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Transportation Fatalities: A Risk Assessment

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ABSTRACT

This paper assesses the relative fatality risk of transportation modes and submodes for use in public safety resource allocation. Average annual fatalities for the modes and submodes are compared. Factors which might influence society's valuation of risk are examined -- victim age, trends in fatalities, and variability of fatalities. Finally, other measures of risk (fatalities per ton-mile, per passenger-mile, and per vehicle) are presented to help judge the acceptability of existing risk levels.

THE PURPOSE OF THIS PAPER is to develop an assessment of transportation fatality risk which is appropriate for use in considering federal expenditures on transportation safety. A measure of transport fatality risk should have two properties: It should measure the probability or relative frequency of a defined event, and the consequences of the event across modes shodld be similarly valued by society. The average number of fatalities per year is one of the best measures of modal transportation fatality risk for use in public policy analysis. This measure has a roughly comparable measure of the consequences of the event, a death, across modes and measures the expected frequency of the event. Average fatalities per year measures the extent of the problem and, therefore, is better for judging resource allocation than other commonly used measures of risk such as fatalities per passenger mile. Clearly, average fatalities per year does not provide all of the information needed to assess fatality risk, so other measures are also presented to complete the assessment of modal transportation fatality risk.

AVERAGE ANNUAL FATALITIES

Transportation fatalities are largely highway fatalities, as Figure 1 illustrates.

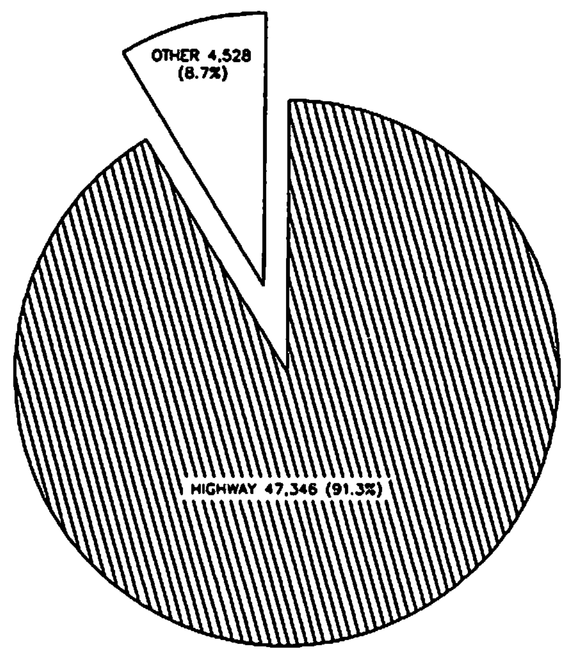

FIGURE 1. TRANSPORT FATALITIES - HIGHWAY AND OTHER (1975-1983) MEAN

During the 1975 to 1983 period over 90 percent of all fatalities were highway fatalities.

The major modal components of non-highway transportation fatalities are shown in Figure 2. Airway, railway, and waterway fatalities each account for about one-third of the non-highway transportation fatalities.

Figure 3 shows the major submode components of non-highway fatalities.

- o Airway fatalities are mostly general aviation fatalities;

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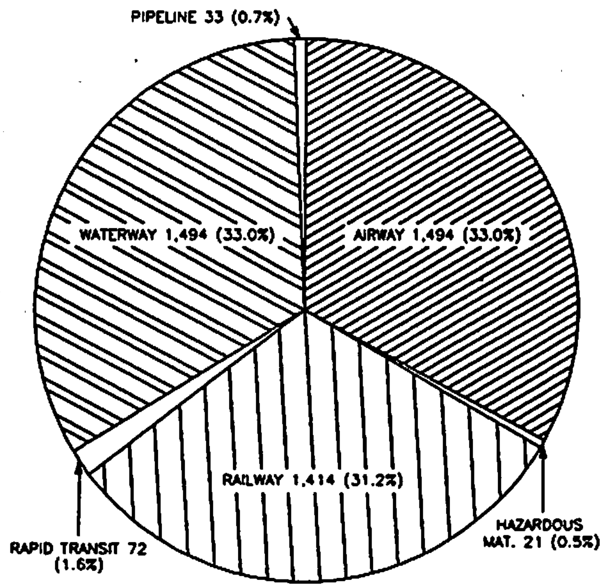

FIGURE 2. COMPONENTS OF NON-HIGHWAY FATALITIES (1975-1983 MEAN)

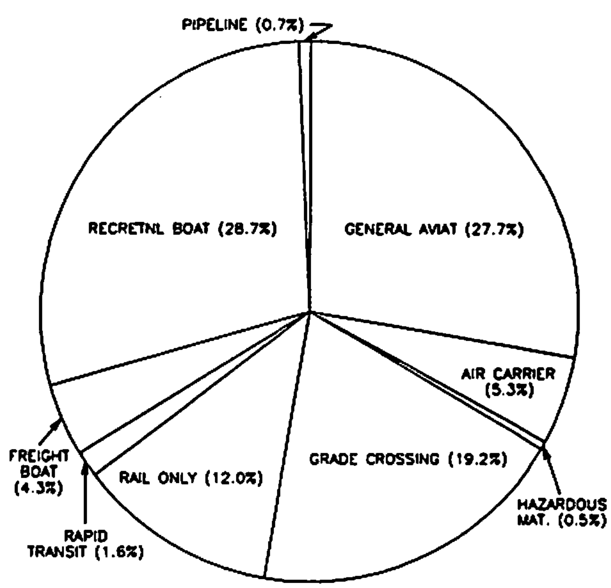

FIGURE 3. COMPONENTS OF NON-HIGHWAY FATALITIES (1975-1983 MEAN)

- o Grade crossing accidents, which are counted as both railway and highway fatalities in Figure 1, represent 60 percent of all railway fatalities; and

- o Waterway fatalities are dominated by recreational boating fatalities.

For each of these three modes, most fatalities are occupants of non-commercial vehicles. (See Prensky et al. (1)*for other categorizations of submodes for both accidents and fatalities.) Pipeline, hazardous materials, and rapid transit account for relatively few fatalities.

A breakdown of highway fatalities into occupant fatalities by submodes (see Figure 4) reveals that the commercial vehicles (medium and heavy trucks and buses) account for less than five percent of highway occupant fatalities. However, because trucks and buses are heavier than the vehicles they typically hit, the occupant of the other vehicle is more likely to die. Therefore, commerical vehicles are involved in more fatal accidents than Figure 4 indicates. More than 75 percent of highway occupant fatalities are accounted for by the non-commercial vehicle submodes: passenger cars, light trucks and vans, and motorcycles.

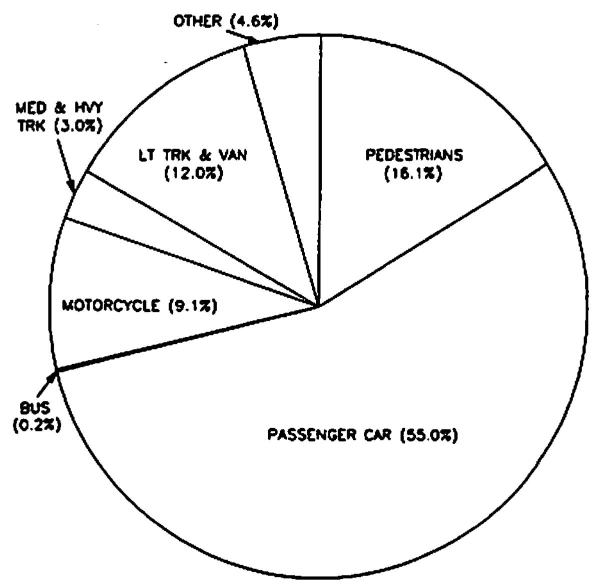

FIGURE 4. COMPONENTS OF HIGHWAY FATALITIES (1975-1983 MEAN)

For perspective on the relative number of fatalities by transport mode, notice that each year about as many people die in motorcycle accidents as in all non-highway accidents combined.

OTHER ATTRIBUTES OF FATALITY RISK

Three other factors are important to consider in assessing the relative fatality risk of each mode: the age of the victims, the variability of the modal fatality levels, and the recent trends in fatalities. These three factors might suggest that the measure of relative fatality risk presented above should be modified to account for modal differences.

*Number in parentheses refer to references listed at the end of the paper.

VICTIM AGE: In using average annual fatalities to compare modal fatality risk, we assume that a death on one mode is equal to a death on another mode. While this seems like a good assumption, it may not be adequate to capture the economic loss to society. Studies of the economic cost of motor vehicle accidents (for example Hartunian et al (2) or NHTSA (3)) have found that a very large share of the cost of highway fatalities is the present value of foregone earnings. Since the present value of foregone earnings depends on the income and age of the victim, a death on one mode is equal to a death on another mode only if the joint age-income distribution of the victims is the same for both modes. Since only the age distribution of the victims is available, Figure 5 shows the age distribution of the victims. The major modes are very similar. Airway victims are slightly older than highway, railway, and waterway victims, but the victims of all modes are dramatically younger than the victims of heart attack--the major killer in the United States. Therefore, comparisons of fatality risk between transportation and heart attack causes should value each transport fatality more than each heart attack fatality because of the substantial difference in the age (and future earnings) of the victims. In contrast, the differences in the age distribution of the victims among the transportation modes is so slight that no adjustment to the measure of overall risk is necessary based on the age of the victim.

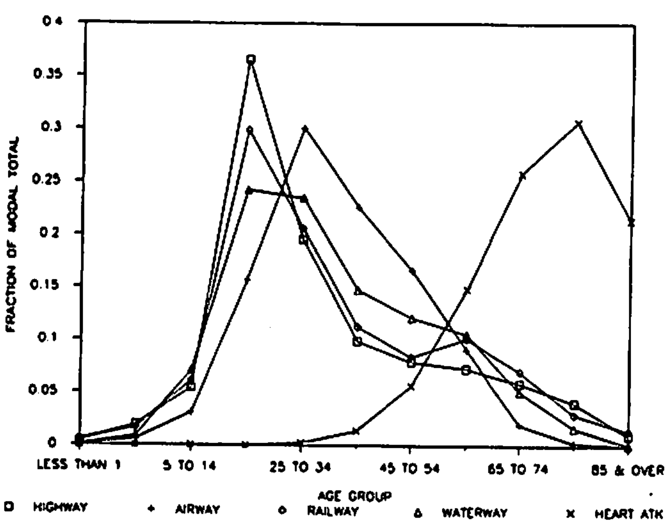

FIGURE 5. AGE DISTRIBUTION OF THE DEAD: FRACTION OF MODAL TOTAL
Sources: Baker et al. (4) and U.S. National Center for Health Statistics (5)

VARIABILITY OF FATALITIES: Accidents where many people die at once create an impression of high risk which affects not only the general public, but also those in government who allocate safety resources. While few would argue that resources should be allocated based on the worst accident, advocates might argue that certain modes have the potential to be dramatically more dangerous than they currently are and that any reduced vigilance will result in very substantial increases in annual fatalities. This argument is difficult to evaluate, but one approach is to examine the variability of modal fatalities. High variability may be an indication of the "potential risk" of a mode. To illustrate the variability of each submode, the fatalities for the year with the highest number of fatalities in the 1975 to to 1983 period is plotted against the nine-year mean in Figure 6. If the worst year were equal to the mean, the point would fall on the diagonal line on the graph. The larger the distance from the line, the higher the variability of fatalities for the mode. Notice that air carrier, pipeline, and hazardous materials are the three submodes where the worst year varies the most from the mean. However, even if the worst year were considered rather than the mean for these three submodes, their relative rank among all transportation submodes would not change. Furthermore, the fatalities which result from these modes would still be dwarfed by the mean fatality levels for the highway submodes.

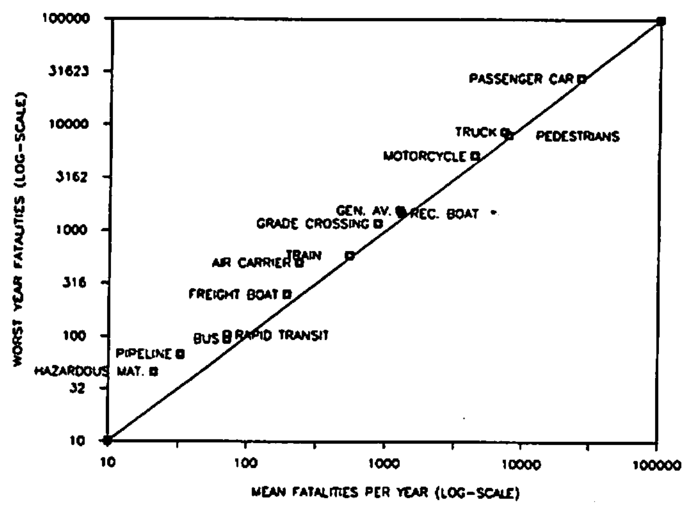

FIGURE 6. VARIABILITY: WORST YEAR VS. MEAN (1975-1983)

RECENT TRENDS: Another important characteristic of the submode fatality levels which is not captured by the mean is the recent trend in fatalities. If the recent trend were toward either dramatically lower or higher fatality levels, it would suggest that the mean overestimates or underestimates the current expected fatality level. One measure of the recent trend is the average annual percentage change in fatalities for the five years since 1978. However, some of this change may be due to random variation. To help judge the reliability of the average annual percentage change, it is plotted against the probability that the change was due to chance. This probability is calculated for each mode from the change for each year during the five years using the Student's t distribution.

As Figure 7 shows, in 1983 all the transportation submodes had fatality levels that were below the 1978 level. The submodes with the highest percentage declines (air carrier and hazardous materials) are <u>not</u> the submodes most likely to have declines which are not due to chance. Grade crossing and passenger car fatalities are much more likely to be declining than air carrier or hazardous material fatalities.

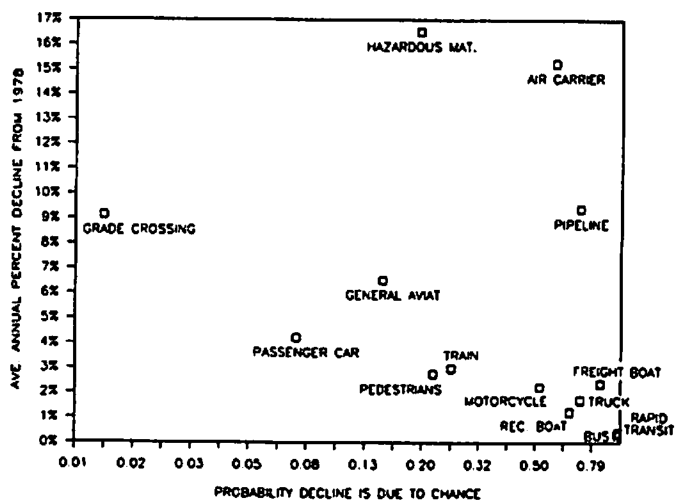

FIGURE 7. FATALITY DECLINES: FIVE YEAR TRENDS (AV.ANNUAL % DECLINE VS.RELIABILITY)

What can be said about the trend <u>differences</u> among the modes? Grade crossing fatalities are most certainly declining more than the submodes which are clustered in the bottom right corner of Figure 7, (motorcycle, freight boat, truck, recreational boat, rapid transit, and bus). Are grade crossing fatalities declining more or less than passenger car fatalities, or more or less than hazardous material fatalities? Even at the fairly permissive confidence level of 80 percent, the grade crossing fatality decline cannot be distinguished from the passenger car or the general aviation or the hazardous material decline, the submodes with the greatest likelihood of declining trends. So, without a clear difference among the modes, no adjustment to average annual fatalities to account for differences in modal fatality trends is warranted.

Are these declines in transportation fatalities for all modes likely to continue? Hedlund et al (6) suggests that for highway fatalities the depressed economy was the major factor responsible for the decline, implying that economic recovery would lead to higher highway fatality levels. As Figure 8 indicates, highway fatality levels for 1984 were higher than 1983 levels and forecasts for 1985 still higher. These forecasts are based on DRI's forecasts (7) of disposable income and TSC's econometric model (8) of the relationship between disposable income and highway fatalities. Similar analyses of the fatality levels for other modes have not been found, possibly because of the low numbers of fatalities and the consequent high relative variability of the fatality series. However, it seems likely that the major mechanisms through which the economy influences highway fatalities, income levels influence the amount of driving and associated fatalities, also act to affect other modal fatality levels. So, the declines in transportation fatalities between 1978 and 1983 should <u>not</u> be expected to continue.

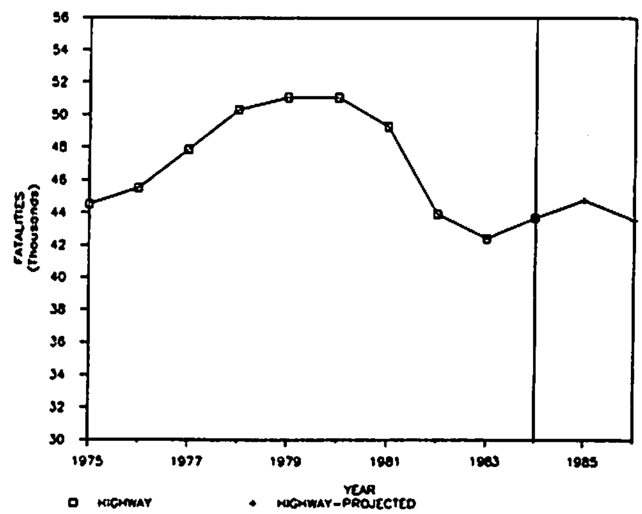

FIGURE 8. HIGHWAY FATALITIES BY YEAR

CONCLUSIONS: The assessment of transportation fatality risk based on average annual fatalities does not need to be modified based on modal differences in the age distribution of the victims, modal differences in the variability of the annual fatality levels; or differences in the trends of modal fatalities. Further, the declines in transportation fatality levels between 1978 and 1983 are not likely to continue. Instead fatalities are likely to grow because of growth in the economy.

OTHER MEASURES OF FATALITY RISK

Average fatalities per year measures modal transportation fatality risk well for public resource allocation, but fatality risk may also be evaluated in relation to the product: ton-miles for freight modes, passenger-miles for passenger modes, and vehicles for personal use modes. These measures, which radically change the risk picture, are useful in judging the acceptability of the risk and controlling for the wide difference in the extent of the modal use. These measures are commonly used to judge year-to-year changes in fatality levels within a mode or submode, but their usefulness in public safety resource allocation is limited because they do not measure the magnitude of the fatality problem.

Figure 9 shows fatalities per billion ton-miles for the major freight modes. Medium and heavy truck occupant fatality rates are the highest. The rate would be even higher if fatal accident involvements were measured that is if all fatalities in accidents involving medium and heavy truck were counted rather than only the truck occupants. If grade crossing fatalities are eliminated from the railway fatality rate (resulting in "Rail Only"), the truck and rail measures would be closer to measuring the same thing (occupant fatalities) since the highway vehicle occupant usually dies in fatal grade crossing accidents.

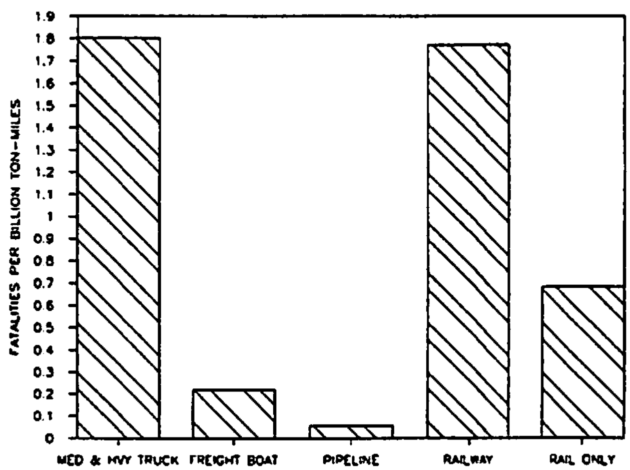

FIGURE 9. MEAN FACILITIES PER BILLION TON-MILES ((1975 - 1983) MEAN, TON-MILES (1982))

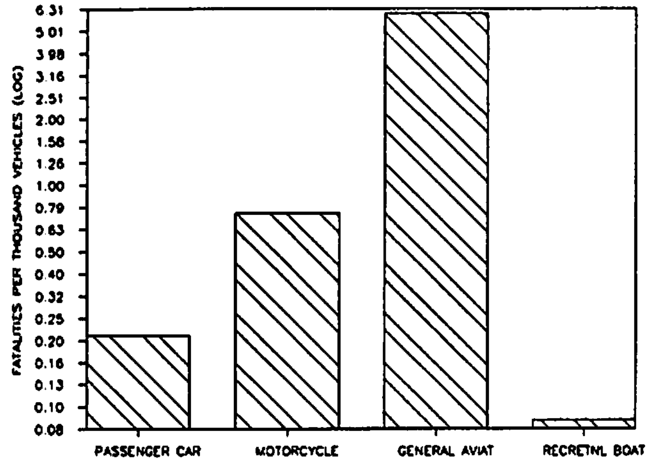

FIGURE 10. MEAN FATALITIES PER VEHICLE ((1975 - 1983) MEAN, VEHICLES (1982))

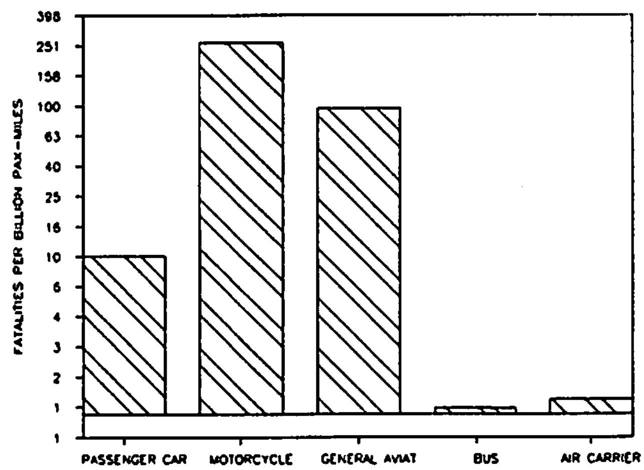

FIGURE 11. MEAN FATALITIES PER PAX-MILE ((1975 to 1983) MEAN, PAX-MILES (1982))

Fatalities per thousand vehicles for the major personal use modes are shown in Figure 10. (A log-scale is used so that the modal differences are more easily compared to those in Figure 11 which will be considered next). General aviation has the highest number of fatalities per vehicle by a factor of about ten. This is at least partly because airplanes are used more intensively (i.e. more passenger-miles per year) than other vehicles. Motorcycles have about three times the number of fatalities per vehicle as passenger cars while recreational boats have about half as many fatalities per vehicle as passenger cars.

Fatalities per passenger-mile reveal a different picture. Figure 11 shows that, when fatalities per billion passenger miles are considered, motorcycles are about 25 times as dangerous as passenger cars and general aviation is about ten times as dangerous. The two common carrier modes, bus and air carrier, are dramatically safer than the personal use modes. This makes sense since the acceptability of risk must be in part determined by the degree of control the risk-taker has over the risk. It could be argued that common carrier modes should be as safe as the safest driver groups, so that no group would be taking more risk using a common carrier than they would take driving themselves. How much safer than passenger car travel should bus and air travel be? This is a matter of judgment but for perspective, Mengert et al. (9) classified involvements in fatal accidents and vehicle miles travelled into 576 categories based on driver age and sex; vehicle age and weight; time of day, day of week, and season; land use; and number of occupants in the vehicle. They found that a ratio of about 200 to 1 exists between fatal accident involvement rates per passenger car-mile of the safest and the most dangerous categories. Should the common carrier modes have fatality rates per mile that are 1/100th of the passenger car rates as this ratio suggests, or should groups which are not quite as safe be chosen as the standard? Much more information on the distribution of passenger car risk as well as public attitudes toward risk would be needed in order to make this judgment.

SUMMARY

Highway accidents account for about 90 percent of all transportation fatalities. As Figure 12 illustrates, passenger car occupant fatalities account for 50 percent of all transportation fatalities, followed by pedestrians (15 percent), light trucks and vans (11 percent), and motorcycles (8 percent). Airway, dominated by general aviation; railway, dominated by grade crossing, and waterway, dominated by recreational boating; comprise equal thirds of the 9 percent of transportation fatalities which are not highway. Examination of the age distribution of the victims, the variability of the fatalities and the recent trend in fatalities by mode suggest that average annual fatalities alone provides a reasonable representation of societal fatality risk for the transportation modes.

Finally, despite significant declines in transportation fatalities, particularly highway fatalites, between 1978 and 1983, fatality levels are likely to grow again with growth in the economy, dramatizing the need for federal support of transportation safety.

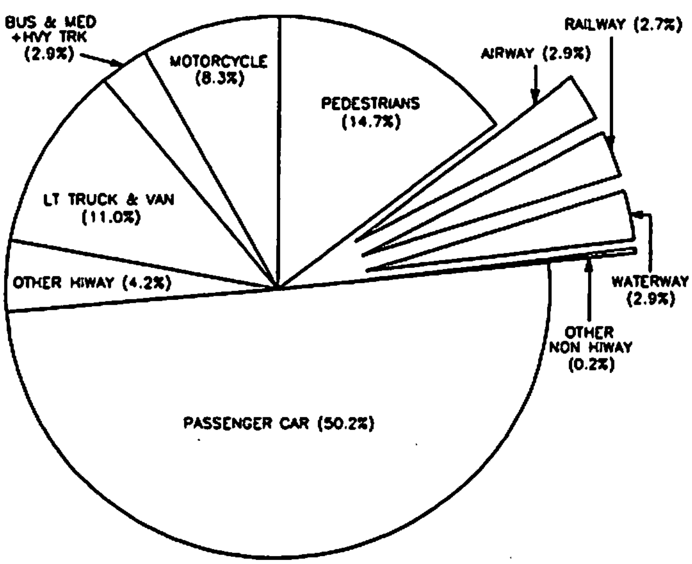

FIGURE 12. TRANSPORTATION FATALITIES ((1975 to 1983) MEAN)

ACKNOWLEDGEMENT

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APPENDIX

DATA USED IN THE STUDY

MODE/SUBMODE	MEAN FATALITIES 75-83	WORST YEAR	AVE DECLINE PER YEAR 1978-83	STD DEV OF THE 5 YR DECLINE	VEHICLES 1982 (10**3)	PAX-MILES 1982 (10**9)	TON-MILES 1982 (10**9)
HIGHWAY	47345.9	51093			165157.9		
PASSENGER CAR	26052.0	28153	1189.4	492.89	123697.9	2607.9	
PEDESTRIANS	7613.2	8096	216.0	148.02			
BUS	72.0	95	0.2	6.76		74.2	
LT TRK & VAN	5693.1	6539	51.0	130.33			
MED & HVY TRK	1429.0	2209	75.6	238.32			792.7
MOTORCYCLE	4295.1	5144	102.4	144.89	5743.5	16.5	
OTHER	2191.4	2493					
AIRWAY	1494.3	1921					
GENERAL AVIAT	1255.9	1558	101.8	56.40	209.8	13.1	
AIR CARRIER	238.4	494	55.4	93.05		213.6	
RAILWAY	1413.7	1684					797.8
GRADE CROSSING	869.9	1174	97.2	24.11			
TRAIN	543.8	584	17.4	13.02			
RAPID TRANSIT	72.0	103	0.2	10.36			
WATERWAY	1494.3	1709					
RECRETNL BOAT	1299.3	1466	16.0	33.79	14900		
FREIGHT BOAT	195.0	248	4.4	21.92			886.5
PIPELINE	32.9	68	3.2	8.28			571
HAZARDOUS MAT.	21.1	46	7.6	4.89			

SOURCES: SACCOCIO (10) AND SPAULDING (11)

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