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Determination of Influence Factors and Accident Rates for the Armored Tractor/Safe Secure Trailer

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Determination of Influence Factors and Accident Rates

for the

Armored Tractor/Safe Secure Trailer

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Abstract

Operating environments, such as road type, road location, and time of day, play an important role in the observed accident rates of heavy trucks used in general commerce. These same factors influence the accident rate of the Armored Tractor/Safe Secure Trailer (AT/SST) used by the Department of Energy to transport hazardous cargos within the continental United States. This report discusses the development of accident rate influence factors. These factors, based on heavy trucks used in general commerce, are used to modify the observed overall AT/SST accident rate to account for the different operating environments

Preface

This report summarizes one aspect of the work done in support of the Defense Programs Transportation Risk Assessment (DPTRA) project which was sponsored by the Department of Energy (DOE). The objective of the DPTRA project was to quantify the risk and consequence of transporting each cargo carried by the Armored Tractor/Safe Secure Trailer within the DOE complex on public highways. The DPTRA project was a multiple task effort which involved many organizations and individuals. The work consisted of assembling new databases in several different areas and developing or refining various tools required to quantify the risk and consequence to the general public of the transportation of these cargoes. Because of the scope and variation of the work required, it was not feasible to produce a single report which fully documents all the supporting work and the results, in a manageable format. Therefore, the quantitative estimates of risk and consequence resulting from the culmination of the DPTRA project will be documented in a single concise volume. All documentation of the supporting work, will be published in several reports covering the specific areas in detail.

This report describes the development of accident rate influence factors as related to the objectives of the DPTRA project.

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1.0 Introduction

Previous studies of heavy trucks in general commerce have shown that the operating environment is associated with large differences in the risk of accident involvement [1-3]. Operating environments usually considered as important are road type (limited access/other), area type (rural/urban), and time of day (night/day). Accordingly, accident rates have been calculated for different combinations of these environmental factors.

Limited access roads have a lower accident rate because lane separation reduces the number of head-on crashes, grade separation at roadway crossings reduces the number of side-on collisions, lack of railroad crossings at the same grade eliminate collisions with trains, and better design (longer sight distances, larger radii on curves, etc.) provides a more forgiving environment for driver error. Conversely, other roadways have higher observed accident rates because they lack many of the features of the limited access roadway.

Time of day is also a factor in the observed accident rate. The accident rate for nighttime is higher than the corresponding daytime rate because sight distances are reduced and driver fatigue becomes a bigger issue.

A final environmental factor contributing to a change in accident rate is the population area (defined here as rural or urban). Accident rates in urban areas are higher because of the higher volume of traffic in these areas and because of the larger volume of traffic, there is a greater chance for multiple vehicle involvement.

These same environments will affect the Armored Tractor/Safe Secure Trailer (AT/SST) used by the Department of Energy to transport hazardous cargos within the continental United States. However, the AT/SST accident experience is too limited to determine the effect of these operational environments directly. The objective of the work reported herein is to extrapolate the data concerning operating environment obtained from general commerce to the operation of the AT/SST.

This report summarizes an approach for applying the heavy truck accident experience in general commerce to the AT/SST vehicle. The methodology is presented in Section 2.0. The data sources, accident rates, and travel distributions for general commerce and the AT/SST are discussed in Section 3.0. The resulting accident rate influence factors are given in Section 4.0. Section 5.0 provides a summary and conclusions.

2.0 Methodology used to Develop Influence Factors

The term "influence factor" as used in the context of this report is the ratio of an accident rate in a certain operating environment, or cell, to the overall accident rate. The accident rate in any particular cell is the number of accidents within that cell divided by the number of miles traveled within that cell. The overall accident rate is the total number of accidents divided by the total number of miles traveled.

The determination of the influence factor is relatively simple as long as there is sufficient data to determine the travel distribution within the exposure cells and an accident count for each cell. [1] The AT/SST accident experience can be used to compute an overall accident rate. However, there have not been a sufficient number of accidents of AT/SST accidents to allow for reliable estimates of the accident rate in all operating environments directly. Therefore the influence factors for the AT/SST, IF_i, are estimated in order to calculate the AT/SST accident rate in different operating environments, R_i, from the overall AT/SST accident rate, R_o:

$$R_i = R_o \cdot IF_i \tag{1}$$

where the subscript i is an index for the different operating environments.

The AT/SST influence factors are estimated from general commerce accident data and the distribution of travel for the AT/SST in the operating environments of interest. The influence factors for the AT/SST are defined by rearranging Eq. 1:

$$IF_i = \frac{R_i}{R_o} = \frac{R_i}{\Sigma (T_i \cdot R_i)} \tag{2}$$

where $T_i = M_i / \Sigma M_i$ is the fraction of total AT/SST travel in cell i. M_i is the AT/SST travel in cell i. The accident rate in each operating environment for the AT/SST is assumed to be related to that for a surrogate, R_{si}, by a single scalar constant, C:

$$R_i = C \cdot R_{si} \tag{3}$$

Substitution of Eq. 3 into Eq. 2 leads to:

$$IF_i = \frac{R_{si}}{\Sigma (T_i \cdot R_{si})} \tag{4}$$

The TIFA database and NTTIS survey provide a count of fatal involvements and travel for heavy trucks that can be broken down by road type, area type, time of day and vehicle characteristics. The surrogate is defined based on restricting vehicle characteristics to some set that approximates the characteristics of the AT/SST. The accident rate for the surrogate in each operating environment can be calculated directly:

$$R_{si} = \frac{N_{si}}{M_{si}} \tag{5}$$

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1 These data exist for general commerce in the National Truck Travel Information Survey (NTTIS) [4] and the Trucks Involved in Fatal Accident (TIFA) database [5], respectively. The travel distribution of the AT/SST in the exposure cells is obtainable from the Transportation Safegaurds Division (TSD) Shipment database [6] and the geographic characterization of the routes used [7]. The number of accidents involving the AT/SST is available in the TSD Incident/Accident database [8] and the total mileage is derived from [6] and [7]. These databases are described in Section 3.0.

where N_{si} is the number of fatal involvements and M_{si} is the travel in operating environment i for vehicles with characteristics matching those of the surrogate. This data as well as the data needed to calculate the travel distribution and the overall accident rate for the AT/SST is described in Section 3.

3.0 Accident Rates

This section presents the data used in the development of the environmental influence factors recommended for use in risk assessments involving transportation of hazardous materials in the AT/SST. Section 3.1 discusses the data available from general commerce, describes the different surrogates used for analysis, and develops the environmental influence factors for these surrogates. In Section 3.2 the AT/SST accident data and travel distribution are discussed.

3.1 General Commerce

Surrogates for the AT/SST in the Accident Data

Rates were calculated for four vehicles that approximate the characteristics of the AT/SST with increasing accuracy: a tractor-semitrailer; a 5-axle tractor-semitrailer (3-axle tractor, 2-axle semitrailer); a 5-axle tractor-semitrailer with a 60-80,000 pound gross combination weight; and, all of the previous characteristics with a van cargo body semitrailer. The purpose of defining multiple surrogates was to approximate the physical characteristics of the AT/SST relevant to traffic safety as closely as possible. At the same time, it was necessary to use surrogates that were general enough to obtain adequate sample sizes in the accident data. In this section, rates for all four surrogates will be presented.

Environmental Factors

Road type is divided into limited access roads and all other roads.[2] Area type is divided into urban or rural, where urban is defined according to Federal Highway Administration (FHWA) definitions as a population area with 5,000 or more inhabitants. Time is split into day or night, where night is defined as 9:00 PM to 6:00 AM.[3] Two levels for each of three factors results in eight combinations of environmental factors.

Accident Definition and Data Sources

The rates presented here are for fatal truck involvements. Ideally, it would be desirable to have rates for all accidents above a given threshold, not just fatals. However, there is no non-fatal

2 While divided, non-limited access roads have a somewhat reduced number of head-on collisions along open stretches of road, there are still a significant number of severe accidents occurring at intersections. Thus, these roads are included in the "other" road category.

3 Selection of the hours defining daylight for all time zones and all times of the year is not an exact science. No matter what choice was made, some times will be misclassified. The defining times used here were confirmed by reviewing the time and lighting conditions recorded on accident reports by the reporting officer. In this review it was apparent that use of the 9:00 PM - 6:00 AM time frame as the definition of daylight hours minimized the misclassification of hours.

accident data available with enough detail to break down accidents by road type and area type. The National Highway Traffic Safety Administration's (NHTSA) General Estimates System (GES) files provide a nationally representative sample of truck accidents of all severities. Unfortunately the variables for road type and area type in GES do not identify limited access roads or rural areas according to FHWA definitions. Consequently, GES data cannot be used to determine rates by the various environmental factors. Although being limited to fatal rates is not optimal, fatal accidents do encompass the bulk of accidents that are of greatest concern to the AT/SST.

The accident rates were calculated using accident and travel data from two surveys conducted by the University of Michigan Transportation Research Institute (UMTRI). The accident counts are taken from the TIFA survey and mileage estimates are provided by the NTTIS. Both provide sufficient detail to identify each AT/SST surrogate and to disaggregate accidents and travel by the environmental factors. In fact, NTTIS was specifically designed to calculate rates using TIFA data.

The TIFA survey combines information from the Fatal Accident Reporting System (FARS) of the NHTSA with data from FHWA Office of Motor Carriers (OMC) MCS 50-T reports, state police accident reports, and comprehensive follow-up telephone interviews conducted by UMTRI research staff. The FARS file provides the initial identification of trucks involved in a fatal accident, as well as extensive information at the accident level. OMC reports include much detail on the physical configuration of the trucks involved. However, only carriers that operate across state lines are required to file MCS 50-T reports, and only about a third of the FARS cases can be matched with MCS 50-T reports. For the FARS cases that cannot be matched with MCS 50-T reports, UMTRI contacts the drivers, owners, or other knowledgeable involved parties for a detailed physical description of the trucks. The combination of these data sources is the TIFA file. TIFA is currently complete for accident years 1980 through 1990. The dataset provides detailed descriptions of medium and heavy trucks, defined as trucks with a gross vehicle weight rating (GVWR) greater than 10,000 lbs. For data years 1980 through 1986, TIFA is a census file, meaning that it contains records for all medium and heavy trucks involved in a fatal accident. Data years 1987 through 1990 include some limited sampling. The purpose of the sampling was to reduce the number of cases requiring telephone interviews while not compromising the quality and completeness of the data. The raw number of cases for the data years where sampling was done is about 1,000 records fewer than if all cases had been taken. Appropriate weights have been determined that allow national population totals to be estimated. Statistical work has shown that sampling has had little effect on the accuracy of estimates from the files [9]. The 1980-90 TIFA file contains records on 33,363 tractor-semitrailer combinations, with a weighted total of 36,269 tractor-semis.

The data used in this effort was the 1980-86 TIFA [9]. This subset of the total TIFA was chosen because these years provide a better match with the NTTIS travel data used. The NTTIS is described in more detail later but some facts are pertinent to the discussion here. The NTTIS includes trucks registered in model years up to and including 1983. Government owned vehicles were not included the survey. The survey itself was conducted in 1986. Excluding the 1987-90

TIFA data is not a significant limitation because a number of these accidents would involve trucks registered after 1983 which would be excluded from the accident count for the sake of consistency. In addition, using accidents many years after the sampling year of the travel could lead to biases. This dataset contains records on 20,338 tractor -semitrailer accidents. The accident count per exposure cell is shown in Table 1.

Table 1: TIFA 1980-1986 (model years < 1984, no govt. vehicles)

AT/SST Surrogate	Limited /Day/ Urban	Other/ Day/ Urban	Limited /Day/ Rural	Other/ Day/ Rural	Limited /Night/ Urban	Other/ Night/ Urban	Limited /Night/ Rural	Other/ Night/ Rural	UNK	Total
semi	1,406	2,413	1,634	7,715	997	1,025	1,701	3,213	234	20,338
5xl semi	1,110	1,796	1,409	6,365	837	827	1,493	2,730	182	16,749
5xl,60-80K	478	624	766	2,785	462	397	898	1,382	84	7,876
5xl van, 60-80k	244	214	439	827	252	198	530	585	35	3,324

Computerized checks are performed on data in the MCS 50-T reports to identify inconsistencies and problems. Where these problems cannot be resolved by consulting the police reports or the original raw data, calls are made to the reporting carrier or police officer. In addition, every case produced by the telephone survey is subjected to extensive editing to ensure the accuracy and completeness of the data. The VIN (vehicle identification number) is decoded to identify positively the vehicle, and the physical description from the phone interview is compared with manufacturer's specifications. Inconsistencies or contradictions are resolved by further interviews, whenever possible. The result is a file with low missing data rates and high accuracy. TIFA provides the most complete and accurate record of fatal truck accidents available.

Mileage data for the rates is provided by the National Truck Trip Information Survey. NTTIS was a national survey of truck population and use, conducted primarily in 1986. The objectives of NTTIS were to estimate the number of large trucks in the U.S. and to provide detailed mileage data. NTTIS was designed to be used in conjunction with TIFA, with the same definitions of all common variables. NTTIS can be used to provide mileage estimates for calculating fatal accident rates using TIFA data.

The NTTIS survey was built on a probability-based sample of trucks registered in the U.S. as of July 1, 1983. Trucks were sampled from registration files maintained by the R.L. Polk Company. Polk collects registration data from the states and their files allow a national sample to be drawn from one source. Government-owned vehicles are not included in the Polk files. The owners of the 8,144 trucks initially sampled were contacted to obtain a detailed description of the vehicle and some information about the total travel of the vehicle over the course of a year.

More extensive interviews about the daily travel of the vehicles were conducted on 5,112 vehicles selected for follow-up. The owner of each vehicle was contacted by phone four times over a one-year period and asked about the vehicle's travel on a randomly assigned date. Calls were made as close to the assigned date as possible. The travel data were collected according to "trips." A new "trip" began whenever driver, operating authority, vehicle configuration, (e.g.,adding or changing trailers), or cargo type or amount changed. Thus if the driver changed, or cargo was loaded or unloaded, or one trailer type was exchanged for another, the interviewer began a new trip form to track the mileage accumulated by the new configuration. For each survey day, the owner was asked to describe every trip made and to provide information on trailer use (if any), cargo and cargo weight, and driver age.

The trips were split into daytime and nighttime mileage, and each trip was mapped on special atlases developed by UMTRI. Precise boundary definitions were established to distinguish urban from rural highways according to FHWA definitions obtained from each state. County level maps were obtained for defining urban boundaries on the state scale layout. This made it possible to map exactly the portion of the mileage that was in different urban density zones. Every county in the United States was mapped individually. Roads were also divided into limited access highways, other major or primary highways, and other roads. Such mapping techniques capture a level of detail that permits breaking trips down into day and night miles over three road types, with actual loaded weights for each portion of every trip on the survey day. Each individual mile of a surveyed trip can be characterized in terms of the factors of interest.

Of the 5,112 trucks selected for trip day calls, 4,789 responded on at least one of the four survey days. In all, information was obtained on over 17,660 survey days, or 86% of the potential survey-day interviews. Travel on the survey days was broken down into 13,097 trips, covering 913,276 miles of travel, of which over 862,000 could be mapped on the specially prepared atlases. The annual mileage per exposure cell as determined from the NTTIS is summarized in Table 2.

Table 2: NTTIS Travel (10^9 miles)

AT/SST Surrogate	Limited/ Day/ Urban	Other/ Day/ Urban	Limited/ Day/ Rural	Other/ Day/ Rural	Limited/ Night/ Urban	Other/ Night/ Urban	Limited/ Night/ Rural	Other/ Night/ Rural	Total
semi	5.023	3.562	9.458	8.167	1.320	0.357	3.036	1.272	32.194
5xl semi	3.791	2.101	7.875	6.664	1.025	0.266	2.459	1.014	25.195
5xl, 60-80K	1.487	0.578	4.041	2.451	0.552	0.113	1.409	0.495	11.123
5xl van, 60-80K	0.833	0.170	2.480	0.572	0.355	0.064	0.934	0.248	5.658

In sum, NTTIS provides the most detailed estimates available of heavy truck travel in the United States. The survey was carefully designed to provide a good match with the TIFA accident file. The same definitions of common variables were used in each survey, and the same standards and knowledge base were used in editing the cases. Finally, of the publicly available, nationally representative files of accident and travel data, the combination of TIFA accident frequencies and NTTIS travel estimates provides an unmatched ability to calculate rates for detailed truck configurations by road type and area type.

Fatal Accident Rates for AT/SST Surrogates

The rates are based on seven years (1980-86) of TIFA data and the 1986 NTTIS travel data. As stated earlier, the years 1980-86 of TIFA were chosen as the best match for the NTTIS travel data. The NTTIS sample was based on truck registrations as of 1983 and the actual survey was conducted in 1986. The truck population evolves over time (though the major change in that period is the increase in the use of doubles, which does not affect this project), and the travel data should not be too far removed in time from the accident population. Trucks with model years after 1983 are also excluded from the TIFA data, since those models were not in the NTTIS sample. The accident rates for each exposure cell are shown in Table 3.

Table 3: Fatal Involvement/Million Miles, TIFA 80-86 (model years<1984, no govt. vehicles)

AT/SST Surrogate	Limited/ Day/ Urban	Other/ Day/ Urban	Limited /Day/ Rural	Other/ Day/ Rural	Limited/ Night/ Urban	Other/ Night/ Urban	Limited/ Night/ Rural	Other/ Night/ Rural	Average
semi	0.040	0.0968	0.0247	0.1350	0.1079	0.4107	0.0800	0.3609	0.0902
5xl semi	0.0418	0.1221	0.0256	0.1364	0.1166	0.4442	0.0867	0.3848	0.0950
5xl,60-80K	0.0459	0.1548	0.0271	0.1623	0.1195	0.5017	0.0910	0.3989	0.1012
5xl van, 60-80K	0.0419	0.1801	0.0253	0.2064	0.1013	0.4399	0.0811	0.3366	0.0839

Ideally, accident rates for all eight cells would be carried throughout the entire analysis. Unfortunately, sample sizes in the accident data available for determining frequencies of accident types and severity distributions are insufficient to support that level of detail. Consequently, it is desirable to collapse some of the categories. The goal was to retain only those categories that had significant differences in rates or accident types after AT/SST operation was taken into consideration.

Because of the driving schedule followed in the operation of the AT/SST, day/night differences (which are primarily related to driver fatigue) are less important than the other environmental factors. In addition, the determination of day/night for the AT/SST is based on a calculation which depends on the starting time and average velocity along a route. These parameters are subject to some uncertainty and therefore the classification of day/night for AT/SST operation is a rough estimate at best.

The accident rate varies by less than a factor of two with area type. This difference by itself would not be considered significant enough to maintain the distinction between area types. However, the distinction was retained because the frequencies of accident types and consequences may differ significantly with area type. As shown in Table 4, the frequencies of several

Table 4: Frequencies of Accident Types (TIFA 1980-1989, tractor semi-trailers)

Accident Type	Limited Urban	Limited Rural	Other Urban	Other Rural
Collision w/ Truck	5.83%	14.19%	1.87%	4.89%
Collision w/ Lt. Truck or Auto	61.05%	47.03%	74.96%	72.66%
Collision w/ Tanker	0.31%	0.38%	0.14%	0.33%
Collision w/ Fixed Object	7.11%	7.87%	1.66%	4.01%
Collision w/ Non-Fixed Object	14.55%	12.50%	17.08%	5.61%
Collision w/ Train	0.00%	0.02%	0.82%	0.76%
Non-collision	11.16%	18.01%	3.47%	11.74%

accident types depend on both road type and area type. Given an accident on non-limited access roads, collisions with tankers and collisions with fixed objects, are approximately 2.5 times more likely in a rural area than in an urban area. Collisions with trucks are approximately 2.5 times more likely given an accident, regardless of road type. Collisions with light trucks and autos, which pose a lesser threat to the AT/SST, are generally more likely in urban areas than in rural areas. Given an accident that results in release of hazardous materials, the consequences are generally higher in an urban area than in a rural area because a greater number of people are likely to be exposed. Therefore, influence factors and accident rates were calculated for all roads, limited and other, in both urban and rural areas.

Table 5 shows fatal involvements, travel, and fatal involvement rates for each of the four AT/SST surrogates in the four exposure cells defined above. The first section of the table shows 1980-86 fatal involvement counts for the surrogates distributed by the four environmental factors. The four environmental factors shown are limited access roads in urban and rural areas and other roads (non-limited access) in urban and rural areas. The second section of the table shows estimated travel for each surrogate, distributed across the four environmental factors. Note that as the definition of the AT/SST surrogate becomes more restrictive, the number of fatal involvements and travel miles decrease. The final section of the table shows the annual rate of involvements per million miles for each surrogate in each environment of interest, with the total column showing the overall rates for the surrogates. The most striking feature of the rates is the variability by environment, chiefly road type. The rates for each surrogate in the urban/rural split for other roads are close to the same value (ratio of urban/rural ~1). The largest difference is in the tractor-semitrailer surrogate (ratio of urban/rural ~0.8). There is a larger difference in the rates calculated for the urban/rural split for limited access roadways (ratio of urban/rural 1.4 to 1.5 for all surrogates). Involvement rates for limited access roads are lower than other roads by factors of about 3 to 6, depending on the surrogate. For tractor-semitrailers, the fatal involvement rate is 0.13 per million miles on other urban roads and 0.17 per million miles on other rural roads. Involvement rates for limited urban and limited rural roads are 0.054 and 0.038 per million miles, respectively. Ratios of involvement rates based on road type for this surrogate are 2.3 (urban) and 4.3 (rural). The difference by road type is greater for the 5- axle, 60-80,000 pound, van cargo body combination. There the ratios are 4.2 (urban) and 6.1.

Table 5: Involvements, Travel, and Involvement Rates for Four AT/SST Surrogate Vehicles - 1980-86 TIFA and 1986 NTTIS Data

AT/SST Surrogate	Limited Urban	Limited Rural	Other Urban	Other Rural	Total
Fatal Involvements 1980-86					
Semi	2,403	3,335	3,442	10,936	20,116
5xl Semi	1,947	2,902	2,627	9,103	16,579
5xl, 60-80K	940	1,664	1,023	4,170	7,797
5xl Van, 60-80K	496	969	412	1,413	3,290
Travel (10^9 miles)					
Semi	6.343	12.494	3.918	9.439	32.194
5xl Semi	4.816	10.334	2.367	7.678	25.195
5xl, 60-80K	2.039	5.450	0.689	2.946	11.123
5xl Van, 60-80K	1.188	3.414	0.234	0.821	5.658
Involvement Rate (10^6 mile)					
Semi	0.0541	0.0381	0.1255	0.1655	0.0893
5xl Semi	0.0578	0.0401	0.1585	0.1694	0.0940
5xl, 60-80K	0.0659	0.0436	0.2122	0.2022	0.1001
5xl Van, 60-80K	0.0596	0.0405	0.2514	0.2459	0.0831

The variability in the rate by road type is much greater than that by area type, though bear in mind that the particular environmental factors were not chosen to show the separate effects of road type and area type. Nevertheless, rates on other rural roads are somewhat higher than other urban roads for the first two surrogates, and virtually identical for the second two. The overall rates of the four surrogates are quite similar, though the rate for the 5-axle, 60-80,000 gross weight vehicles is slightly elevated, and the rate for the surrogate when the cargo body style is restricted to vans is somewhat lower.

Across the environmental factors, road type clearly dominates. Limited access roads are the safest roads in the highway system. They are engineered for high-speed operation, with wider lanes and predictable, forgiving curves. In addition, the fully controlled access allows for safer entrance to and exit from the traffic stream. Non-limited access roads are much more variable, and can have tighter curves, shorter sight distances, less predictable traffic patterns, and generally more restrictive geometries.

The effect of these factors also can be seen when comparing rates for the different surrogates. All the rates for limited access roads are quite similar. They vary from 0.0437 to 0.0498. Vehicles with gross combination weights between 60,000 and 80,000 lbs. can be expected to have poorer handling relative to the other vehicles. The higher center of gravity and greater weight of the vehicles should tend to make negotiating curves and braking more difficult. Heavier vehicles have a higher probability of involvement in rollovers and rear-end accidents. The negative effects of these factors are not large on limited access roads, indicating that the design of limited access roads mitigates the degradation in handling. Involvement rates on limited access roads for the heavier vehicles are only slightly higher than the other vehicles, though the comparison is not pure since the heavier surrogates are a subset of the other surrogates.

In contrast, on other roads, the involvement rate is significantly higher for the two heavier surrogates than it is for the others. On other urban roads, the rate jumps from about 0.14 to 0.23. On other rural roads, the change is from about 0.17 to 0.22. In both operating environments, it is clear that heavier vehicles have significantly more problems. Though the heavier surrogates have higher rates on other roads, the overall rate for the surrogate with a van cargo body is the lowest of all, despite its weight. The reason for this is differences in the distribution of travel across the environmental categories. Table 6 shows the proportion of travel for each surrogate in each operating environment. Limited access roads dominate for all surrogates, but the 5-axle van, 60-80,000 lbs., vehicle has by far the highest proportion of limited access roads. Five-axle vans are used typically to haul general freight. A combination in the 60-80,000 lbs. weight range is fully loaded, so its travel is mainly on interstates going to its destination, rather than collecting a load or pickup-and- delivery. Since more of its travel is spent on the safest roads, its overall rate is lower than the other surrogates. The heavy surrogate not restricted to a van cargo body can include dump and logging trailers, which spend more time off major highways. The least restrictive surrogate, the tractor-semitrailer, shows the general distribution of operations of single-trailer combinations. Urban pickup-and-delivery, long-haul freight, and rural construction and industrial operations are all included. The distribution of travel reflects this mix.

Table 6: Distribution of Travel for Four Vehicle Classes using 1986 NTTIS Data

AT/SST Surrogate	Limited Urban	Limited Rural	Other Urban	Other Rural
Semi	19.7%	38.8%	12.2%	29.3%
5xl Semi	19.1%	41.0%	9.4%	30.5%
5xl, 60-80K	18.3%	49.0%	6.2%	26.5%
5xl Van, 60-80K	21.0%	60.4%	4.1%	14.5%

3.2 AT/SST Experience

Accident Rate

The AT/SST accident experience was taken from incident reports maintained by TSD for fiscal years 1975-1992 [8]. Because of changes in administrative procedures, driver training, and vehicle design, an accident rate based on the most recent 10 year period is believed to be most representative of future performance. Between 1984 and 1993, 1 tow-away accident involving an AT/SST occurred in 15,267,924 miles of travel. Using the number of tow-away accidents and the total mileage accumulated, the mean value of the SST accident rate is determined to be 0.066 tow-away accidents per million miles. Analysis of GES data suggests that only 4.2% of tow-aways involve a fatality. Therefore, the AT/SST rate of fatal involvements can be estimated as 0.0028 per million miles.

There is some inconsistency in the AT/SST accident experience and general commerce in that there have been no fatal accidents involving the AT/SST during normal transport operations.[4] In an effort to assess if significant differences in the influence factors arise due to the use of different accident reporting thresholds, an analysis of influence factors calculated from Michigan data [3] was done and the results compared to the TIFA data used in this study.

There were two accident thresholds used for the Michigan accidents. These were property damage only (greater than $200 in value) and casualty (fatal plus injury). The truck category was equivalent to the "semi" classification used in the current study. Three sets of influence factors were calculated from the Michigan data: 1) property damage; 2) injury; and 3) all. Table 7 shows the influence factors calculated from TIFA/NTTIS compared with the influence factors calculated from the Michigan data. In general, the influence factors compare well over the range of accident severities represented. This indicates that the difference in accident coverage (towaway vs. fatal) between TIFA and the AT/SST accident database should not be expected to result in very different influence factors for the operating environments. Influence factors for these environments can be regarded as independent of accident severity.

Table 7: Comparison of Influence Factors Determined from Different Accident Reporting Thresholds

Road Type	Area Type	TIFA/ NTTIS Influence Factor	MI - Casualty Influence Factor	MI - Property Damage Only Influence Factor	MI- All
Limited	Urban	0.606	0.415	0.355	0.368
	Rural	0.427	0.674	0.552	0.579
Other	Urban	1.406	1.261	1.827	1.701
	Rural	1.854	1.934	1.761	1.799

4 An inebriated pedestrian was struck and killed during a training exercise.

Distribution of Travel

The distribution of travel of the AT/SST was determined from the number of trips, total distance, and the fraction of the total distance that is classified as limited/urban, limited/rural, other/urban, and other/rural for each of the 112 routes travelled by the AT/SST for the transportation of Defense Programs materials between FY87 and FY89. The route distance and the determination of rural/urban and road type (limited/other) was made with the help of the TIGER/Line [10, 11] and PL94-171 [12, 13] products of the U. S. Census Bureau.[5] For the purposes of this report it is sufficient to know that road type is a coded variable in the TIGER/Line files and used directly. The rural/urban distinction is derived from the census count (PL94-171) and the data in the TIGER/Line files. To be consistent with the classification used by the FHWA, a rural area is defined as an area with a population less than 5000.[6] The distribution of travel of the AT/SST is shown in Table 8.

Table 8: Distribution of Travel for the AT/SST FY 1987-89

Cell	% Travel
Limited Urban	10.4
Limited Rural	79.2
Other/Urban	9.3
Other/Rural	1.1

4.0 Influence Factors for the AT/SST

The influence factors determined from general commerce and AT/SST accident experience are shown in Table 9.The factors recommended for risk assessments involving transportation of

Table 9: Influence Factors Determined for the Operation of the AT/SST

AT/SST Surrogate	Limited Urban	Limited Rural	Other Urban	Other Rural
Semi	1.029	0.725	2.383	3.145
5xl Semi	1.045	0.726	2.864	3.062
5xl, 60-80K	1.053	0.698	3.376	3.231
5xl Van 60-80K	0.932	0.634	3.931	3.844

hazardous materials in the AT/SST are those determined for the surrogate that most resembles the AT/SST, i.e., the 5 axle Van with a 60-80 klbs GCW.

5 Care was taken to ensure the definitions of area type and road type were consistent with those used in TIFA.

6 An "area" is defined differently for each state. Based on information gathered by UMTRI and Sandia, an FHWA area is roughly equivalent to a "place" as defined in the census data. A "place" is an incorporated place or census designated place which is loosely equivalent to a town or city.

5.0 Summary and Conclusions

A technique to extrapolate general commerce accident experience to AT/SST operation has been presented. General commerce data were presented and analyzed in an effort to define accident exposure cells that had sufficient sample sizes. These data were used to provide a credible technical basis for the development of accident rate influence factors for the AT/SST. A discussion of the AT/SST accident experience and travel distribution that led to the calculation of accident rate influence factors was given.

The conclusions from this work are:

- Influence factors for the AT/SST can be calculated from surrogate accident rates for each operating environment of interest and the AT/SST travel distribution across the same operating environments. Influence factors are relatively insensitive to the differences in the reporting threshold used to define accidents for the surrogate.
- Of the eight exposure cells originally identified, the most significant in terms of the operation of the AT/SST are limited access urban, limited access rural, other urban, and other rural.
- The class of general commerce vehicles which most closely matches the AT/SST in physical characteristics and travel distribution is the 5 axle, tractor-semitrailer with a van cargo body and a GCW 60-80 Klbs. This is the vehicle class used to develop the recommended influence factors.
- Accident rate influence factors recommended for use in risk assessments involving transportation of hazardous materials in the AT/SST study are 0.93, 0.63, 3.9, and 3.8 for the limited urban, limited rural, other urban, and other rural exposure cells, respectively.

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