional evaluation of the system as a means to screen truck brakes at weigh-enforcement stations. This would enable enforcement personnel to determine whether a more detailed inspection should be conducted to determine the status of the braking system for a truck. The roller brake tester was also being considered for use as a means of verifying another screening device for truck brake inspection which relies on infrared sensing of the heat generated by truck brakes.

## 4.0 RECOMMENDATIONS

Following are recommended lists of potential countermeasures to address accidents involving heavy trucks. The countermeasures are divided into those relating to the vehicle, roadway, and driver.

### Vehicle Countermeasures

- a. Provide adequate rear underride protection (all trucks, both single unit and combination, should be equipped with rear impact guards which meet the requirements of Federal Motor Vehicle Safety Standards 223 and 224).
- b. Provide adequately maintained and properly located lights and reflectors (specifically reflective strips of tape on the sides of trailers and lights/reflectors on the rear).
- c. Provide continuing maintenance with emphasis on brakes, lighting, and tires. Specific emphasis should be placed on the need for operation front brakes on all trucks.
- d. Develop a truck rollover warning system.
- e. Consider the use of side underride protection.
- f. Provide proper load security with improved procedures and enforcement.
- g. Consider use of interactive technologies such collision avoidance and obstacle detection systems, on-board safety monitoring systems, and intelligent mirror systems.
- h. Implement and evaluate truck brake screening systems (infra-red systems and performance-based brake testing systems should be considered).
- i. Braking tests have shown that heavily loaded single-unit coal trucks do not meet Federal Motor Carrier Safety Regulations for stopping distance and increased enforcement should be concentrated on those trucks.

### Roadway Countermeasures

- a. Install centerline rumble strips at selected locations (warrants for installation of centerline rumble strips should include curved sections of two-lane roads with a high frequency of opposite-direction accidents).
- b. Widen pavement and post appropriate advisory speeds at sharp curves.
- c. Install advance warning at traffic signals on high-speed roadways (advance warning flashers where warranted).
- d. Install related signing at steep grades.

- e. Install rumble strips on all paved shoulders.
- f. Place "no parking" signs on shoulders at locations where trucks have been observed stopping for non-emergency reasons. Post delineators should also be installed to provide a physical barrier at locations with a high incidence of use (near on-ramps at rest areas).
- g. Provide additional parking for truck drivers and enforce parking restrictions. Promote use of parking at existing weigh stations.
- h. Construct truck climbing lanes at locations with steep grades and high truck volumes.
- i. Consider truck performance characteristics in the highway design process (for example, consider the truck volume when determining the maximum allowed grade).
- j. Consider lane use restrictions for trucks on multilane roadways with steep grades.
- k. Consider the construction of truck escape ramps at locations with high truck volumes and where there is roadside development and a lack of a clear zone at the end of a long downgrade.
- l. Place active warning devices in advance of curves where accidents have occurred involving overturning trucks.
- m. Provide roadway lighting where there is a high incidence of nighttime accidents.
- n. Consider roadway geometrics (grade and curvature) when determining whether a road should be placed on the Extended-Weight Coal Haul Road System.

### **Driver Countermeasures**

- a. Provide training for truck drivers (i.e. always use flashers when speed slow for conditions, do not stop on shoulder unless there is an emergency as specified in KRS 189.450, be aware of the center of gravity of the load and its related handling characteristics, be aware of offtracking characteristics of trucks, and emphasize log book and hours in service requirements).
- b. Provide education for the general driving population relating to trucks' operational characteristics (i.e. longer stopping distances, limited handling characteristics).
- c. Address driver fatigue through an improved method of logging driving hours in combination with development of an in-vehicle driver monitoring system.
- d. Reinforce the need for improved/increased enforcement of typical moving violations by non-vehicle enforcement law enforcement agencies.

## **Problem Areas**

The following specific roadway problem areas were identified as locations with a potential for truck accidents. Where high truck volumes are expected, related countermeasures should be considered.

- a. interchange ramps,
- b. steep grades,
- c. sharp curvature on two lane roads, and
- d. intersections with sight distance restrictions and/or high speed.

## **Recommended Weight Limit for Extended-Weight Coal Haul Road System**

The question of an appropriate weight limit for the Extended-Weight Coal Haul Road System has been debated and various legislation has been proposed. Weigh-in-motion data confirmed that existing truck weights for loaded coal trucks typically exceed the current weight limits. A revision to the current system which should be considered is to increase the weight limit for combination trucks and develop an enforcement mechanism which would improve compliance. An increase beyond the current level of 126,000 pounds, but less than 150,000 pounds, could have the effect of decreasing overall weights. Limiting the steering axle to 15,000 pounds and all other axles to 25,000 pounds would result in a gross weight of 140,000 pounds for a six-axle truck. This could reduce the number of excessive loads which contribute to safety problems and pavement damage.

## **5.0 FUTURE RESEARCH**

Many of the recommendations previously cited include new technology applications for improvement in the operation of heavy trucks. This appears to be an area with significant potential for advances in safety related to the vehicle, roadway, and the driver. Future research should be concentrated in this area.

## **6.0 REFERENCES**

1. Agent, K.R. and Pigman, J.P.; "Analysis of Traffic Accident Data in Kentucky (1993-1997)," Kentucky Transportation Center, University of Kentucky, KTC-98-16, September 1998.
2. Pigman, J.G. and Agent, K.R.; "Investigation and Analysis of Heavy Truck Accidents," Kentucky Transportation Center, University of Kentucky, KTC-98-5, April 1998.