The Highway and Railroad Operating Environments for Hazardous Shipments in the United States—Safer in the '90s?

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ABSTRACT

This paper seeks to illuminate the status of transportation safety and risk for large-quantity shipments of spent commercial reactor fuel and mixed and hazardous wastes by examining road and rail accident and vehicular travel data from the mid-1990s. Of special interest are the effect of speed limit changes on controlled–access expressways (chiefly the Interstate Highway System) and the possible effect of season-to-season climatic variation on road transport. We found that improvements in railroad technology and infrastructure have created a safer overall operating environment for railroad freight shipments. We also found recent evidence of an increase in accident rates of heavy combination trucks in states that have raised highway speed limits. Finally, cold weather increases road transport risk, while conditions associated with higher ambient temperatures do not. This last finding is in contrast to rail transport, for which the literature associates both hot and cold temperature extremes with higher accident rates.

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INTRODUCTION

Although the original waste acceptance timetable of the Nuclear Waste Policy Act of 1982 (42 U.S.C. 10101) was delayed, the U.S. Department of Energy within the next few years will begin to accept consignments of shipping casks containing spent reactor fuel (SRF) from licensed commercial nuclear power generating plants for transport and disposal. In all likelihood, these shipments will be conveyed by road or rail directly from each power plant site or from one or more shipment consolidation depots to the Yucca Mountain Nuclear Waste Repository in Nevada. Shipments of high-level nuclear and mixed waste are already being accepted at the Waste Isolation Pilot Project (WIPP) repository near Carlsbad, New Mexico, and these shipments will intensify in the future. Thus, within three to five years more hazardous nuclear and mixed wastes will be moving over the United States' railroads and highways than at any time in the recent past.

Even low-severity accidents involving such wastes can have negative consequences with respect to both potential neutron exposure and to overall public perception of the shipment of nuclear materials. Given the surface transportation operating environment of the 1990s, we ask here if these and other hazardous shipments can be assured a lower risk of accident while in transit than when these shipments were originally scheduled to begin. Apparently, there has been no systematic attempt to address this question since 1994 when Argonne National Laboratory (ANL) published "Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight" (Saricks and Kvitek 1994). This study investigated highway, rail, and waterborne freight safety on a state-by-state basis, as revealed by mid-1980s transportation statistics.

FACTORS TO CONSIDER IN THE 1990s

The 1994 "Longitudinal Review of State Level Accident Statistics for Carriers of Interstate Freight" documented an analysis conducted earlier in the decade that had been performed for the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM) to improve the prospects for safe transport of hazardous shipments under the DOE's purview. These shipments would involve both commercial SRF and radioactive and mixed wastes from DOE facilities. A decade ago, when such shipments were originally slated to begin, there were important differences in the domestic surface transportation environment relative to today. Four key changes in the intervening years follow:

1. As recently as 1988, a few states still had incomplete links in their designated Interstate Highway System networks, which necessitated the relatively unsafe practice of combination trucks (that is, large, highway cargo vehicles in which one or more trailers are hauled behind a prime mover) having to depart controlled-access, multilane highways for two-lane roads. Moreover, standardized guidance for the routing of large, hazardous-material shipments over highways was lacking; such guidance was not issued by the U.S. Department of Transportation (DOT) for class 7 (radioactive) materials until 1992 (49 CFR 397.101). Today, both the completed interstate system and the appropriate routing guidance are in place.
2. An increase in speed limits by a factor of up to 36% relative to mid-1980 values was enacted during the past decade in most states for both controlled-access and at-grade (i.e., directly intersecting) highways (National Safety Council 1997). Between 1995 and 1996 alone, many states raised their maximum speed limit (nominally applicable only to automobiles and light trucks but generally adopted by all vehicle types) to 70 or 75 miles per hour on interstates and other controlled-access expressways in rural areas.
3. The U.S. rail freight system has experienced considerable restructuring, with consolidation both in the number of carrier corporations (leaving but five U.S.-controlled class 1 systems) and in the number of lines that carry the heaviest freight volumes. This change was accompanied by extensive elimination of "redundant" capacity (e.g., parallel rail routes formerly owned by pre-merger competitors), which in turn imposed unprecedented limits on rail shipment routing options.

4. The period also witnessed significant track and roadbed improvements on surviving rail routes, important advancements in locomotive technology (including the emergence of highly efficient and reliable AC traction motors), and a shift toward relatively cost-effective and time-sensitive intermodal haulage in which truck and rail (and occasionally waterborne freight) each carry a portion of an individual shipment.

In the absence of a more formal assessment, it is logical to assume that (1) and (4) have affected transportation safety positively, while (3) has been neutral to slightly negative, and (2) has been very likely negative in its effects. This reasoning neglects any potential synergism between (1) and (2) that might on balance result in a safer operating environment on controlled-access highways, even at significantly higher speeds. It may also be true that (3) and (4) are mutually exclusive in their effects, with one or the other having relatively little connection to safe operations.

Our objective is to highlight some recent statistical indicators about accidents, fatalities, and injuries sustained in the course of large-shipment commodity flow in heavy-duty vehicles (combination trucks and rail cars) during the middle years of the current decade and, if possible, to connect the trends or tendencies they may reveal to any of these four developments. Ideally, it might then be possible to test one or more useful hypotheses about the risks en route of hazardous materials transportation in the 1990s.

INVESTIGATIVE APPROACH

Although the occurrence of an accident involving a freight-hauling vehicle is not a priori a sign of unsafe conditions, the frequency or density of accidents on a given class of roadway in a defined geographical area may indicate, if other routing choices are available, that a particular road type and area combination should be avoided. Similarly, due to weather and topographic factors, the operating environment for freight railroads may not be uniformly safe across geographic regimes, even for a single carrier. The basic unit of movement for highway transport of spent fuel is the heavy tractor-trailer combination truck and the railcar. Estimating the total movement in kilometers of such units by geographic area provides a set of denominators for risk rates that, when coupled with the corresponding numerators of event counts, provides an indication of the relative safety of an operating regime. Systematic grouping and comparison of these rates (summing over numerators and denominators) can also be instructive with respect to other characteristics that cannot be defined on a strictly geographic basis. A common speed limit regime is one example. In this paper, we generate basic accident, fatality, and injury rates at the state-level of aggregation for the purpose of identifying the spread or range of values, and then we construct statistical groups in an effort to shed light on the possible effects of the factors discussed in the preceding paragraphs. We first discuss how the data for developing these rates were extracted.

DATA SOURCES FOR ESTIMATING STATE-LEVEL ACCIDENT, FATALITY, AND INJURY RATES

Combination Truck Accidents, Fatalities, and Injuries

Until March 4, 1993, Part 394 of Title 49 of the *Code of Federal Regulations* required motor carriers to submit accident reports to the Federal Highway Administration (FHWA) in the "50-T" reporting format. By Final Rule of February 2, 1993 (58 *Federal Register* 6726), this reporting requirement was removed; instead of submitting reports, carriers were required to maintain a register of occurrences meeting the definition of an accident (see below) for a period of one year after such an accident occurred. Carriers were to make the contents of these registers available to FHWA agents investigating specific accidents. They were also required to give ". . . all reasonable assistance in the investigation of any accident, including providing a full, true, and correct answer to any question or inquiry," to reveal whether hazardous materials other than spilled fuel from the fuel tanks were released, and to furnish copies of all state-required accident reports (49 CFR 390.15). The reason for this change in rule was the emergence of an automated state accident reporting system created out of law enforcement accident reports. Pursuant to provisions of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991

(Public Law 102.240), the new system was being established under the Motor Carrier Safety Assistance Program (MCSAP). Under Section 408 of Title IV of the Motor Carrier Act of 1991, a component of ISTEA, the Secretary of Transportation is authorized to make grants to states in order to help them achieve uniform implementation of the police accident reporting system for truck and bus accidents recommended by the National Governors' Association. Under this system, called SAFETYNET, accident data records generated by each state follow identical formatting and content instructions. The records are entered on approximately a weekly basis into a federally maintained database. This database is, in turn, compiled and managed by a DOT contractor as part of the Motor Carrier Management Information System (MCMIS).

Motor carrier reporting rules in 49 CFR 390.5 define an accident as an occurrence involving a commercial motor vehicle operating on a public road that results in a fatality, that results in bodily injury to a person that requires medical treatment away from the accident scene, and/or when one or more involved motor vehicles incur disabling damage as a result of the accident such that the vehicle must be towed from the scene. Specifically excluded from this definition of "accident" are occurrences involving only boarding or alighting from a stationary vehicle, only the loading or unloading of cargo, and passenger cars or other multipurpose passenger vehicles owned by the carrier when transporting neither passengers for hire nor hazardous materials in placard quantities (i.e., above the weight or volume threshold for placard set by DOT).

Heavy combination truck accident counts have been extracted for this paper from the public use MCMIS accident files. The first year of database development, 1993, under the new system discussed above witnessed considerable inconsistency in data quality from state to state; many state-level records were found to be useless because of missing or incomplete data fields. Overall data quality improved steadily from 1994 through 1996, but some problems remain. Several states either do not furnish location-specific information, rendering assignment to a highway type impossible, or they provide this information in a coded manner, unintelligible to the general user. This problem was resolved for Texas, thanks to cooperation from state-level personnel there. However, Georgia, Louisiana, New York, Oregon, and South Carolina lack rates by road type. Also, a handful of other states, including Florida, Maine, Maryland, North Dakota, Ohio, and Tennessee, are missing data from portions of one or more of the years 1994 to 1996. This lack necessitated reliance on only the complete year(s) of data from these states for the purpose of developing state-level accident rate estimates.

Only MCMIS-reported accidents involving the categories (see table 1) of heavy combination trucks operated by interstate-registered carriers are included in our numerators. This is due to the near certainty that only such carriers will be authorized to transport spent reactor fuel (SRF) to a distant repository.

Three state-level denominators for highway combination-truck-kilometers were needed for each analysis year in order to complete the accident rates by using the above data. Estimates of combination truck travel on interstates, other principal highways (generally, other components of the National Highway System), and other roads (e.g., county highways, farm-to-market roads, local streets) for 1994, 1995, and 1996 were developed from the FHWA's annual publication *Highway Statistics* (USDOT FHWA 1995-97), tables VM-1 through VM-4 for 1995 and 1996 (see the web page of the Bureau of Transportation Statistics).

Table VM-2a of *Highway Statistics* provides updated, annual state-level vehicle-miles traveled (VMT) by functional system for the prior year. U.S. VMT totals by highway category (interstate/other, arterial/other) and vehicle type are found in table

TABLE 1 MCMIS Truck Categories Included in Rate Estimation

MCMIS vehicle configuration mode	Truck type
4	Truck/trailer
5	Bobtail (tractor only)
6	Tractor/semitrailer
7	Tractor/double
8	Tractor/triple

VM-1. The share of state-level VMT (distance traveled) accounted for by combination trucks (single and multiple trailer) was obtained from table VM-4, which consists of a series of tables that provide the distribution of annual VMT by vehicle and road classification. In general, the road classification categories found in table VM-4 correspond to those in table VM-2a, although some aggregation of the latter table's totals is required. Table VM-2a totals for rural minor arterial, major collector, minor collector, and local roads were combined into the category "rural other," and the truck share from "rural minor arterial" found in table VM-4 was applied. Similarly, the sum of urban "minor arterial," "collector," and "local" shares from table VM-2a was consolidated as table VM-4's "urban minor arterial;" this was used to estimate the "other urban" truck VMT, as in table VM-1. (Urban VMT totals could only be calibrated to "interstate" and "other," the aggregation level of table VM-1.) At the end of this process, there were three sets of state-level VMT totals, corresponding to the respective combination-truck fraction of national VMT for each highway type in table VM-1.

This distribution of truck VMT by state was compared with state data on highway diesel ("special fuels") sales (see table MF-21 of USDOT FHWA 1995–97) and results of an analysis of 1993 truck flows in the Commodity Transportation Study performed by Oak Ridge National Laboratory (Chin et al. 1998). Adjustments were made on the basis of this cross check. In general, the state shares for diesel sales from table MF-21 and adjusted truck-miles traveled were comparable. Additionally, the mean and variance of the respective distributions of state-level combination truck VMT shares and special fuels sales shares were not significantly different statistically.

Miles for the denominator of each state's rate were converted to kilometers and reduced by 25% to parallel the exclusion of accidents of non-interstate (local and regional) carriers from the numerator. This adjustment is supported by data from the 1992 *Truck Inventory and Use Survey* (TIUS) (USDOC 1992). Tabulated information from TIUS indicates that of the 41.9 billion miles (67.4 billion kilometers) of nationwide combination truck movement in 1992 that could be directly assigned to interstate, intrastate, or locally registered carriers, 34.1 billion (54.9 billion kilometers or about 81%) were by carriers of interstate registry. This might argue that the 25% discount is too conservative and should be set closer to 20%. However, some 29.6 billion combination truck miles in the TIUS could not be so assigned due to missing data entries on the survey data form. We assumed a slightly greater propensity on the part of non-interstate carriers to leave the needed entries blank and thus allocated to these carriers a higher proportion of the unattributable kilometers (35%) than their share of the recorded attributable kilometers (19%). This produced the final 75/25 split assigned to each of the three study years.

Railroad Freight Accidents, Fatalities, and Injuries

Under 49 U.S.C. 20901, rail carriers must file a report with the Secretary of Transportation, not later than 30 days after the end of each month in which an accident or incident occurs, that states the nature, cause, and circumstances of the reported accident or incident. The format for such reports is provided by the Federal Railroad Administration (FRA) under 49 CFR 225.11. The criteria for a reportable accident or incident currently encoded in 49 CFR Part 225 follow:

- Impact occurs between railroad on-track equipment and 1) a motorized or non-motorized highway or farm vehicle, 2) a pedestrian, or 3) other highway user at a highway-rail crossing.
- Collision, derailment, fire, explosion, act of God, or other event involving the operation of standing or moving on-track equipment results in aggregate damage (to on-track equipment, signals, track and/or other track structures, and/or roadbed) of more than $6,300 (as of 1998).
- An event arising from railroad operation results in 1) the death of one or more persons, 2) injury to one or more persons, other than railroad employees, requiring medical treatment, 3) injury to one or more employees requiring medical treatment or resulting in restriction of work or motion for one or more days, one or more lost work days, transfer to another job, termination of employment, or loss of consciousness,

and/or 4) any occupational illness of a railroad employee diagnosed by a physician.

Certain types of railroad carriers are exempted from these requirements, specifically those owning or operating on-track equipment entirely within a facility not part of the general freight railroad system, rail urban mass transit operations not connected to the general railroad transportation system, and those owning or operating an exclusively passenger-hauling railroad entirely within an installation isolated from the general freight railroad system.

Carriers covered by these requirements must fulfill several bookkeeping tasks. FRA requires the submittal of a monthly status report, even if there were no reportable events during the period. Accidents and incidents must be reported on the FRA standardized form, but certain types of incidents require immediate telephone notification. Logs of both reportable injuries and on-track incidents must be maintained by each railroad on which they occur, and a listing of such events must be posted and made available to employees and to the FRA, along with required records and reports, on request. The data entries extracted from the FRA reporting forms are consolidated into an accident/incident database that separates reportable accidents from grade-crossing incidents. These are annually processed into event, fatality, and injury count tables as part of the *Accident/Incident Bulletin* (USDOT FRA 1994-96) published on the Internet by the Office of Safety. All reported trespasser and non-trespasser fatalities and injuries have been included in the data used for the analysis discussed here. According to the FRA *Accident/Incident Bulletin* for 1996, only approximately 3.3% (141) of the 4,257 highway-rail accidents reported in 1996 exceeded the damage cost threshold required for reportable train accidents. In most years, this proportion is well under five percent. Thus, the vast majority of accidents at grade crossings in the FRA database appear due to fatality or injury.

Rate denominators (car-kilometers) come directly from state-level data on carloads handled by year as reported by the Association of American Railroads (AAR). Statistics for 1995 and 1996 have been posted on the Internet for easier access (Association of American Railroads 1998). We estimated the average distance traveled in kilometers by railcar shipments in each state based on the distance from the rail "centroid"[1] of each state to the nearest border, except for corridor states clearly dominated by through (as opposed to originating and terminating) hauls. For states in this category, average haul length was increased by 25%. Examples include Kansas, Mississippi, Montana, New Mexico, and North Dakota. The product of the AAR number times the resulting distance was then multiplied by the ratio of total car-miles to loaded car-miles shown in the "Freight Car Miles" figure of AAR's annual publication *Railroad Facts* (Association of American Railroads 1997). In recent years, this ratio has fluctuated closely around 1.68. Finally, the state-level totals of car-kilometers thus derived are summed for comparison to the control total for railcar miles (kilometers) in *Railroad Facts*. The control total for each year is the metric-converted value for total U.S. freight car miles in the "Freight Car Miles" table (American Association of Railroads 1997, p. 34). Any discrepancy with respect to this control total is corrected by adjusting the average haul length for all states by a uniform percentage, which in no case resulted in a state-level increase or decrease of greater than 10 kilometers per average haul.

VARIATION IN RATES ACROSS THE STATES

From the description above, it should be manifest that an accident rate computed for any single state's combination truck or railcar flows is subject to error from many sources in both numerator and denominator. However, no one state is necessarily more prone to such error than another, unless its sample size in both numerator and denominator is relatively small. We have elected not to present the individual composite (1994 to 1996) state rates computed according to the procedure described but instead to give an indication of their distribution, if it may be assumed that errors are uniform from state to state. Computed rates for individual states are tabulated in Saricks and Tompkins

[1] A "centroid" is the midpoint between east and west or north and south state border crossings on the principal rail line, based on flow data.

TABLE 2 Distribution by Road Type of MCMIS Composite 1994–96 State-Level Accident, Fatality, and Injury Rates per Unit of Travel by Heavy Combination Trucks of Interstate Registry

	I	P	O	T
Accident rate (10^{-7} per truck-km.)				
Total rate	3.00	2.78	4.56	3.21
Mean rate	3.15	3.66	6.54	3.52
Standard deviation	1.87	2.41	8.02	2.06
5th percentile	0.87	0.75	0.23	0.94
Median	2.83	3.15	3.59	3.34
95th percentile	6.19	8.00	27.16	7.12
Fatality rate (10^{-8} per truck-km.)				
Total rate	0.96	1.78	1.71	1.42
Mean rate	0.88	2.32	1.96	1.49
Standard deviation	0.45	1.64	2.19	0.68
5th percentile	0.09	0.22	0.00	0.38
Median	0.92	2.06	1.13	1.30
95th percentile	1.49	5.30	6.32	2.57
Injury rate (10^{-7} per truck-km.)				
Total rate	2.25	2.17	3.33	2.39
Mean rate	2.27	2.73	4.69	2.56
Standard deviation	1.32	1.75	5.91	1.48
5th percentile	0.57	0.60	0.24	0.77
Median	1.93	2.51	2.52	2.20
95th percentile	4.56	5.95	19.31	5.35

I = Interstate Highway System
P = Primary (non-interstate) National Highway System
O = Other roads and highways
T = All highways and other roads

TABLE 3 Total and Standard Deviation for OMC Composite 1986-88 State-Level Accident, Fatality, and Injury Rates per Unit of Travel by Road Type by Heavy Combination Trucks of Interstate Registry[1]

	I	P	O
Accident rate (10^{-7} per truck-km.)			
Total rate	2.44	3.94	3.48
Standard deviation	0.69	1.77	6.98
Fatality rate (10^{-8} per truck-km.)			
Total rate	2.03	5.82	4.62
Standard deviation	0.63	3.01	11.74
Injury rate (10^{-7} per truck-km.)			
Total rate	2.28	3.82	3.30
Standard deviation	0.69	1.79	7.10

[1] Reported in Saricks and Kvitek (1994)—percentile distributions not computed.
I = Interstate Highway System
P = Primary (non-interstate) National Highway System
O = Other roads and highways

(1999). The respective "spreads" of highway, heavy combination truck accident, fatality, and injury rates of interstate-registered carriers by road type for the continental U.S. as a whole is shown in table 2, with the three sets of rates distributed over all road types charted in figure 1. These distributions are similar to those reported for earlier data series in Saricks and Kvitek (1994), shown in table 3, but with modest reductions for National Highway System road classifications below that of Interstate Highway.

The "total rate" in table 2 reflects the sum of all applicable MCMIS incidents for all interstate-registered heavy combination trucks in the category, divided by corresponding national travel-kilometers, while the "mean rate" is the average over the rates for the 47 continental U.S. states with qualifying (reportable) accidents in the three-year period. The latter value is generally higher in each instance because of the disproportionate weight assumed by states with less total truck activity. Overall, the data appear to show that, although the likelihood of injury in accidents involving heavy combination trucks is higher for most states than during the 1980s, the likelihood of being killed is almost uniformly lower. This may be due primarily to an increase in seat belt use and safer vehicle design, including the use of airbags and other active restraints, rather than to generally safer roadway conditions. However, the root cause remains unknown. If, due in part to the new restraint systems, those that would formerly have been fatalities are now injuries instead, then the observed increase in injury rate should be expected.

The corresponding spread of accident rates per railcar-kilometer is shown in table 4. Domestic rail freight accidents, fatalities, and injuries on class 1 and 2 railroads have apparently stabilized or declined slightly since the late 1980s (see table 5). Reductions in fatalities and injuries, likely due to an extent to increased grade-crossing safety, ongoing grade-crossing elimination programs, and AAR's "Operation Lifesaver" program, are especially noteworthy.

TABLE 4 Distribution of FRA State-Level Accident, Fatality, and Injury Rates per Railcar-km

	Accidents	Grade crossing incidents	Non-trespasser fatalities	Trespasser fatalities	All fatalities	Non-trespasser injuries	Trespasser injuries	All injuries
Mean rate	2.74E-07	2.16E-07	1.38E-08	6.44E-08	7.82E-08	1.04E-07	1.25E-08	1.17E-07
Std. dev.	7.61E-07	5.68E-07	1.16E-08	2.13E-07	2.15E-07	3.80E-07	1.64E-08	3.79E-07
5th pctile.	1.95E-08	1.39E-08	1.86E-09	1.64E-09	5.78E-09	5.87E-09	6.72E-10	9.62E-09
Median	6.10E-08	1.02E-07	1.31E-08	8.92E-09	2.27E-08	3.40E-08	1.15E-08	4.26E-08
95th pctile.	1.53E-06	3.87E-07	4.17E-08	2.11E-07	2.23E-07	1.86E-07	5.44E-08	2.07E-07

SPEED LIMIT EFFECTS

Between 1995 and 1996, the 25 states listed in table 6 raised the maximum daylight speed limit for cars and light trucks on interstate highways. Although nominally restricted to a speed limit lower than the posted maximum, heavy combination trucks are often seen moving on rural interstates at speeds comparable to the rate of primary vehicular flow (i.e., the overall maximum limit). Using the accident data compiled for this study, we analyzed the relationship between maximum speed and accident rate. For this investigation, we examined only data for interstate highways by state for 1995 and 1996. Of the 48 states included in the study, 5 had incomplete road class information, and 1, Rhode Island, had no qualifying accidents. Therefore, these six states were excluded from the speed limit analysis. The five states without road class information were Georgia, Louisiana, New York, Oregon, and South Carolina. Two of these states, Georgia and New York, raised the maximum speed limit: Georgia to 70 miles per hour and New York to 65 miles per hour. (Note that all accident rates are in units of 10^{-7} accidents/kilometer.) The remaining states were separated into two groups: states that raised the speed limit during the 1995 to 1996 period (group A) and those that did not (group B). The mean and variance for accident rates in 1995 and 1996 for all states combined and for groups A and B, respectively, are shown in table 7.

The mean accident rate for all states increased from 2.93 in 1995 to 3.45 in 1996. The mean accident rate for the group A states, those that raised the speed limit, increased from 2.70 to 3.69, while the mean accident rate for group B states remained approximately the same. The quality and inherent variability of the data across states indicates caution be used in imparting significance to any differences noted, but it is interesting nonetheless that the change in mean accident rates is in the expected direction.

TABLE 5 Composite 1985–88 FRA State-Level Accident, Fatality, and Injury Rates per Unit of Railcar Movement[1]

	Total[a]	Mainline only
Accident rate (10^{-8} per railcar-km.)		
Total rate	5.57	2.66
Standard deviation	21.48	11.12
Nontrespasser fatality rate (10^{-8} per railcar-km.)		
Total rate	2.35	—
Standard deviation	(not reported)	
Nontrespasser injury rate (10^{-7} per railcar-km.)		
Total rate	5.37	—
Standard deviation	(not reported)	

[1] Reported in Saricks and Kvitek (1994)—percentile distributions not computed; grade crossing incidents not included in accident counts.
[a] Includes switching yards and industrial lead tracks.

TABLE 6 States that Raised the Maximum Controlled-Access Highway Speed Limit 1995–96

Alabama	Nevada
Arizona	New Mexico
California	New York
Colorado	North Carolina
Delaware	Oklahoma
Florida	Pennsylvania
Georgia	South Dakota
Idaho	Tennessee
Kansas	Texas
Mississippi	Utah
Missouri	Washington
Montana	Wyoming
Nebraska	

FIGURE 1 Two-Tail Distributions of Composite 1994–96 Mean State-Level Accident, Fatality, and Injury Rates for Interstate-Registered Combination Trucks Over All Highway Types

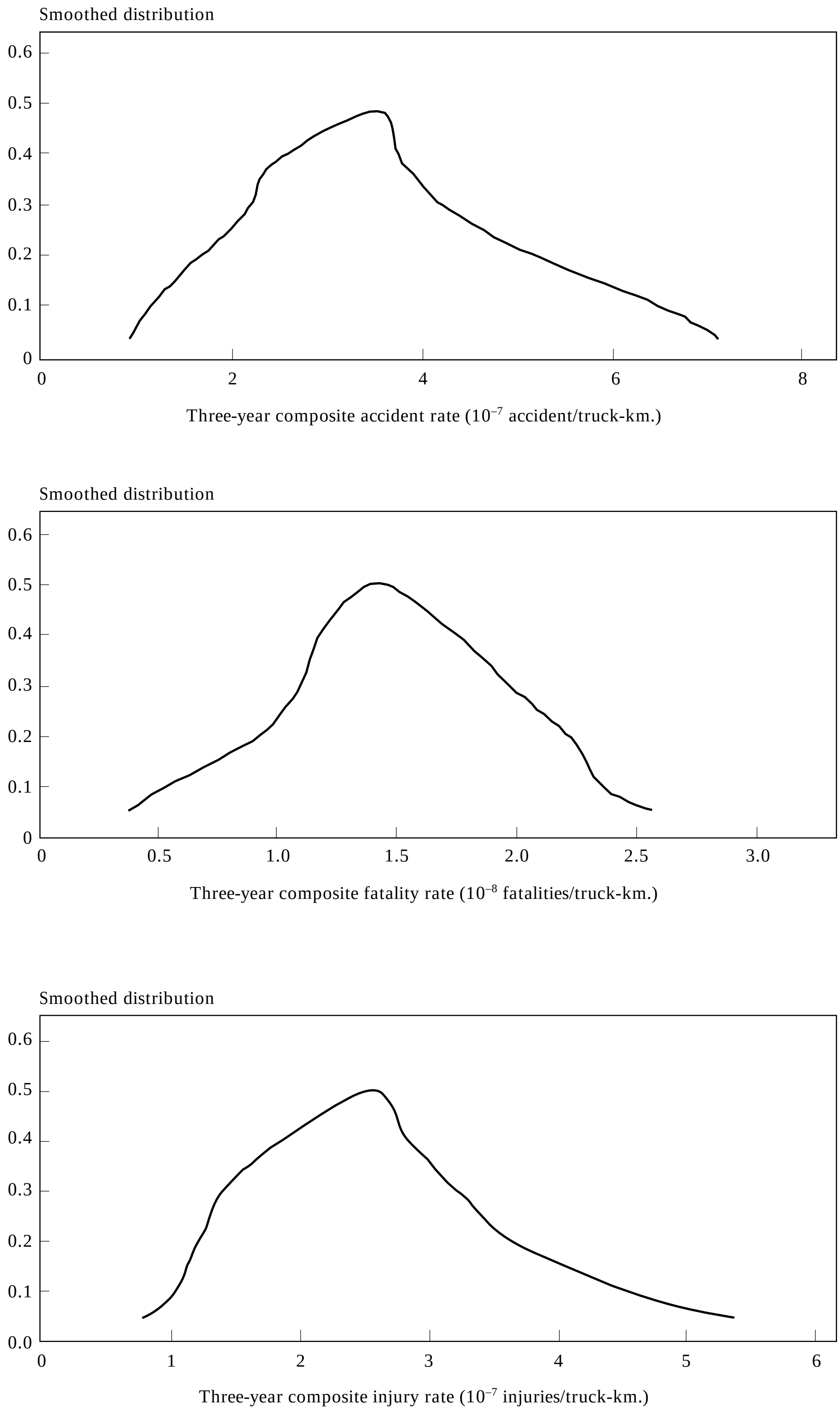


TABLE 7 Accident Rates 1995 and 1996—Descriptive Statistics

Accident rate	1995	1996
All states		
mean	2.93	3.45
variance	3.62	5.56
Group A		
mean	2.70	3.69
variance	3.05	3.93
Group B		
mean	3.22	3.15
variance	4.36	7.68

No further statistical analysis is presented here, but underlying relationships in these data should remain a topic for future investigation. Many factors affect the occurrence or avoidance of an accident, and speed is but one of them. The ability to adjust to a rapidly developing, dangerous situation on the roads can be impaired at higher speed driving, but under some circumstances speed differences within the traffic stream, rather than at its maximum speed, have greater importance. Without access to comprehensive reports on individual accidents and their causes, it is premature to judge whether an increase in speed limits per se is inherently less safe for heavy combination truck movements.

CORRIDOR ANALYSIS

In earlier analyses applying extensive statistical testing to all rail accident and incident records in the FRA database for 1984 through 1988, strong and consistent positive correlation was discovered between temperature extremes and accident frequencies (Lee and Saricks 1991; Saricks and Janssen 1991). Descriptive statistics using the MCMIS data are presented in an effort to gain some insight into whether a similar phenomenon occurred for truck accidents. States were partitioned into three primary east-west highway corridors representing different seasonal temperature regimes (shown in figure 2). These states and east-west interstate highways were included in each corridor:

Central: CO, IL, IA, KS, MO, NE, NV, UT, WY; I-44 (MO), I-70, I-76, I-80, I-88

North: II, MI, ME, MT, ND, OR, SD, WA, WI; I-82, I-84, I-86, I-90, I-94

South: AK, AZ, AR, CA, FL, GA, LA, MS, NM, NC, OK, SC, TN, TX, VA; I-8, I-10, I-20, I-30, I-40, I-44 (OK)

Along each corridor, three years of MCMIS truck accident counts were partitioned into three-month groupings approximately representing the four seasons. Accident involvement counts of interstate-registered heavy combination trucks for the years 1994, 1995, and 1996 were pooled and compared for the corridors. From monthly counts, it appeared that there is greater seasonal variation in the number of accidents for the north corridor (west of Chicago) and less pronounced variation in the south corridor (entire Sun Belt). Results for the central corridor are mixed and may involve differences between routes such as I-70 and I-80 that were not investigated. Table 8 shows the mean number of accidents and the variance along each of the defined corridors for the winter and summer seasons. The months January, February, and December are designated as winter, and the months June, July, and August are designated as summer. No formal tests are presented in this paper due to the quality and inherent variability of the data. The descriptive statistics, however, indicate that there may be a seasonal variation in truck accidents. In particular, based on the accident counts, it appears that truck transport risk, like rail transport, may exhibit sensitivity to conditions associated with winter driving, such as short days with their low-light conditions, snow, sleet, and ice. However, unlike rail transport, it may be relatively insensitive to conditions associated with extreme heat.

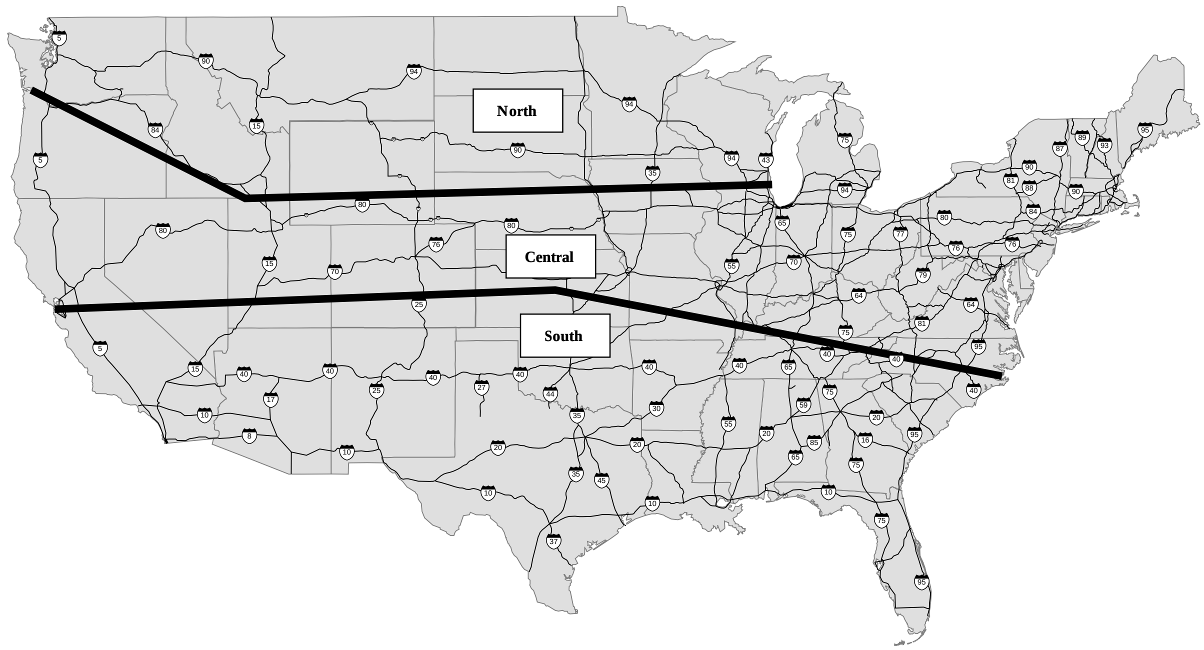
DISCUSSION AND CONCLUSIONS

Earlier, four relatively recent developments were identified as possible modifying influences on acci-

TABLE 8 Descriptive Statistics of Corridor Accident Involvement Counts: 1994–96 Composite

	Summer	Winter
South		
mean	1,644	1,625
variance	25,101	48,326
Central		
mean	1,220	1,508
variance	16,168	139,311
North		
mean	539	874
variance	9,168	45,650

FIGURE 2 Transcontinental Corridors Defined for Comparative Seasonal Analysis



dent involvement rates of surface freight transportation, relative to their mid-1980s counterparts. The first of these, completion of the Interstate Highway System, appears to have contributed to a mitigation of these rates. For example, West Virginia was one of the last states to see completion of its designated interstate highway network. There, the accident involvement rate for interstate-registered heavy combination trucks on the primary (non-interstate) highway system—some of which in the mid-1980s was carrying truck traffic diverted from interstate highways under construction—declined by at least 65%. The fatality rate dropped by over 60%, and the injury rate, by over 70%.

There is limited evidence that the second development, increased highway speed limits, especially on the interstate system, poses a valid concern, as documented in earlier sections of this report. Additional analysis is warranted when a longer time series of data that includes at least three years prior to and three after 1996 becomes available. Such an interval will be necessary to reveal whether higher 1996 rates for states that raised the speed limit represent an anomalous fluctuation in the time series or the beginning of a sustained reversal of long-term downward accident trends for heavy combination trucks.

The third development, the continued consolidation and rationalization of the railroad freight system, also appears positive in that such consolidation has, to date, resulted in a network capable of safer, more efficient operations. Changes in economic conditions have combined with elimination of "excess" track miles to bring about shifts in state shares of total freight flows; for example, major increases are evident on the consolidated trunk lines in several central, northern, and western states. A continuing shift of shorter hauls to trucks is reducing total railcar flow in New England and in some Mid-Atlantic States. This latter phenomenon causes incremental accidents to have an exaggerated effect on state-level rates in the affected areas. Although this analysis could not positively identify a consistent mid-1990s reduction in accident rates relative to mid-1980s conditions (in fact, the national rate is statistically unchanged), it did identify a downturn in most fatality and injury rates. Again, this may be the result of increased awareness of good safety practice both on the railways and among the general public at railroad crossings due to such outreach efforts as "Operation Lifesaver."

The final development cited in the first section of this report may no longer be relevant to an intensive shipping campaign for large consignments of radioactive and hazardous materials. Road and rail routing options are now generally constrained by published guidance (49 CFR 397.101). However, options remaining for routing via railroad can be worked out directly with carriers during contract negotiations and, in any case, based on recent data do not to possess (other factors being equal) a clearly "safer" routing choice in the current selection set. With respect to intermodalism and technological advance, current plans for the spent reactor fuel shipping campaign generally exclude all but necessary near-site transshipment, with casks moving by either railroad or highway exclusively from plant site to repository. If additional transshipment options were actively under consideration, the effect and relative safety of intermodal haulage would merit further discussion, but such analysis is now premature. Also, statistics presented in sources noted above appear to support the concept that that the adoption of higher operating speeds over improved track in advanced-technology locomotives does not compromise safe railroad operation.

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