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NATIONAL ESTIMATES OF THE NUMBER OF TRUCKS, TRAVEL, AND ACCIDENT EXPERIENCE OF TRACTOR SEMITRAILERS USED TO TRANSPORT HAZARDOUS MATERIALS

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16. Abstract

This report presents national estimates of the annual travel and accident experience of tank semitrailer combinations carrying hazardous materials. Travel estimates are developed from the University of Michigan Transportation Research Institute (UMTRI) National Truck Trip Information Survey (NTTIS) and the 1982 Truck Inventory and Use Survey (TIUS) conducted by the Bureau of the Census. Based on these data files, it is estimated that a national population of about 67,000 tractors typically pull a single tank semitrailer. These single tank semitrailer combinations accumulate approximately 1.4 billion miles carrying hazardous cargo, 0.7 billion miles carrying non-hazardous cargo, and 1.7 billion miles empty. Approximately 90 percent of this travel is by five-axle combinations.

The coverage and detail of existing national accident data is not sufficient to provide a direct estimate of the accident experience of these tank semitrailer combinations. National projections of the accident experience are developed from the OMC 50-T accident reports submitted by interstate carriers to the FHWA Office of Motor Carriers. The annual involvement projected for the tank semitrailer combinations is approximately 6,500 accidents resulting in a fatality, any injury treated away from the scene, or $2,000 property damage, the OMC reporting threshold. The projected total includes about 1,600 rollovers. The probability of a rollover per mile traveled for the tank semitrailers is about 30 times higher when carrying cargo than when empty.

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NATIONAL ESTIMATES OF THE NUMBER OF TRUCKS, TRAVEL, AND ACCIDENT EXPERIENCE OF TRACTOR SEMITRAILERS USED TO TRANSPORT HAZARDOUS MATERIALS

Introduction

This report presents national estimates of the accident experience of tractors pulling a single semitrailer. The focus is on tank trailers and hazardous materials. The primary accident events of interest are rollover and cargo spillage. In preparing this report, information has been extracted from several sources. Estimates of the national population of trucks, miles traveled, and cargo loading can be developed from the UMTRI National Truck Trip Information Survey (NTTIS). These population and overall travel estimates can be corroborated by estimates from the 1982 Truck Inventory and Use Survey (TIUS) conducted by the Bureau of the Census. Complete information on the national fatal accident experience is available from the UMTRI Trucks Involved in Fatal Accidents (TIFA) files for 1980 through 1984. However, there is no national data file for nonfatal accidents with good coverage of the accident population and complete information on vehicle configuration, cargo loading, rollover, and cargo spillage.

The primary source of information on police-reported accidents nationwide is the NHTSA National Accident Sampling System (NASS). A probability-based sampling procedure allows national estimates of all police-reported accidents to be developed from the NASS file. The shortcomings of the NASS file are the lack of some necessary data elements and small sample sizes. Information on trailer body style, loading, and cargo spillage are not included in NASS. The relatively small sample sizes for tractor semitrailers (about 500 per year) produce considerable variation in the estimates from year to year. Thus the NASS file will support estimation of national totals of injury and property damage accidents for all tractor semitrailers, but will not support further detail. The OMC 50-T reports filed by interstate carriers with the Office of Motor Carriers (formerly the Bureau of Motor Carrier Safety, or BMCS) include the necessary detail on trailer body style and loading, but the coverage of accidents is not complete. Only about one-sixth of all police-reported accidents involving a tractor semitrailer are reported to the Office of Motor Carriers.

In order to develop national estimates with the desired level of detail, the various components of the under-coverage of the OMC file must be identified and suitable projections applied. The approach developed for this report and the resulting projections are presented in the section entitled Projections of the National Accident Experience. Population and travel estimates are covered in the section preceding that material. A summary is presented in the next section.

Only tractors pulling a single semitrailer were included in this analysis. Straight trucks (with or without a trailer) and tractors pulling anything other than one trailer have been excluded. Tractors pulling a single semitrailer account for about 65% of all large truck mileage and 93% of all tractor mileage (Reference 1). Large trucks are any power unit with a gross vehicle weight rating over 10,000 pounds.

Summary

The national population of tank semitrailer combinations is approximately 67,000 vehicles. Because an individual tractor may pull more than one type of trailer, or more than one trailer of the same type, it is only possible to characterize approximately the tractor population by the type of trailer most commonly pulled. Since the estimate of 67,000 is based on an inventory of power units, it does not estimate the national inventory of trailers, which is typically two to three times greater than the number of power units.

In contrast, the NTTIS data provides a relatively accurate estimate of travel by trailer body style by keeping track of the trailer body style for each mile traveled. Based on the NTTIS file, tank semitrailers accumulate 8.3 percent of all tractor semitrailer mileage, or 3.9 billion miles per year. The tank semitrailer mileage can be further broken down to 1.7 billion miles (46%) empty, 1.4 billion miles (37%) carrying hazardous cargo, and 0.7 billion miles (17%) carrying non-hazardous cargo. In contrast, only one-sixth of the hazardous materials travel is in van trailers. Hazardous materials are included in the cargo on only 1.5 percent of all van semitrailer mileage. In fact, even that figure may overestimate the importance of hazardous cargo transported in vans. Unlike bulk cargo in tank semitrailers, only a small portion of the cargo may be hazardous in a van semitrailer.

No existing national accident file has both the detail and coverage to provide a direct estimate of the accident experience of tank trailers carrying hazardous materials. Consequently, for this report it was necessary to develop projections from the existing data, primarily the NASS and OMC files. The primary group of carriers reporting to OMC are the interstate authorized carriers. Thus, the projections are based on ratios of travel for the interstate authorized carriers to all carriers developed from the NTTIS data. The accuracy of these projections depends on the validity of the necessary assumptions and the accuracy of the original data. It was also necessary to compensate for differences in the reporting threshold and definition of rollover between the NASS and OMC accident files. If a police accident report was filed, the accident is eligible for selection in NASS, whereas OMC only requires reports on accidents resulting in a fatality, any injury requiring treatment away from the scene, or $2,000 property damage. NASS records all rollovers, while OMC codes only primary event rollovers, that is, rollovers which are the first harmful event in an accident.

After adjusting the OMC accident counts for under-coverage of non-authorized carriers (interstate private and exempt, and intrastate), the projected annual number of tractor semitrailer combinations involved in accidents resulting in a fatality, treated injury, or $2,000 or more property damage is about 64,000. In contrast, the NASS estimate of all police-reported

accidents involving tractor semitrailers is 181,000. The difference in these two figures is primarily due to police-reported accidents that did not produce $2,000 property damage. However, there may also be some further underreporting of property damage accidents to OMC, since the projections were based on the underreporting of fatal accidents. The less serious accidents may be even more underreported.

The annual national estimate from the 1983 NASS file of the number of tractor semitrailer combinations that were involved in police-reported accidents and rolled over is 15,800. The projected OMC figure is about 4,800 rollovers, less than one-third of the NASS figure. These differences can be attributed to two sources: the definition of rollover and the reporting threshold. In the NASS file, rollover is coded separately from collision type, a procedure that should catch all rollovers, while rollover is only coded on the OMC 50-T form if it is the primary accident event. A comparison of rollover counts for fatal and injury accidents indicates that the ratio of all rollovers as reported in NASS to primary event rollover as on the OMC 50-T report is 2.25. Adjusting by this ratio produces an estimated 10,800 rollovers corresponding to the OMC reporting threshold of $2,000. The difference between this figure and the NASS figure of 15,800 are presumed to be rollovers that did not result in $2,000 property damage (or an injury treated away from the scene or fatality). Many of the additional rollovers in NASS may have occurred subsequent to other primary accident events (collisions). It is worth noting that the NASS projections are quite variable from year to year. In the next year, the NASS estimate is only 10,500. However, the proportion that are property damage only is about the same in 1983 and 1984.

Of the two files, tank semitrailers can only be identified in the OMC file. However, the figures above provide a basis for relating the projections from the OMC data to the NASS reporting level. The OMC projections indicate that tank semitrailer combinations are involved in 465 primary event rollovers resulting in $2,000 or more property damage when carrying hazardous materials. Approximately 90 percent of these are 5-axle combinations. An additional 581 are projected to roll over subsequent to some other primary accident event. Total property damage would exceed $2,000 for these also. This total of 1,046 primary and subsequent rollovers for tank semitrailers hauling hazardous cargo is the more conservative estimate, and is consistent with the 1984 NASS file. However, the 1983 NASS data implies that there would be another 484 primary and subsequent rollovers that did not produce $2,000 in property damage.

The TIFA file contains information on the spillage of hazardous cargo in rollover accidents. For 5-axle tank semitrailers with hazardous cargo, at least 44 percent of the rollovers resulted in spillage of cargo. The variable in which this information is recorded is hierarchical, so some spillage could be masked by the code categories with a higher priority, fire and explosion. This appears likely. For hazardous cargoes, 31 percent of the rollovers included a fire or explosion, while for non hazardous cargoes only 11 percent of the 5-axle tank rollovers included a fire or explosion. Since most hazardous cargoes are flammable or explosive, it seems likely that the excess of fires/explosions in hazardous cargo rollovers are due to or include a spill of the hazardous cargo. This would mean that in roughly 64 percent of the hazardous cargo rollovers resulting in fatality, some cargo was spilled. Using

the estimate of 1,046 primary and secondary rollovers of tanks with hazardous cargo, one could estimate that 669 hazardous spills occur due to rollover per year in accidents of all severities. These data include no information on the size of the spill.

Truck Population and Travel Estimates

Tables 1 and 3-5 in the group of tables at the end of this report were prepared from the National Truck Trip Information Survey (NTTIS) conducted by UMTRI in 1985-86 to estimate the national population of large trucks and their travel(2). The NTTIS sample was taken from registrations nationwide as of July 1, 1983. These tables present results for five separate tractor semitrailer combinations: 5-axle van, all other vans, 5-axle tank, all other tanks, and all other semitrailers. The 5-axle vans and tanks are the two trailer types of interest. The other types are shown to provide a perspective on the rest of the semitrailers. The bottom row of each table shows the total for all tractor semitrailers.

It should be pointed out here that the population and mileage estimates are developed from samples of registered power units (tractors). Descriptive information on the trailers is only obtained when they are pulled by a tractor. Individual trailers are not identified in the data. Consequently, parked trailers are not covered, and the population estimates may be one-half to one-third of an inventory count of trailers. This approach provides a complete inventory of registered power units, no matter how little they are used, and the mileage traveled by the power unit can be classified by the type of trailer pulled. In this approach, vehicle miles traveled is the exposure measure for accident involvement.

Table 1 shows the NTTIS estimates of the national population of tractor semitrailers by the type of semitrailer usually pulled. The number of vehicles, average annual miles, and total mileage (in billions of miles) are shown for each semitrailer type along with the total for all semitrailers.[1] Assuming that the unknown body styles are distributed the same as the known categories, the 5-axle tanks are about 6 percent of the vehicles, and accumulate about 7 percent of the travel. The average annual mileage for the 5-axle tanks is about 65,000 miles, somewhat above the average.

Comparable estimates are developed from the 1982 Truck Inventory and Use Survey (TIUS) and presented in Table 2. Overall, the agreement is good. The NTTIS estimate of the number of tractors that usually pull semitrailers is about 881,000 and the TIUS estimate is 863,000. These estimates are within two percent of one another. Some of the difference is probably due to the fact that the NTTIS sample came from 1983 registrations whereas the TIUS sample was from 1982 registration data. The 5-axle tanks

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1. Travel figures presented in this report are based on annual mileage estimates reported by the owner, or "self-reported" travel. In both the TIUS and NTTIS, the owner was asked to estimate the annual mileage of the sampled truck. The annual travel of all tractor semitrailers is approximately 46 billion miles based on the self-reported annual mileage. Currently, the self-reported mileage estimate is the more commonly used figure. However, the NTTIS also asked for odometer readings from the sampled truck at the beginning and end of the survey year. Based on the odometer readings, the annual travel estimate for tractor semitrailers is only 33 billion miles. Previous UMTRI reports using the NTTIS data were based on the odometer data (UMTRI-88-17 and UMTRI-88-28).

are about 7 percent of the vehicles, and accumulate about 8 percent of the travel.

With regard to tractors with tank semitrailers, both files indicate that the 5-axle configuration dominates. From NTTIS, Table 1 shows that the 5-axle tank combinations are 83 percent of the vehicles and over 90 percent of the travel. The comparable figures from the TIUS, Table 2, are 85 percent of the vehicles and also over 90 percent of the miles traveled. After adjusting for the 11 percent missing data in the NTTIS file, the population estimate for all tank semitrailer combinations is 62,000 from NTTIS and 71,000 from TIUS. The number of these that are 5-axle tank combinations is from 51,000 to 61,000.

An advantage of the NTTIS file is that each mile traveled is coded for the type of trailer pulled. This provides a more accurate estimate of total travel. Table 3 shows the distribution of travel by cargo type for each of the five semitrailer types. Cargo is categorized as none (empty), hazardous, and non-hazardous for each mile traveled in the NTTIS data. Empty miles were not classified by the type of cargo normally carried. Based on the coding of survey miles by trailer type in the NTTIS file, the tank trailers accumulate 8.3 percent of the total travel by tractors pulling a single semitrailer. This figure is between the figures shown in Tables 1 and 2, and corresponds to an annual travel for all tank semitrailers of 3.9 billion miles (3.7 billion for 5-axle only). This is our best estimate of the annual travel for tank semitrailers.

Table 3 also shows that the proportion of empty miles varies with the semitrailer type, with the tank trailers having the highest proportion of empty miles, about 45 percent. Van semitrailers carry hazardous cargo on only 1.5 percent of their mileage, or about 260 million miles annually. The coding of hazardous cargo indicates only that some of the cargo required a placard; it may have been all of the load, or only a small portion. Also, the NTTIS data do not identify the different types of hazardous cargoes. For the tanks, it is probably safe to assume that if the cargo is coded hazardous, the entire cargo is hazardous. While the van semitrailers haul hazardous cargoes very seldom, about two-thirds of the cargo carried in tank semitrailers is hazardous.

Overall, the tank semitrailers annual travel breaks down to 1.7 billion miles (46%) empty, 1.4 billion miles (37%) carrying hazardous cargo, and 0.7 billion miles (17%) carrying non-hazardous cargo. Five-axle tank semitrailers accumulate virtually all of the tank travel carrying hazardous cargoes. Only 15 percent of all tractor semitrailer travel with hazardous cargo is by van semitrailers, and nearly all the rest is in tanks. Thus, the bulk shipment of hazardous cargoes accounts for five times the mileage of hazardous cargo in containers. The ratio of ton-miles is probably much higher, since only a portion of the cargo may be hazardous in the van semitrailers.

Tables 4 and 5 provide some guidance for developing national estimates from the accident reports filed by the carriers with the Office of Motor Carriers. Only interstate carriers are required to submit accident reports to OMC. Accident statistics presented in the next section will suggest that only the interstate authorized carriers are covered reasonably well in the OMC

file. Consequently, it will be useful to know how the interstate authorized carriers compare to the rest of the carriers (interstate private and exempt, and intrastate). Table 4 shows the number of trucks, average annual mileage, and total travel of interstate authorized carriers versus all other carriers by trailer body style. Overall, the authorized carriers have a higher average annual mileage, nearly 73,000 miles as compared to 46,000 miles for the other carriers. Interstate authorized carriers operate less than 40 percent of the trucks, but accumulate nearly 50 percent of the total travel. However, it is particularly important to notice that the situation is somewhat different for the tank trailers. There are more than twice as many 5-axle tank trailers operated by other carriers as by the authorized carriers. The other carriers accumulate more than 60 percent of the total mileage for 5-axle tank trailers.

Table 5 provides the distribution of travel by cargo type separately for interstate authorized carriers and all other carriers. The other carriers also accumulate more than twice the travel with hazardous cargo as the interstate authorized carriers. This information will guide the development of national projections from the OMC accident data in the next section.

Projected National Accident Experience

The existing population and travel data on trucks supports estimates of the national fleet transporting hazardous materials without difficulty. The general agreement between the NTTIS and TIUS estimates corroborates the resulting figures. However, developing estimates of the national accident experience of these vehicles is problematic, as discussed in the Introduction.

The best overview of the national accident experience of tractor semitrailer combinations available is provide by the NHTSA National Accident Sampling System (NASS) files. Tables 6 and 7 provide estimates from the 1983 and 1984 NASS files respectively by accident severity (fatal, injury, and property damage) for all accidents and rollover accidents. Table 8 provides comparable information from the OMC 50-T reports submitted to the Office of Motor Carriers. Comparison of these two tables illustrates the magnitude of the under-coverage of the OMC file. The NASS estimate of the annual accident experience of tractor semitrailers is nearly six times the OMC total.

Table 9 subsets the OMC data to interstate authorized carriers versus other interstate carriers (private and exempt). Based on the NTTIS travel data, the interstate authorized carriers accumulate about 47 percent of the total travel by tractor semitrailers, interstate private and exempt 39 percent, and the intrastate carriers 14 percent. Table 9 illustrates that 84 percent of the reports to OMC are submitted by authorized carriers. Thus, it is clear that the interstate private and exempt carriers generally do not file accident reports with OMC.

The NASS file will not support the additional detail needed on trailer body style and cargo, while the OMC data will. Consequently, to obtain projections at the desired level of detail, the only approach possible is to develop projections from the OMC data. In order for the projections to be accurate, they should take into account the sources of the under-coverage. Three sources of under-coverage of the OMC data seemed critical to this

effort: carrier type, reporting threshold, and subsequent event rollover. Each is treated separately.

Under-coverage of the OMC 50-T reports for authorized carriers was estimated for fatal accidents by using the UMTRI Trucks Involved in Fatal Accidents (TIFA) files. Coverage is complete in this file, and carrier type is identified. Comparison of the fatal accidents reported by carrier type in the TIFA file with the number of reports submitted to OMC by the various carriers shows that the interstate authorized carriers appear to report only about 86 percent of their fatal accidents to OMC. An adjustment factor of 1.14 will be used to account for underreporting by the authorized carriers to OMC. This is conservative in that it assumes that the underreporting is not greater for injury and property damage accidents.

The larger adjustment from interstate authorized carriers to all carriers is based on the travel statistics presented in the previous section (Tables 4 and 5). Overall, the interstate authorized carriers cover about 50 percent of all tractor semitrailer travel. Ratios of total travel to the travel of interstate authorized carriers were developed by trailer body style from Table 4. These ratios were also calculated separately for empty and not-empty miles for each trailer body style. This procedure was necessary in order to avoid distorting the accident experience. For example, Table 4 indicates that there are twice as many tank trucks operated by the "other" carriers as there are by the authorized carriers. On the assumption that the accident rate for the "other" carriers is not too different from that for the authorized carriers, the travel data provides a basis for projecting from the authorized carriers to all carriers. Adjustment factors were developed separately for rollover and non-rollover accidents, and for injury and property damage accidents. Fatal accident counts were taken from the TIFA files, and did not require any adjustment.

The 1984 and 1985 OMC files were subset to tractor semitrailers operated by authorized carriers, and the injury and property-damage counts were inflated by the ratios developed. Overall, the adjustment for carrier type increased the injury and property damage counts by a factor of 2.13. The results of this estimation procedure are shown in Table 10. Annual estimates were developed from the average of the 1984 and 1985 OMC data. The fatal accident counts are taken from the TIFA file, while the injury and property damage counts are inflated annual counts from the OMC file. The inflation factors only adjusted for under-coverage based on carrier type. Thus, the total of 63,569 shown on Table 10 is the number of reports that would be expected if *all* carriers (inter- and intrastate) submitted an OMC 50-T form for every tractor semitrailer involved in an accident resulting in a fatality, an injury treated away from the scene, or $2,000 property damage.

The other sources of under-coverage can be seen by comparing the NASS estimates in Tables 6 and 7 with the projected OMC figures in Table 10. The most obvious difference is the reporting threshold for property damage accidents. The NASS file includes any police-reported accident, while OMC reports are only required on accidents resulting in $2,000 property damage, or any injury requiring treatment away from the scene. Consequently, NASS reports 110,000 more property damage accidents than the OMC projections. Presumably, these all result in less than $2,000 property damage.

Another difference between these two files that has been treated as under-coverage is the difference in the definition and coding of rollover. In the NASS file, rollover is coded separately from the type of collision. Thus, any truck that did not remain upright would be coded as rolled. The OMC 50-T form only identifies rollover when it is the primary accident event. A rollover that occurs subsequent to a collision is not coded on the OMC accident report form. The relationship of primary to subsequent rollover can be determined by examining the TIFA file. In the TIFA file, all rollovers that occur in an accident are recorded and primary event rollovers are distinguished from subsequent event rollovers. Notice that the number of fatal and injury rollovers in Table 10 is approximately half the number of fatal and injury rollovers in the 1983 NASS file (Table 6). This ratio is consistent with the ratio of primary to subsequent rollover in TIFA.

Our best effort to reconcile counts from the 1983 NASS file (Table 6) and the projected OMC figures in Table 10 is tabulated below. The 1983 file was used because the estimated number of fatal involvements agrees very well with the average annual census counts from the TIFA file. The fatal estimates from the 1984 NASS file are more than 25 percent low. Thus, the last column (labelled "total") in the table below is the 1983 NASS data on rollover from Table 6 after allocating the missing data to the three accident severity categories. The first column labelled "primary" is taken from the OMC projections in Table 10, except for the first entry, "less than $2,000 property damage." For the "treated injury" and "fatal" rows, the second column (labelled "subsequent") was obtained by subtracting the OMC projection ("primary" column) from the NASS count ("total" column). The ratio of primary to subsequent rollover for the sum of these two categories is 1.25, and this ratio was used estimate the subsequent rollovers resulting in $2,000 or more property damage and to ratio the remaining 5,000 rollovers resulting in less than $2,000 property damage between the primary and subsequent columns.

Projected Annual Rollover Accident Involvement By Accident Severity—All Tractor Semitrailers

Accident Severity	Rollover		
	Primary	Subsequent	Total
<$2,000 Property Damage	2,200	2,800	5,000
>$2,000 Property Damage	2,000	2,500	4,500
Treated Injury	2,600	3,300	5,900
Fatal	200	200	400
Total	7,000	8,800	15,800

This table illustrates the differences in the definition of rollover and the reporting threshold between the NASS file and the OMC file after adjusting for the under-coverage of private and intrastate carriers. The projected OMC figure of 4,800 rollovers corresponds to primary event rollover resulting in $2,000 or more property damage, treated injury, or fatality. Comparison

with the NASS estimates implies that 6,000 rollovers occur in these accidents subsequent to some other collision event, for a total of 10,800 primary and subsequent rollovers in accidents resulting in $2,000 or more property damage, treated injury, or fatality. Finally, there appear to be an additional 5,000 primary and subsequent rollovers that resulted in less than $2,000 property damage. Overall, there are about 7,000 primary event rollovers and 8,800 subsequent rollovers.

The ratio of primary event rollover as defined by the OMC 50-T form to all rollovers as reported in NASS is consistent with the definition of primary and subsequent rollover in FARS (and TIFA). However, it is a little difficult to imagine 5,000 rollovers a year that produce less than $2,000 property damage. Some of these may simply reflect additional underreporting by the carriers to OMC. However, one must also keep in mind that the NASS estimates of rollovers are quite variable from year to year. The 1984 estimate was only 10,500. If the previous table had been reconstructed from the 1984 NASS estimates, the results would have been somewhat different. Overall, there would have been about 6,500 primary event and only 4,000 subsequent event rollovers. Only 2,700 rollovers would appear to produce less than $2,000 property damage, and the remaining 7,800 would exceed the OMC reporting threshold. These figures underscore the uncertainty in these projections.

Considering the range of these estimates, a figure of 10,800 rollovers seems most plausible. The 1983 NASS data would imply that all of these exceed the $2,000 reporting threshold, while the 1984 NASS file implies that about 25 percent are below that reporting threshold. The number of primary event rollovers is relatively stable, ranging from 6,500 to 7,000, while the number of subsequent rollovers ranges from 4,000 to 8,800.

From the previous discussion, it is clear that percentage of accidents that involve a rollover also depends on the definition of rollover and the accident reporting threshold. Based on the NASS data in Tables 6 and 7, the probability of injury in accidents involving rollover is more than double that in non-rollover accidents. Primary event rollovers are 3.6 to 3.9 percent of the 181,000 NASS-reported accidents involving tractor semitrailer combinations. Subsequent event rollover is another 2.2 to 4.9 percent of all NASS-reported accidents. As above, the range of estimates comes from the use of the 1983 or 1984 NASS data respectively. Because rollover accidents have a higher probability of injury, they are a greater percentage of the accidents identified by the OMC reporting threshold of $2,000 property damage (or any injury treated away from the scene). Primary event rollovers are 7.5 percent of OMC-reported accidents, and subsequent event rollovers are 4.7 to 9.4 percent. Thus, the combination of primary and subsequent event rollover is about 6 to 9 percent of all NASS-reported accidents involving tractor semitrailers, and 12 to 17 percent of all OMC-reported accidents.

Estimates from the NASS file cannot be broken down by type of semitrailer or cargo. However, this level of detail is available in the OMC data, and rollover estimates by combination type and cargo are presented in Table 11. Two definitions of rollover are shown. The top half of the table shows the breakdown by configuration and cargo of the 4,800 primary event rollovers resulting in $2,000 property damage or more. These figures are inflated to 10,800 primary and subsequent rollovers on the bottom half of

Table 11. Projections for all accidents meeting the OMC reporting threshold are shown in Table 12 by the same breakdown.

Based on Table 11, approximately 550 primary event rollovers ($2,000 or more property damage) involve hazardous cargo, about 85 percent of those with tank semitrailers. Only about 2 percent of the rollover accidents occur while empty, even though 29 percent of the travel is empty. The figure from the bottom half of the table for primary and subsequent rollovers is 1,046 involving tank semitrailers carrying hazardous materials. These figures translate to a rate of between 300 and 700 per billion miles traveled. The rate of 300 per billion miles corresponds to primary event rollover producing $2,000 or more property damage (based on 465 rollovers from the top half of Table 11 and 1.44 billion vehicle miles from Table 3), while the rate of 700 per billion miles corresponds to the primary and subsequent rollover resulting in $2,000 property damage, treated injury, or fatality (based on 1,046 rollovers from the bottom half of Table 11).

Accident rates are tabulated below by trailer body style and loading. Tank semitrailers are compared to the overall rate for all tractor semitrailers combinations, and empty operation is compared to operation with any load (not empty). For this table, hazardous cargoes have been combined with non-hazardous. The top half of the table below shows rates for primary and subsequent rollovers that result in $2,000 or more property damage, a treated injury, or fatality. These rates are calculated from the travel estimates in Table 3 and the rollover counts from the bottom half of Table 11. Tank semitrailers with cargo have a rollover rate roughly thirty times that of empty tankers. Non-tank semitrailers with cargo roll over at a rate 17 times that of empty non-tank semitrailers. The rollover rate of tank semitrailers with cargo is more than double that of non-tank semitrailers with cargo.

Accident Rates per Billion Miles
by Trailer Body Style and Loading
for Rollover and All Accidents—Tractor Semitrailers

Loading	Trailer Body Style		All
	Tank	Non-Tank	
Primary and Subsequent Rollover >$2,000			
Empty	26	17	18
Not Empty	750	290	320
All Rollovers	420	220	230
All Accidents >$2,000			
Empty	810	890	880
Not Empty	2,400	1,500	1,600
All Accidents	1,700	1,300	1,400

The bottom half of this table shows rates for all accidents resulting in $2,000 property damage, a treated injury, or fatality. These rates were calculated from the projected annual accident counts from Table 12. A similar pattern is shown, although the effect of cargo is not nearly so great. The rate for tank semitrailers with cargo is about three time the rate for empty tanks, while the rate for non-tank semitrailers with cargo is less than twice the empty rate. Overall, tank semitrailers that are not empty have an accident rate 60 percent higher than non-tank semitrailers carrying cargo. Combining operation with and without cargo, the tank semitrailers have an accident rate that is 24 percent higher than non-tank semitrailers.

The figures in this table must be interpreted with caution. Many factors may be responsible for the differences in the accident rates of tank semitrailer combinations as compared to all other semitrailer body styles. For example, the rate of fatal accident involvement on limited access (interstate) roads is less than one-third the rate on all other roads. Similarly, the rate at night is more than double the daytime rate. Thus, differences in the use of tanks as compared to other semitrailers probably accounts for some of the differences in the overall rates by trailer body style shown above. However, such factors do not seem likely to account for rollover rate for tank semitrailers that is more than double that of all other semitrailers. This finding is supported by calculations presented by Ervin (4) showing the static roll threshold (lateral acceleration at which incipient rollover occurs) of the tank semitrailer to be about 30 percent lower than a typical 5-axle van semitrailer.[2] Thus, the elevated rate of rollover accidents for the tractor and tank semitrailer combination is associated with the decreased resistance to rollover of this configuration.

Tank trailers carrying hazardous cargo also spill their cargo in both rollover and all accidents at a higher rate than non-tank trailers. Looking at fatal accidents, tank semitrailers with hazardous cargo spill at least some of their cargo in 64 percent of rollover accidents, while all other trailer types containing hazardous cargo suffer a spill in 54 percent of rollover accidents. Similarly, considering all fatal accidents in which the trailer was carrying hazardous cargo, rollover and non-rollover alike, tank trailers experienced cargo spillage in 35 percent of their involvements, while non-tank trailers lost

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2. The rates presented by Ervin in UMTRI-88-28 were developed from accident and travel data for van semitrailers because the available sample size better supported estimation of fatal accident rates by weight category. However, these rates must be adjusted for differences in the estimation of both annual travel and non-fatal rollover accidents. Rates in the earlier report were based on the NTTIS odometer-based travel. The ratio of the odometer-based annual mileage to the owner-estimated annual mileage is 0.713. The total number of police-reported primary and subsequent rollover accidents was estimated by Ervin to be 33 times the number of rollover accidents resulting in fatality. This corresponds to an annual estimate for all tractor semitrailers of about 13,200. This report has concluded that 10,800 is the best estimate that we can make from the existing data. The ratio of 10,800 to 13,200 is 0.818. Thus, the rates presented by Ervin must be multiplied by 0.713 x 0.818, or 0.583, in order to be comparable to the rates presented in this report. Using this adjustment, the predicted rollover rate of 0.466 for the baseline van fully loaded presented in the table at the bottom of page 13 becomes 0.272, and the predicted rate for this vehicle with 75% of full weight is 0.263. The travel data from Table 3 and the projected number of primary and subsequent rollover accidents in Table 11 of this report yield an overall rate for 5-axle vans that are not empty of 0.223 per million miles. This overall figure is consistent with the data presented in Ervin's report.

A rollover rate for the 5-axle tank was projected as 0.438 (after multiplication by 0.583) by Ervin based on the calculated roll threshold for the tank and the relationship between roll threshold and accident rates developed for vans. The corresponding overall rate for non-empty tanks developed in this report is 0.750, substantially higher. The authors are not able to resolve this difference. Sloshing may increase the actual rate for partially full tanks. Other factors related to differences in the operation of tanks and vans (such as more travel on the less safe non-interstate roads by tanks as compared to vans) may contribute to the difference. Finally, the difference may be a consequence of the inadequacy of the existing data and the many assumptions that were necessary to develop these estimates.

cargo in only 18 percent of their involvements. The pattern of spillage was similar when the scope is broadened to include non-fatal accidents. In the 1984-85 OMC data, tank semitrailers carrying hazardous cargo experienced a spill in 51.1% of rollover accidents and 19.7% of all accidents. All non-tank semitrailers with hazardous cargo suffered a spill in 40.4% of their rollovers, but only 10.6% of all accidents in which they were carrying hazardous cargo. It is clear that tank trailers suffer spills at significantly higher rates than other trailer types, given similar accident severities.

Discussion

These figures still leave room for a great deal of interpretation and uncertainty. Some of the issues they raise will be discussed here. With regard to the population estimates, the relationship of the number of tractors that typically pull tank semitrailers to the total number of tank semitrailers in the United States is uncertain. The exposure (travel) survey was designed to estimate accident rates. Consequently, vehicle miles traveled is the measure of interest. While the survey is based on an inventory of power units, the travel of each tractor was only classified by the type (body style) of trailer. The number of different trailers of the same body style that were pulled by an individual tractor, or the number of additional trailers that were parked, was not recorded. Vehicle miles traveled is the most commonly used measure of exposure to accidents. But, if one is considering modifications to the existing fleet, then the number of tank trailers is necessary to estimate the total cost of modifying the national fleet. In general, the trailer population is two to three times the power unit inventory. This ratio is probably lower for tank trailers because of their greater cost and longer life, perhaps closer to 2. However, no references were found to substantiate these figures.

Another issue is estimating the number of property damage accidents. It was necessary to assume that police injury codes A and B, critical and serious injuries, were approximately equivalent to the OMC requirement of treatment away from the scene. The C injuries, complaint of pain, were grouped with the property damage accidents. Given this assumption, the distribution by injury severity in the 1983 NASS file (2.2% fatal, 15.7% injured, 82.2% property damage) is about the same as for police-reported accident in Michigan (1.1% fatal, 13.0% injury, 85.9% property damage). But in the OMC file, approximately equal numbers of injury and property damage accidents are reported, while the projected OMC fatal and injury counts agree reasonably well with the NASS estimates. Thus, it seems clear that the OMC reporting threshold omits approximately 110,000 police-reported property damage only accidents involving tractor semitrailers. Most of these accidents must be very minor. It is hard to imagine many of them posing any threat to the integrity of the tank structure. From that point of view, a conservative approach would be to focus on the 64,000 serious injury or $2,000 property damage and the approximately 10,500 rollovers that occur in these collisions.

The difference in the reporting of rollover on the OMC 50-T form and in NASS file is another complication. While it would seem that the additional rollovers in NASS could be characterized as "subsequent" events, the coding in the NASS file does not make this distinction. In fact, nearly all the rollovers in NASS are coded as non-collision, which implies that they are primary events. In the TIFA file, primary event rollover is distinguished

from subsequent event, and they are about equal in number. Furthermore, the number of primary event rollovers in fatal accidents in TIFA agrees approximately with the number coded in the OMC file, while the number of primary plus subsequent rollovers in TIFA agrees approximately with the number of fatal rollovers in NASS. While the reasons for this difference are not clear, it is still the case that when rollover is coded separately from collision type (in the NASS file), approximately twice as many are identified.

References

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3. *National Truck Trip Information Survey (NTTIS)*. Daniel Blower and Leslie Pettis. Ann Arbor Michigan: The University of Michigan Transportation Research Institute, Report No. UMTRI-88-11. March 1988.

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TABLES

TABLE 1

Population and Travel[a]
For Five Combinations of Tractor-Semitrailers
National Truck Trip Information Survey

Combination	Estimated Population	Percent	Average Annual Mileage	Total Miles (10^9 Miles)	Percent
5-Axle Van	205,057	23.3%	80,404	16.487	35.5%
Other Van	156,619	17.8	45,648	7.149	15.4
5-Axle Tank	45,569	5.2	65,218	2.972	6.4
Other Tank	9,487	1.1	34,615	0.328	0.7
Other Semi	365,999	41.6	46,581	17.049	36.7
Unknown	97,847	11.1	24,671	2.414	5.2
Total	880,578	100.0%	52,693	46.400	100.0%

[a]Based on annual mileage as reported by the owner.

TABLE 2

Population and Travel[a]
For Five Combinations of Tractor-Semitrailers
1982 Truck Inventory and Use Survey

Combination	Estimated Population	Percent	Average Annual Mileage	Total Miles (10^9 Miles)	Percent
5-Axle Van	262,592	30.4%	76,482	20.084	44.1%
Other Van	184,053	21.3	38,507	7.087	15.6
5-Axle Tank	60,723	7.0	62,447	3.792	8.3
Other Tank	10,576	1.2	39,407	0.417	0.9
Other Semi	344,617	40.0	41,172	14.188	31.1
Total	862,561	100.0%	52,829	45.568	100.0%

[a]Based on annual mileage as reported by the owner.

TABLE 3

Travel[a] by Cargo Type
For Five Combinations of Tractor-Semitrailers
National Truck Trip Information Survey

Combination	Empty (10^9 Miles)	Hazardous Cargo (10^9 Miles)	Non-Hazardous Cargo (10^9 Miles)	Total (10^9 Miles)
5-Axle Van	3.15	0.26	14.21	17.62
(Percent)	17.9%	1.5%	80.6%	100.0%
Other Van	1.46	0.003	5.43	6.89
(Percent)	21.1%	0.0%	78.8%	100.0%
5-Axle Tank	1.67	1.40	0.67	3.74
(Percent)	44.7%	37.5%	17.8%	100.0%
Other Tank	0.07	0.04	0.02	0.12
(Percent)	52.3%	33.8%	13.9%	100.0%
Other Semi	6.97	0.06	10.99	18.02
(Percent)	38.7%	0.3%	61.0%	100.0%
All Semis	13.31	1.77	31.3	46.40
(Percent)	28.7%	3.8%	67.5%	100.0%

[a]Based on annual mileage as reported by the owner.

TABLE 4

Population and Travel[a] For Five Combinations of Tractor-Semitrailers And Carrier Type National Truck Trip Information Survey

Combination	Estimated Population	Percent	Average Annual Mileage	Total Miles (10^9 Miles)	Percent
Interstate Authorized Carriers					
5-Axle Van	113,441	12.9%	89,146	10.113	21.8%
Other Van	78,463	8.9	45,817	3.595	7.7
5-Axle Tank	14,158	1.6	79,921	1.132	2.4
Other Tank	908	0.1	84,832	0.077	0.2
Other Semi	86,163	9.8	74,841	6.449	13.9
Subtotal	293,133	33.3%	72,885	21.365	46.0%
All Other Carriers					
5-Axle Van	91,616	10.4%	69,580	6.375	13.7%
Other Van	78,156	8.9	45,478	3.555	7.7
5-Axle Tank	31,411	3.6	58,591	1.840	4.0
Other Tank	8,578	1.0	29,298	0.251	0.5
Other Semi	279,836	31.8	37,880	10.600	22.8
Subtotal	489,597	55.6%	46,203	22.621	48.8%
Unknown	97,847	11.1%	24,671	2.414	5.2%
GrandTotal	880,578	100.0%	52,693	46.400	100.0%

[a]Based on annual mileage as reported by the owner.

TABLE 5

Distribution of Travel[a] by Cargo Type For Five Combinations of Tractor-Semitrailers And Two Carrier Types National Truck Trip Information Survey

Combination	Empty (Percent)	Hazardous Cargo (Percent)	Non-Hazardous Cargo (Percent)	Total (Percent)
Interstate Authorized Carriers				
5-Axle Van	14.7%	1.1%	84.2%	100.0%
Other Van	13.2	0.0	86.8	100.0
5-Axle Tank	46.1	27.0	26.9	100.0
Other Tank	48.5	38.5	13.0	100.0
Other Semi	32.2	0.3	67.5	100.0
All Semis	22.0%	2.2%	75.7%	100.0%
All Other Carriers				
5-Axle Van	22.7%	2.1%	75.2%	100.0%
Other Van	26.6	0.1	73.4	100.0
5-Axle Tank	44.0	42.7	13.3	100.0
Other Tank	53.1	32.8	14.1	100.0
Other Semi	42.9	0.3	56.7	100.0
All Semis	34.6%	5.2%	60.2%	100.0%

[a]Based on annual mileage as reported by the owner.

TABLE 6

Distribution of Accident Severity By Rollover Involvement for All Tractor-Semis 1983 National Accident Sample Survey

Accident Severity	No Rollover	Percent	Rollover	Percent	Total	Percent
Property	129,857	79.5%	8,963	56.8%	140,706	77.5%
Injury	21,194	13.0	5,683	36.0	26,878	15.0
Fatal	3,295	2.0	399	2.5	3,693	2.1
Unknown	8,939	5.5	730	4.6	9,669	5.4
Total	163,285	100.0%	15,775	100.0%	180,946	100.0%

TABLE 7
Distribution of Accident Severity
By Rollover Involvement for All Tractor-Semis
1984 National Accident Sample Survey

Accident Severity	No Rollover	Percent	Rollover	Percent	Total	Percent
Property	128,251	74.5%	5,671	54.2%	133,923	73.7%
Injury	29,028	16.9	4,038	38.6	32,066	17.7
Fatal	2,529	1.5	312	3.0	2,841	1.6
Unknown	12,403	7.2	437	4.2	12,840	7.1
Total	171,211	100.0%	10,459	100.0%	181,670	100.0%

TABLE 8
Annual Distribution of Accident Severity
By Primary Event Rollover Involvement for All Tractor-Semis
1984–85 OMC Data

Accident Severity	No Rollover	Rollover	Total
Property	14,076	973	15,049
Injury	13,004	1,265	14,269
Fatal	1,799	75	1,874
Total	28,879	2,313	31,192

TABLE 9
Annual Distribution of Accident Severity
By Primary Event Rollover Involvement for All Tractor-Semis
By Carrier Type
1984–85 OMC Data

Accident Severity	No Rollover	Rollover	Total
Interstate Authorized Carriers			
Property	11,852	817	12,669
Injury	10,938	1,087	12,025
Fatal	1,371	62	1,433
Subtotal	24,161	1,966	26,127
All Other Carriers			
Property	2,224	156	2,380
Injury	2,066	178	2,244
Fatal	428	13	441
Subtotal	4,718	347	5,065
Grand Total	28,879	2,313	31,192

TABLE 10
Projected Annual Distribution of Accident Severity
At the OMC Reporting Threshold
By Primary Event Rollover Involvement for All Tractor-Semis

Accident Severity	No Rollover	Rollover	Total
Property	28,770	1,986	30,756
Injury	26,911	2,612	29,523
Fatal	3,092	198	3,290
Total	58,420	4,796	63,569

TABLE 11
Projected Annual Rollovers
At the OMC Reporting Threshold
For Four Combinations of Tractor-Semitrailers
By Cargo Type

Combination	Empty	Hazardous Cargo	Non-Hazardous Cargo	Total
Primary Event Rollover				
5-Axle Van	29	39	1,393	1,461
Other Van	8	6	210	224
All Tanks	20	465	244	729
Other Semi	50	36	2,294	2,380
Total	107	546	4,141	4,794
Primary and Subsequent Event Rollover				
5-Axle Van	65	88	3,134	3,287
Other Van	18	14	473	504
All Tanks	45	1,046	549	1,640
Other Semi	113	81	5,162	5,355
Total	241	1,229	9,317	10,787

TABLE 12
Projected Annual Accidents
At the OMC Reporting Threshold
For Four Combinations of Tractor-Semitrailers
By Cargo Type

Combination	Empty	Hazardous Cargo	Non-Hazardous Cargo	Total
5-Axle Van	3,890	431	17,360	21,681
Other Van	1,377	66	5,390	6,833
All Tanks	1,403	3,151	1,906	6,460
Other Semi	4,977	253	23,360	28,590
Total	11,647	3,901	48,016	63,564