Bick, T., C. Hohenemser, and R. W. Kates, 1979. "Target: Highway Risks, II, the Government Regulators", Environment 21, pp. 6-15, 29-38.

TARGET: HIGHWAY RISKS

BY TOM BICK, CHRISTOPH HOHENEMSER and ROBERT KATES

II. The Government Regulators

Motor vehicles are among the most destructive of technological hazards. Since 1900 there have been 2.1 million motor vehicle fatalities in the United States—three times the number of all U.S. war dead during this period. Compared to other technological hazards, the causes of auto injuries and deaths are relatively well understood. Not only are risk factors for various driving conditions defined by a broad base of statistical data but the physical theory needed to describe key aspects of collisions is relatively straightforward.

Last month in *Environment* we described the risk factors and key elements of physical theory underlying motor vehicle injuries, and extracted from these a prescription for individual risk reduction and a series of simply stated highway and vehicle design criteria intended to reduce the impact of motor vehicle accidents (see "Target: Highway Risks—Taking Individual Aim"). We concluded our analysis with the question: Why, if we have the scientific knowledge to eliminate eighty percent of present auto fatalities, do we not do so? It is this question which forms the central focus of this second article.

Our answer is framed in terms of models of hazard and hazard control. One such model was developed at Clark University and is discussed in detail in the second article in this series ("Handling Hazards," *Environment*, October 1978). A second, equivalent model is the work of Dr. William Haddon, president of the Insurance Institute for Highway Safety; Haddon's model has been used to classify highway and vehicle control actions in the Department of Transportation (see W. Haddon, Jr., "A Logical Framework for Categorizing Highway Safety Phenomena and Activity," *Journal of Trauma* 12.) Both models are illustrated and described in Figure 1. As can be seen, each envisions stages of hazard development over time, starting with early and fundamental "causes," continuing to intermediate stages, and leading finally to experienced consequences. As presented in Figure 1, the models define the structure of hazard causality and the range of control actions available to managers; as such, their purpose is primarily to encourage logical thinking. The models in themselves do not enable us to understand why extensive scientific knowledge has not led to greater success in reducing fatalities and injuries. For this, it is necessary to look at the history of auto hazard management, the subject of this article.

ROADBUILDING BECAME A SERIOUS PURSUIT in the United States in the late 1880s. Its purpose was primarily to provide feeder and connector routes for the rapidly expanding rail system. In the beginning the building and maintenance of roads was a local responsibility. Because of the dominance of railroads, highways played only a secondary role in the nation's transport system. In 1916 a federal Bureau of Public Roads was established for the purpose of providing farmers with access to markets. During World War I, U.S. roads were still so poor that nearly all long-distance transport was by rail. One shipment of army trucks from Detroit to New York, sent by road rather than rail, took more than a week to arrive. Roadway safety management during this period centered largely on dealing with the disturbing influence of a few automobiles on horse and bicycle traffic.

With the beginning of the mass production of automobiles in 1920, the roadway problem was rapidly transformed. Existing local roads soon became inadequate to carry the increasing traffic, and everywhere new roads were being built by the states. Along with this change came the first highway safety programs. By the mid-1920s many states had laws dealing with safe driving, driver education, driver licensing, traffic courts, the identification and correction of hazardous highway areas, pedestrian safety, periodic vehicle inspection, and safe highway construction and maintenance.

In terms of the Clark model of hazard management, the principal focus of these early safety management efforts was stage 3—modifying or blocking initiating events leading to accidents. For whatever reason, early regulators of highway safety largely ignored accident outcomes (stage 4) and did little about modifying and mitigating consequences (stages 5 and 6). In terms of the three-phase model developed by Dr. William Haddon, president of the Insurance Institute for Highway Safety, effort was primarily focused on the pre-crash phase with little effort being devoted to the crash and post-crash phases. (See Figure 1 and Table 1.) This emphasis was to dominate the thinking of highway safety experts for the next forty years.

Federal Involvement

During this period, highway fatalities kept pace with the burgeoning number of vehicles. From 1910 to 1925, while the number of motor vehicles rose from one-half million to 20 million, the number of annual highway fatalities rose from 3,000 to 22,000.[1] In 1924 public concern about the problem prompted a response by the federal government, albeit a modest one. Secretary of Commerce Herbert Hoover called a National Conference on Street and Highway Safety, in which specialists were brought together to discuss traffic safety management and to suggest ways of putting this knowledge to use. Over the next ten years three similar federal conferences were held. None of them led to any specific action.

In the 1930s the federal government became increasingly involved in construction and maintenance of highways, in part as a means of combatting the unemployment of the Depression. In 1935, at a time when the federal government accounted for 17 percent of total highway construction expenditures,[2] Congress passed its first highway safety legislation. In the Motor Carrier Act of 1935 Congress authorized the Interstate Commerce Commission to establish and enforce safety standards

Table 1

MODELS OF HIGHWAY AND VEHICLE SAFETY MANAGEMENT

CONTROL ACTIONS		EXAMPLES
Defined in This Work	**Defined by Haddon**	
1. Modify human wants	Pre-crash phase	Reduce car travel, reorder home/work location
2. Modify technology choice	Pre-crash phase	Substitute public transportation, other modes
3. Block initiating events	Pre-crash phase	Improve highway visibility, warning signs, driver training
4. Block outcomes	Crash phase	Median barriers, emergency brakes
5. Block consequences	Crash phase	Seatbelts, shatter-proof glass, removal of roadside barriers
6. Block higher order consequences	Post-crash phase	Fire-proof fuel tanks, prompt emergency medical aid

for motor carriers. A year later Congress directed the Federal Bureau of Public Roads, housed in the Department of Agriculture, to study the cause of highway collisions and to suggest appropriate countermeasures. The Bureau concluded that the primary causes of collisions were excessive speed, careless pedestrians, negligent drivers, poor visibility, and temporary hazards in the roadway. The entire emphasis of the report was on collision prevention, with a special section devoted to identifying the collision-prone driver. There was nothing said about improving the design of vehicles or roadways so as to minimize impact once a crash occurs. The report recommended that all states enact laws providing for the licensing of drivers, periodic vehicle inspection, speed limits, and the use of nationally uniform traffic control signals, accident reporting, and rules of the road.[3] These recommendations, which included provision for a major federal role in highway safety management, were largely ignored.

With U.S. entry into World War II in 1942, the nation experienced its first major decline in motor vehicle fatalities—from nearly 40,000 per year to about half that number (see Figure 2). This was not the result of highway safety management but the consequence of drastically reduced driving and a federally mandated maximum speed of 35 miles an hour designed to save fuel and tires, as well as of the absence of thousands of young men serving in the armed forces. The Bureau of Public Roads' 1935 recommendations were forgotten until after the war.

In 1946 President Truman convened the first President's Highway Safety Conference. At the time, the annual traffic fatality rate had shot back up almost to its pre-war level. The participants in the conference urged the states to implement an "Action Program" designed to create a uniform, nationwide safety effort. The key aspects of this effort were basically similar to earlier proposals in that they concentrated on crash prevention rather than overall loss-reduction; not one of the recommendations in the program included proposals for improving occupant survivability during crashes. As before, Congress stopped short of mandating state compliance with the program.

The Interstate System

Under President Eisenhower in the mid-1950s, the nation embarked on a major new program of federal highway construction, lobbied for vigorously by highway construction interests and financed directly by federal gasoline taxes. The stated goal of the program was replacement of much of the federal highway system built in the 1930s, a system which, by this time, had become inadequate for 65 million motor vehicles and, moreover, did not permit the intercity speeds that were then desired. The new program, originally called the Interstate and Defense Highway System, is now finally nearing completion after an expenditure of 104 billion in 1976 dollars.[4] The Interstate System led to major improvements in mortality per vehicle mile as noted in part one of this article,[5] but this was partly balanced by increases in miles traveled. Because of increased miles traveled, increases in numbers of vehicles, and the arrival on the scene of a large number of young "post-war baby-boom" drivers, the annual number of deaths per year actually increased markedly as the Interstate System became operative (see Figure 2).

In 1954 Eisenhower called yet another White House conference on highway safety. This conference resulted in the creation of the President's Committee for Traffic Safety, the first permanent federal agency whose principal objective was the promotion of highway safety. One of the committee's first projects was to campaign for the adoption of the 1946 Action Program by every state. Though this campaign led to a marked increase in state highway safety expenditures, the response fell far short of the comprehensive nationwide program envisioned by the committee.

For the first time, in 1959 a report to Congress by the Secretary of Commerce called for comprehensive federal legislation mandating highway and vehicle design standards and for the creation of a federal agency to coordinate all federal traffic safety programs and research activities. This distinct departure from the narrow focus of previous regulatory activity foreshadowed the intensive programs of roughly a decade later.

In 1965, when motor vehicles numbered 90 million and traffic fatalities stood at 49,000 per year, a series of congressional hearings were held at which the auto industry and state highway officials were roundly criticized for failing to do more to combat the highway death toll. There were renewed calls for a more active federal role. Later in the same year Ralph Nader published *Unsafe at Any Speed,* a ringing indictment of the auto industry's "deliberate refusal" to make safer cars available to the public.[6] The congressional hearings and Nader's book

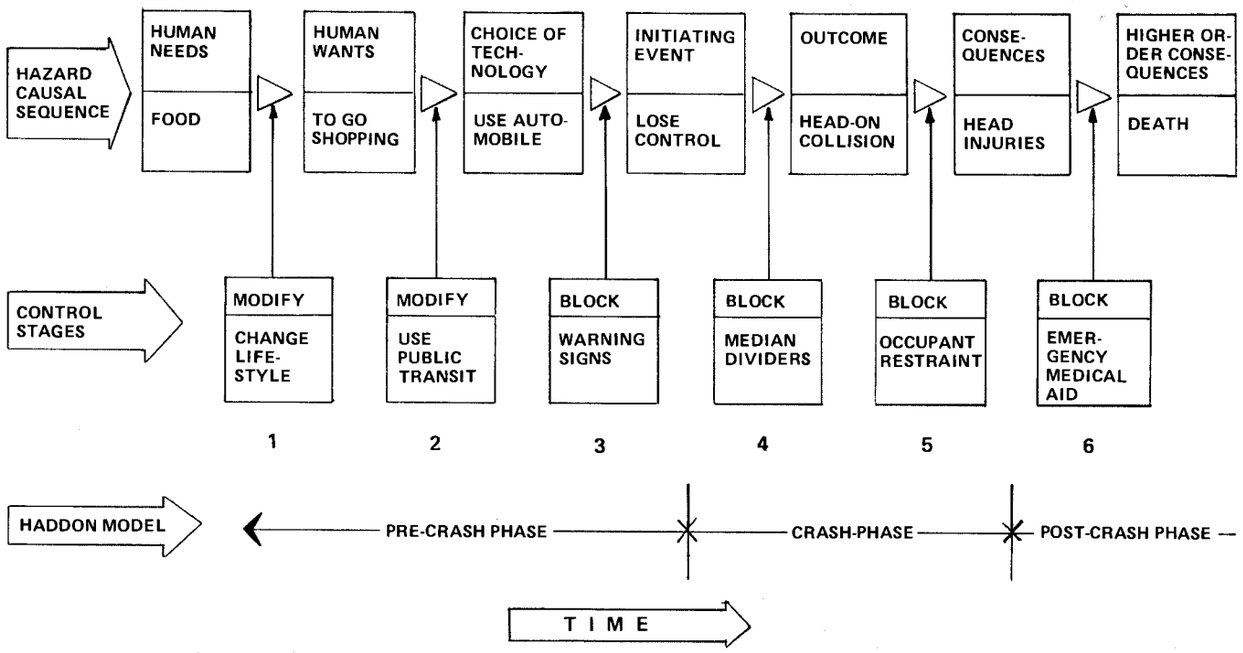

FIGURE 1. An illustration of the causal chain of hazard evolution. The top line indicates seven stages of hazard development, from the earliest (left) to the final stage (right). These stages are expressed generically in the top of each box and in terms of a sample motor vehicle accident in the bottom. The stages are linked by causal pathways denoted by triangles. The middle line indicates six control stages, linked to pathways between hazard stages by verticle arrows. Each is described generically as well as by specific control actions. Thus, control stage 2 should read: "You can modify technology choice by substituting public transit for automobile use and thus block the further evolution of the motor vehicle accident sequence arising out of automobile use." The third line indicates how Haddon and the DOT have structured the causal sequence of hazard. Three stages—"pre-crash, crash, and post-crash"—are envisioned, with various control actions and standards classified in terms of these. The fourth line shows the arrow of time. This applies to the ordering of a specific hazard sequence; it does not necessarily indicate the time scale of managerial action. Thus, from a managerial point of view, certain hazard consequences may occur first and then lead to control actions affecting initiating events.

received broad publicity, as did the conclusion of a special presidential study board that the inadequate performance of state and local highway officials was "a major reason for the current [highway safety] crisis."[7]

This "crisis" developed more than forty years after Henry Ford first began mass-producing motor vehicles, and more than thirty years after the federal government became heavily involved as highway builder. In retrospect, it is clear that the preceding years were a time when safety management, consistently ignoring the issue of automobile and highway crashworthiness and administered in a highly decentralized manner, lagged behind scientific knowledge. While a roughly constant traffic mortality rate per unit of population was maintained as vehicle numbers increased fivefold, this was no longer good enough. Congress, prodded by

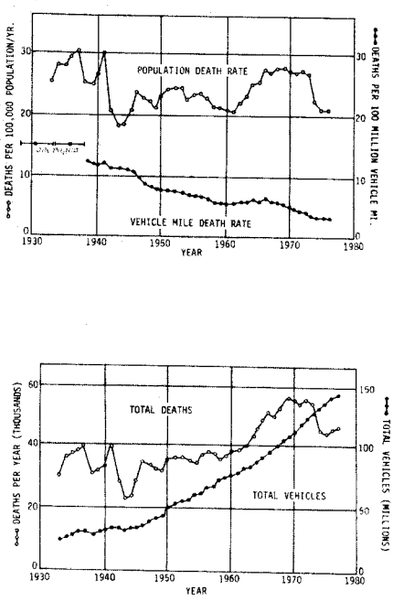

FIGURE 2. Four views of motor vehicle risks in terms of historical trends. *Top graph*: The open symbols indicate the death rate per unit of population and show that this rate, despite fluctuations, has remained at a roughly constant average value of 20-30 per 100,000 people per year for the last 45 years. The closed symbols indicate the death rate per 100 million vehicle miles and show that this rate has declined more than four-fold during the last 45 years. Thus, while the risk to an average individual has changed little over the past 45 years, the risk associated with a mile of travel has gone down considerably. *Bottom graph*: The open symbols indicate the total number of deaths per year and show that this figure has increased by about two-thirds since 1933, due largely to the increase in population. The closed symbols indicate the total number of vehicles on the road during each of the last 45 years and show that this number is now 15 times greater than it was in 1933.

vocal and persuasive critics such as Nader, was finally ready to take action toward creation of a comprehensive federal role in safety management.

The 1966 Safety Acts

The new era began with President Johnson's introduction of landmark legislation in early 1966. This legislation was subsequently divided by Congress into two bills: the Highway Safety Act and the National Traffic and Motor Vehicle Safety Act. Both were passed overwhelmingly by Congress.

The Highway Safety Act provided for an agency which would make federal funds available to the states for planning and evaluating highway safety measures. It directed the Secretary of Commerce (later the Secretary of Transportation) to issue highway safety standards and required states to implement highway safety programs in accordance with these standards. Under the act noncomplying states could lose planning funds and up to ten percent of their federal highway construction subsidies. The act thus directly linked the funding of highway development and safety programs.

The National Traffic and Motor Vehicle Safety Act of 1966 also provided for a federal agency which, together with the agency established under the Highway Safety Act, was to administer a program concerned with the regulation of motor vehicles and equipment. This agency, which later became the National Highway Traffic Safety Administration (NHTSA), was charged with issuing performance standards covering all classes of new motor vehicles. The act also required automakers to notify purchasers about any safety defects. This authority was extended by a 1974 amendment which gave the Department of Transportation the authority to compel manufacturers to recall vehicles determined to be defective. In 1973 Congress passed amendments to the Highway Safety Act which for the first time earmarked federal subsidies for specific categories of highway improvements, such as roadside obstacles, pavement marking, unsafe bridges, and high-hazard locations.

Taken together, these laws set the framework for a significant departure from the predominant emphasis on accident prevention which had persisted for more than forty years. In particular, the second 1966 law envisioned numerous managerial strategies which could be classified as preventing outcomes and consequences in the terms of our hazard model, or as falling within the crash and post-crash phases in Haddon's schema. In addition, the two 1966 laws marked the beginning of an enormous financial commitment to reduce the death and destruction on the nation's highways. From fiscal year 1967 to fiscal year 1977, the federal government spent 6.6 billion dollars to achieve this goal.[8] The cost to state and local governments has been even greater. In fiscal 1977 alone, states and localities spent more than 4 billion dollars to comply with federal highway safety legislation; in the same year, new car buyers spent an additional $260 per car, or a total of about $2.5 billion, for federally mandated safety features.[9] For the first time in history, expenditures on safety became an appreciable fraction of highway and vehicle expenditures.

How effective has the 12-year effort since 1966 been? One measure is the time trend of highway deaths shown in Figure 2. In a recent report (see Table 2), NHTSA claims that a total of 150,900 lives have been saved since 1967 because of the reduction of the mortality rate per 100 million vehicle miles from 5.25 to 3.25.[10] Furthermore, NHTSA strongly suggests that the observed effects are directly related to the Highway Safety Program. For example, the report states:

> There is a way in which the value of traffic safety effort can be roughly measured. If the fatality rate had remained constant since 1967, the direct economic cost would probably now exceed $76 billion each year, and traffic deaths would approximate 77,000 annually. Table 2 demonstrates what might have happened without the positive effects of the motor vehicle and highway safety standards and the institution of the 55 mph speed limit.

While such statements will surely encourage Congress to continue its considerable support of NHTSA, there is some reason to be skeptical that gains since 1967, which as such are undeniable, have in fact *resulted from* the federal highway safety program. Changes in the fatality rate might well have occurred quite independently of the federal program. Thus, a decline during 1967-77 would be likely because of the rapid entry of women into the pool of drivers and the growing proportion of urban driving, while an increase would be predicted based on the changing age

Table 2

LIVES SAVED DUE TO FATALITY RATE REDUCTION[a]

Year	Fatalities (based on 1967 Rate)	Death Rate[b]	Actual Deaths	Lives Saved Due to 55-MPH Speed Limit	Lives Saved Due to Safety Programs	Total Lives Saved
1967	50,724	5.25	50,724		---	---
1968	53,535	5.17	52,725		810	810
1969	55,973	5.02	53,543		2,430	2,430
1970	58,487	4.72	52,627		5,860	5,860
1971	62,142	4.44	52,542		9,600	9,600
1972	66,419	4.32	54,589		11,830	11,830
1973	69,128	4.11	54,052		15,080	15,080
1974	67,376	3.52	45,196	5,070	17,110	22,180
1975	69,865	3.35	44,525	5,100	20,240	25,340
1976	73,979	3.23	45,509	4,500	23,970	28,470
1977	76,940	3.25	47,671	1,600	27,700	29,300
				16,270	134,630	150,900

a. Adapted from Note 10, *Highway Safety.*
b. Death rate is in units of deaths per 100 million vehicle miles.

distribution of drivers and the growing number of young drivers.[11] Given these considerations, it seems possible that gains specifically due to the federal safety program may well be less than has been claimed.

An important reason that the gains since 1967 have not been greater lies in societal failures which have had the effect of preventing the implementation of some strategies which seem to be among the most cost effective. This situation is the outcome of the interplay between decisions made by the Department of Transportation, the motor vehicle industry, and the public. It illustrates the often unbridgeable gap between the science and the politics of highway safety management.

The Highway Safety Act

Two major problems have impeded implementation of the Highway Safety Act of 1966. First, despite the mandate to greatly broaden the scope of risk management,[12] the standards actually set tend to fall primarily within the traditional areas and to break only a modest amount of new ground. Secondly, given the availability of many possible control actions, hazard managers in the Department of Transportation have been excruciatingly slow in defining priorities in terms of cost-effectiveness. Concomitantly, a number of highly cost-effective actions have been delayed and some cost-ineffective actions have been implemented on a grand scale. For both these reasons the 1966 Act has not lived up to its potential.

Standards Set

To date, NHTSA has set eighteen standards, all during the period 1967-1972. Most of these standards are administered by NHTSA; three and part of a fourth are administered by the Federal Highway Administration.[13] We have classified each standard by hazard control stage (recall Figure 1) and plotted the number of standards applicable to each stage in Figure 3. Figure 3 indicates that, the broadened perspective of the law notwithstanding, efforts have been concentrated in stage 3 of our model, that is, blocking of initiating events. Only 19 percent of the standards address control stages 4 through 6, or, equivalently, the crash and post-crash phases in the Haddon model. None of the standards address stages 1 and 2, modification of wants and choice of technology.* In 1978, partly because of the states' reluctance to implement the standards, the Secretary of Transportation proposed scrapping them and substituting six principles which were, if anything, even more traditional in their focus,[14] but this proposal was rejected by Congress.

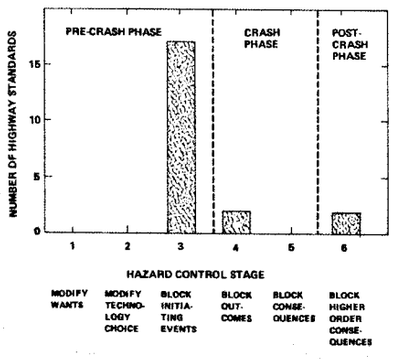

FIGURE 3. Distribution of highway safety managerial effort among the six stages of hazard control defined in our model (Figure 1). Managerial effort in this case is measured by the 18 highway safety standards so far issued by the Department of Transportation. Also shown are the boundaries of the Haddon model (dotted lines). The graph shows that only 19% of the highway safety standards issued so far apply to stages 4-6, none to stages 1 and 2, and 81% to stage 3. (The sum of the bar lengths adds up to 21 instead of 18 because we judged some standards to apply to more than one control stage and in this case counted them under each applicable stage.)

Costs and Benefits

The Highway Safety Act was intended by its authors to be implemented in a cost-effective manner, that is, those measures that would forestall the greatest number of deaths and injuries per safety dollar were to be put into effect first. To estimate the cost-effectiveness of a measure it is necessary to know the comparative costs of different actions designed to achieve an established goal. Ideally, in the case of motor vehicle safety, this goal would include fatalities, injuries, and property damage prevented. In practice, however, as in the Highway Needs Report discussed below, the established goal has been limited to fatalities prevented, since data on injuries and property damage has in the past been too imprecise to permit realistic estimates.

Although the cost of many control actions has been roughly estimated, calculating the benefits of such actions has seemingly proved a more difficult task. To estimate the benefits of a particular control action it is necessary to know something about the causal structure of hazards. One might think that, in the case of motor vehicle hazards, the rather extensive information on risk, combined with underlying physical theory (as summarized in part one of this article), would be sufficient for this purpose. Yet, in 1966, it was widely believed that the number of motor vehicle deaths prevented by specific control actions could not be predicted. Thus, President Johnson in his 1966 Transportation Message said, "Our knowledge of cause is grossly inadequate. Expert opinion is frequently contradictory and confusing."[15]

When standards were set, therefore, they were unaccompanied by benefit estimates. DOT planners, while insisting upon implementation of the standards, left priority ranking largely up to the states. As time passed, many within DOT became convinced that the cost-effectiveness of highway safety standards could never be known with any degree of accuracy. It was thought that most control actions were so interrelated as to make separate evaluation of a given measure impossible. This attitude frustrated state highway officials who felt their states were being forced to implement, at considerable expense, federal standards of unknown effectiveness.

As a result, unhappy states began to rebel openly and took their complaints directly to Congress. In 1973 Congress held full hearings on needed changes in the Highway Safety Act. Included was testimony from state officials who felt

*It should be noted, however, that the Department of Transportation, NHTSA's parent agency, has addressed stages 1 and 2 with major programs furthering the development of subways and other forms of urban mass transit and lesser efforts devoted to such alternatives as bike trails.

that the federal government was not doing all it could to evaluate the potential costs and benefits of alternative safety strategies. Congressional overseers agreed. A House report summarizing the hearings noted that there was little evidence that the money spent on the highway safety program had yet to add much to highway safety. In particular, the report noted:

> One of the greatest weaknesses of the present program is the paucity of specific, up-to-date comprehensive data to support action programs. The trouble is, without adequate data, untold millions in safety monies may be spent unwisely.[16]

To fill this gap in information, Congress in 1973 directed the Department of Transportation to complete a thorough study of the nation's highway safety needs and to prepare estimates of the costs of meeting such needs. In effect, Congress asked DOT to prepare cost-effectiveness studies and priority rankings of control actions.

The Highway Needs Report

In 1976, ten years after passage of the Highway Safety Act, and three years after the congressional mandate to provide a cost-benefit analysis for highway standards, the DOT published *The National Safety Needs Report*,[17] the first comprehensive effort to rank safety measures in cost-benefit terms. The report was based on an extensive literature search and consultation with a blue ribbon panel of 103 highway experts. From an initial list of 200 possible highway safety measures, 37 control actions of "potentially high payoff" were culled and analyzed in terms of cost. As shown in Table 3, the 37 actions cover a wide range. It was estimated that mandatory seatbelt use, the most effective item, would save

Table 3

HIGHWAY SAFETY CONTROL ACTIONS RANKED IN ORDER OF COST-EFFECTIVENESS

Control Action	Number of Fatalities Forestalled	Cost (millions of dollars)	Cost per Fatality Forestalled (1000s of dollars)
Mandatory safety belt usage	89,000	45	0.5
Highway construction and maintenance practices	459	9	20
Upgrade bicycle and pedestrian safety curriculum offerings	649	13	20
Nationwide 55 mph speed limit	31,900	676	21
Driver improvement schools	2,470	53	21
Regulatory and warning signs	3,670	125	34
Guardrail	3,160	108	34
Pedestrian safety information and education	490	18	36
Skid resistance	3,740	158	42
Bridge rails and parapets	1,520	69	46
Wrong-way entry avoidance techniques	779	38	49
Driver improvement schools for young offenders	692	36	52
Motorcycle rider safety helmets	1,150	61	53
Motorcycle lights-on practice	65	5	80
Impact absorbing roadside safety devices	6,780	735	108
Breakaway sign and lighting supports	3,250	379	116
Selective traffic enforcement	7,560	1,010	133
Combined alcohol safety action countermeasures	13,000	2,130	164
Citizen assistance of crash victims	3,750	784	209
Median barriers	529	121	228
Pedestrian and bicycle visibility enhancement	1,440	332	230
Tire and braking system safety critical inspection—selective	4,591	1,150	251
Warning letters to problem drivers	192	50	263
Clear roadside recovery area	533	151	284
Upgrade education and training for beginning drivers	3,050	1,170	385
Intersection sight distance	468	196	420
Combined emergency medical countermeasures	8,000	4,300	538
Upgrade traffic signals and systems	3,400	2,080	610
Roadway lighting	759	710	936
Traffic channelization	645	1,080	1,680
Periodic motor vehicle inspection—current practice	1,840	3,890	2,120
Pavement markings and delineators	237	639	2,700
Selective access control for safety	1,300	3,780	2,910
Bridge widening	1,330	4,600	3,460
Railroad-highway grade crossing protection (automatic gates excluded)	276	974	3,530
Paved or stabilized shoulders	928	5,380	5,800
Roadway alignment and gradient	590	4,530	7,680

NOTE: The above control actions include only those authorized by the Highway Safety Act. They do not include vehicle performance standards, which are authorized under the Motor Vehicle Safety Act.

SOURCE: Note 17. The number of fatalities forestalled is based on a 10-year period. All figures are subject to substantial uncertainties, as described in note 18 and in the text.

ON THE DOLLAR VALUE OF LIFE

In this article we imply that life may be valued in dollars and that, when control actions cost more than $200,000 to $300,000 per fatality forestalled, they ought to be questioned. Some readers may be disturbed by the implications of these statements and will quite naturally ask: "How can you talk about placing a dollar value on life?" To avoid misunderstanding we offer the following explanation.

As is made clear in the text, not all control actions have the same effectiveness. In some cases spending even a million dollars will not save one life on the average. For others, spending $500 is enough to do the job. Thus it is natural to rank control actions according to the dollar cost of a life saved. There is no moral judgment in this.

One might then ask: "What does it matter how much it costs to save a life? Shouldn't we attempt to save all lives possible?" Though the answer to these questions are different in various areas of society (consider how most doctors are obliged to answer them), the answer in the field of risk regulation must be "emphatically no—we cannot save all lives possible." There are not enough dollars or, to put it more concretely, there is not enough societal capacity to forestall all potential fatalities. This means that risk managers, whether they like it or not, must stop somewhere with expenditures on safety.

The difficult question then is at what level of expenditure to stop, not whether to stop. This implies we need some kind of standard. There are two ways of arriving at such a standard. The first approach is comparative—to look around and find out what the cost per life saved is for regulating various risky activities. From this we will learn that the cost varies, and appears to depend on whether the risky activity is voluntary or not. A rough average value for the cost per life saved implied by various standards is in the range of $100,000 to $300,000. A second approach to the problem is to estimate the actual societal costs that arise as a result of fatalities. This is a straightforward if somewhat involved exercise in accounting. It is necessary to add the cost of all the days of labor lost, the cost of medical care, and the cost of insurance. When all these costs are added together and averaged, the answer per life lost is about $200,000 to $300,000. This amount does not give the full value of a life (it cannot measure suffering, for example), but rather gives a rough estimate of the amount one would, on economic grounds, be willing to spend to avoid the loss.

Both approaches thus give roughly the same answer, and both avoid ultimate moral questions about the worth of life. These approaches can serve as useful practical guides to risk managers. Their most important lesson, furthermore, is not that we spend too much in some instances, but that there are hazard areas where the expenditure per life saved would be well below $200,000-$300,000.

89,000 lives over a ten-year period at a cost of $500 per life*; in contrast, roadway alignment, the most ineffective action, was seen as saving only 510 lives in ten years at a cost of $7,680,000 per life (see box).

This report can be used to estimate the effect of implementing control measures in order of their cost-effectiveness—presumably the most efficient way to make decisions about how to spend taxpayers' money. Such an estimate is shown in Figure 4. It indicates that beyond an annual expenditure of $1.5 to $3.0 billion (where the curve becomes essentially flat), very little is gained by further expenditure.

In addition, it is interesting to note

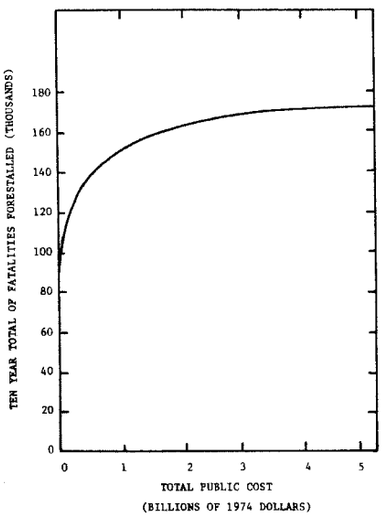

FIGURE 4. The figure illustrates a principal result of the 1976 Highway Safety Needs Report (note 17). It shows the relationship which would exist between public expenditure on highway safety and the number of fatalities forestalled if control actions were implemented in order of cost effectiveness (Table 3). The plot is useful because it indicates beyond what level of expenditure no significant gains would be made in fatalities forestalled. This level appears to be in the neighborhood of $1.5 to $3 billion. Note, however, that this is true only if the assumptions of the plot are satisfied, that is, if the measures are put into effect in increasing order of cost per fatality forestalled, starting with the lowest.

that the 37 control actions considered by the 1976 Highway Needs Report appear to offer a rather well-balanced attack on the problem. As shown in Figure 5, classification of control actions by stage of our hazard model indicates that 40 percent of them address control stages 4 through 6. This should be compared to 19 percent in the case of standards actually issued by DOT (see Figure 3). In this sense, then, the report is more nearly responsive to the initial directives of the enabling legislation than DOT's actions have been.

How has the report been received? Some DOT officials continue to question its value because of the methodology used in arriving at cost-effectiveness estimates. In particular, some officials argue that the report is no better than the intuitive "common sense" approach whereby highway safety experts within

* These figures are, of course, predicated on a high level of compliance with the mandatory laws. Compliance, in turn, is largely dependent on the extent to which the law is enforced. In Puerto Rico, which has had a mandatory belt-use law since 1974, the rate of seatbelt use is 9 percent, 6 percent lower than in the United States. In addition, there is evidence that high-risk individuals, such as teenagers (Ontario) and those persons actually involved in crashes (Denmark) have far lower belt-use rates than the average for the localities.

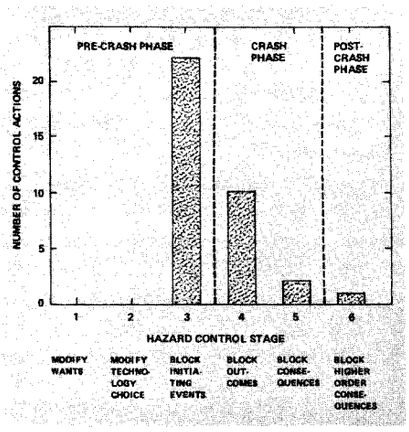

FIGURE 5. Distribution of 37 highway safety control actions analyzed in the 1976 Highway Needs Report among the six stages of hazard control. The figure indicates a more even distribution than the actual standards issued (Figure 3). For example, 40% of the actions fall into stages 4-6, as compared to 19% for the standards issued. (The sum of the bars adds to 40 and not 37 because some actions were judged to apply to more than one control stage and in this case were counted under each applicable stage.)

DOT decide priorities based on their personal experience. Such criticisms are reinforced by the authors of the report itself when they note that "our current information is neither sufficiently accurate nor conclusive to support a truly definitive analysis."[18]

In our view these are valid objections if they are focused on the effectiveness of particular actions. Yet the wide range in effectiveness indicated by the report is a result unlikely to be qualitatively altered by better data.[19] Of particular interest is the fact that a number of control actions appear to have costs substantially below the average of $200,000 to $300,000 per life normally obtained in economic valuations of life.[20]

For the DOT official confronting the present situation, the 1976 Highway Needs Report should prove a valuable consensus document and an important step toward transcending the squabbles between various individual experts. In particular, it illustrates how a cost-effectiveness framework can potentially facilitate the process of resource allocation in highway safety management. But how does such facilitation work in practice?

Seatbelts: A Failure

If the Needs Report makes one thing clear, it is that mandatory seatbelt use is by far the most cost-effective control action when compliance is high. If a seatbelt law and/or an educational campaign were effective enough to promote 80 percent seatbelt use by front-seat passengers, the report states that 89,000 lives could be saved in a ten-year period at the trivial cost of $500 per life. The report notes:

> Since the effectiveness of belt systems is so great, and almost all cars now have these belt systems installed, it could be said that the country's greatest highway safety need, above all others, is for a countermeasure program which will achieve higher belt wearing rates by car occupants.[21]

In this context it is worth noting that the surveys monitoring present seatbelt use indicate that only about 14 percent of front-seat occupants currently wear belts in the United States.

What are the obstacles that have prevented the implementation of much higher belt usage rates? Or, put another way, why has not a single state enacted a mandatory seatbelt-use law similar to those now found in more than twenty nations around the world, despite many attempts in state legislatures to pass such laws? A detailed analysis of this issue would be interesting but is beyond the scope of this review. Instead, we provide a synopsis of major issues in Table 4. This summary suggests that the single major obstacle to seatbelt-use laws in the United States is popular rejection of such laws. On the basis of experiments on risk perception and acceptance by the general public, it is possible to understand why and how the U.S. public arrives at its opposition.[22] However, it is more difficult to generalize about official conceptualizations of the problem when countries as diverse as Australia, France, and Sweden have mandated use of belts. What is clear is that DOT managers have vacillated over time between behavioral approaches

Table 4

THE DEBATE OVER COMPULSORY SEATBELT USE LAWS

Arguments against Compulsory Use	Rebuttal
Even if such laws were enacted nationwide and resulted in 80% use, they would not significantly reduce motor vehicle accident mortality.	There is substantial agreement that 80% use would reduce motor vehicle accident mortality by 20-25%.
Mandatory belt use laws would not significantly increase current levels of use, which are about 14%.	Extent of compliance depends on degree of enforcement. Some nations, including France, have achieved 75-80% use through enforcement of seatbelt laws.
The prospective installation of passive restraints makes seatbelt laws a moot issue.	It will take 10 to 15 years to equip all cars with passive restraints. Thus, belt-use laws passed today could still save thousands of lives.
A broad educational campaign would significantly increase voluntary use, thus obviating the need for compulsory use.	So far educational campaigns, including highly intensive media campaigns in specific communities, have failed to achieve significant improvements.
The expense and difficulty of enforcing seatbelt laws makes them impractical.	Enforcement costs are included in cost-effectiveness estimates given in the 1976 Highway Needs Report and, even so, seatbelt laws come out as a control action that is 40 times cheaper than any other.
Mandatory seatbelt laws cannot be considered politically feasible.	This is the position presently taken by the Department of Transportation, and it is supported by public opinion polls. Thus Gallup found 76% opposed compulsory seatbelt laws. Yet given the success of such laws in some other countries, it is not clear that public acceptance is unobtainable.

(such as education and coercion), and technological approaches (such as passive restraints).

Other countermeasures that are high on the Needs Report cost-effectiveness list but remain unimplemented or underimplemented can be analyzed in a manner similar to the seatbelt case. Thus, enforcement of the 55 mph speed limit (fourth in cost-effectiveness) and state laws requiring the use of motor cycle helmets (thirteenth in cost-effectiveness) are both currently in this category. In both cases the major obstacles appear to be socio-political. For 55 mph enforcement the major block to implementation appears to be the resistance of state highway officials to federal intrusion, coupled with the open defiance of many long-distance truckers. In the case of motorcycle helmet enforcement, opposition comes from highly effective special interest groups composed mainly of motorcycle enthusiasts.

FIRST AMERICAN AUTOMOBILE—1893

PMVI: Too Successful

The Needs Report is also valuable for singling out actions of low cost-effectiveness that nevertheless consume relatively large shares of the highway safety dollar. One example is the requirement that states conduct periodic motor vehicle inspections (PMVI), which according to the Needs Report ranks thirty-first of 37 possible safety measures, at $2.1 million per life saved.

Prior to 1976 the concept of PMVI had been one of the most persistently advocated vehicle safety measures. In the 1966 House Report accompanying the Highway Safety Act, PMVI was named as one of the seven highway safety areas requiring a national standard.[23] Thus, PMVI was one of the first federal safety standards and, since 1970, approximately $120 million per year has been spent on its implementation by the states. If the standard were fully enforced by every state in 1980, the total cost would probably be close to $300 million per year.[24]

Many states, citing inconclusive evidence of the benefits to be derived, have resisted implementation of the PMVI standard. The decade from 1966-76 was marked by repeated efforts by DOT to encourage state compliance—efforts that included listing PMVI as one of DOT's "must-items in 1972" and one of its five "bottom line emphasis elements" in 1974. In 1975 DOT announced its intention of beginning sanction hearings against thirteen states that had failed to implement all the requirements of the PMVI standard. These hearings were later canceled by Congress in reaction to DOT's threat to use its sanction power.

Assuming the Needs Report's cost-effectiveness estimate to be reasonably reliable, the past emphasis on this measure represents a significant misallocation of federal and state safety resources. To its credit, DOT has, since publication of the Needs Report, deemphasized PMVI. It has, for example, recently recommended making implementation of the PMVI standard optional,[25] suggesting the standard serve only as a guideline to those states wishing to maintain inspection programs voluntarily. DOT has also resisted the recommendation of the General Accounting Office that it undertake further priority research into the effectiveness of PMVI.

Efforts to retain PMVI as a mandatory requirement persist nevertheless. Recently the Government Accounting Office recommended to Congress that it pass legislation directing DOT to undertake PMVI research and preventing DOT from making the standard optional. In response, Congress recently moved, over DOT objections, to retain the mandatory PMVI standard.

What motivates this persistent effort in the face of the evidence? One major reason for the continued misplaced emphasis on PMVI is the misconception that PMVI can forestall a large number of accidents. This view in turn grows out of the traditional fixation on accident prevention rather than overall loss reduction. In addition, it is important to note that, after many years of PMVI, there now exists a large, self-perpetuating bureaucracy—from filling stations to state administrators—who have a vested interest in continuation of the status quo.

Judging from Table 3, PMVI is by no means the only case of gross misallocation

(continued on page 29)

The 1969 National Environmental Policy Act (NEPA), the cornerstone of environmental legislation, has come under increasing attack as impact statements continue to be used to delay or even block environmentally damaging federal projects. Environmentalists expect continued efforts will be needed to defend the act.

In the meantime, arguments over the international applications of NEPA could stimulate a wide range of legislation. At issue is the exemption of the Export-Import Bank from having to prepare full environmental impact statements on such U.S. exports as nuclear reactors, factories that produce hazardous substances, and federal programs that affect such global commons as the oceans. Exempting legislation, advanced last year by Senator Adlai Stevenson (D-Illinois), is expected to be reintroduced this year. Environmentalists hope to see Congress defer to the wishes of the Council on Environmental Quality on this issue.

* * *

Other legislation to watch for: federal funding for public interest groups to intervene in agency proceedings; lobbying disclosure requirements that may inhibit the efforts of environmental groups; attacks on the Clean Air Act when it comes up for renewal; possible increase in timber cutting on the national forests; federal regulations relating to DNA research; aircraft noise control; and increased funding for safe drinking water programs.

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USEFUL FOR FOLLOWING ENVIRONMENTAL LEGISLATION

Conservation Report, published weekly by the National Wildlife Federation, 1412 16th St., N.W., Washington, D.C. 20036.

Environmental Action, monthly publication of Environmental Action, Inc., 1346 Connecticut Ave., N.W., Washington, D.C. 20036.

National News Report, Sierra Club legislative newsletter, 530 Bush Street, San Francisco, California 94108

Not Man Apart, semi-monthly publication of Friends of the Earth, 124 Spear St., San Francisco, California 94105.

Highway Risks

(continued from page 15)

of safety funds. Enormous sums have been spent annually in recent years on measures that the Needs Report rates as thirty-sixth and thirty-seventh in cost-effectiveness. These are paved or stabilized shoulders, at $5.8 million per life saved, and roadway alignment, at $7.7 million per life saved. Why, considering these low levels of cost-effectiveness, are states continuing to spend limited safety funds on these countermeasures? One answer is that the funds in question are not really that limited, nor are they specifically designated for safety purposes.

According to some DOT officials, continued spending results from the availability of large amounts of highway construction money in both federal and state highway trust funds and from the powerful influence exerted at the state level by a consortium of highway construction interests, including labor unions, highway contractors, and materials and equipment suppliers. A particularly clear example of this phenomenon was the recent attempt by Governor Dukakis of Massachusetts to return to Washington funds earmarked for superhighway shoulder-widening. Dukakis argued that such measures are a waste of the taxpayer's money. He was met by a storm of protest from the construction industry and its supporters and was finally forced to do the politically expedient thing, that is, rescind his earlier order to return the funds.

Dealing rationally with low-priority highway safety items thus presents every bit as difficult a problem as dealing with high-priority items. The 1976 Highway Safety Needs Report in both cases serves as a valuable framework for formulating hazard decisions. In some cases involving blatant political interference with hazard management policy, it can also serve as an uncomfortable reminder that all that is good for a particular interest or group may not be sound safety policy. Yet, as a purely logical and analytical framework, the Highway Needs Report does literally nothing to resolve these problems. The solution ultimately involves balancing the varied and complex forces set in motion by public perception and acceptance, official dogma, and the private benefits derived from the public hazard management dollar.

The Motor Vehicle Safety Act

The administration of the 1966 Highway Safety Act, as outlined in the previous section, has generated considerable controversy. Yet, in comparison, the other 1966 law, the National Traffic and Motor Vehicle Safety Act, has been even more controversial. The act for the first time gives the federal government authority to issue vehicle performance standards that must be met by all new cars sold in the United States. These standards are to be designed not only to prevent vehicles from crashing but to protect vehicle occupants and other crash victims once a crash occurs. Hence,

like the Highway Safety Act, the Vehicle Safety Act represents an historic shift from a narrow emphasis on crash prevention toward the broader perspective of crash prevention plus crash survivability.

Standards Set

So far DOT has issued 50 vehicle standards which, as a group, show a remarkable concentration in the areas of the hazard causal sequence previously ignored in motor vehicle accident management. Thus, as seen in Figure 6, 80 percent of the standards affect control stages 4 through 6 in our model, and 24 of the

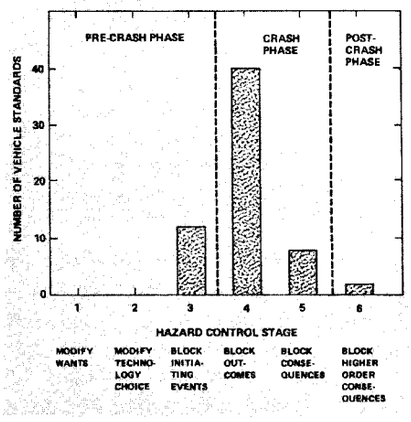


FIGURE 6. Distribution of vehicle safety managerial effort among the six stages of hazard control defined in our model (Figure 1). Managerial effort in this case is measured by the 50 vehicle standards issued so far by the Department of Transportation. The distribution of effort is seen to be heavily weighted toward stages 4-6, with 80 percent of the standards issued falling in this region.

50 standards are located within the crash or post-crash phases of the Haddon model. Typical of the new vehicle standards are regulations about energy-absorbing steering assemblies, padded dashboards, occupant restraint systems, and fuel system safeguards—all designed to block consequences or prevent their exacerbation into higher order consequences.

Like the highway standards discussed earlier, vehicle standards can have widely varying costs and benefits. Unlike most highway standards, the cost of vehicle standards is largely borne by the private rather than the public sector of the economy. As such, the cost of vehicle standards is less "hidden" than that of highway safety standards. Some individual car owners who think of themselves as safe drivers feel the equipment may not be necessary. The automobile industry fears the costs will affect the demand for new cars.

In addition, serious doubts can easily be raised about the cost-effectiveness of a particular standard. These doubts are particularly compelling for those who are opposed on principle to any mandated private expenditure on public safety. In addition, DOT decision makers are not required by their enabling legislation to make economic factors the controlling consideration in their decisions. They are required to "consider" economic impacts and other "costs" of vehicle standards, but they may issue new standards, whatever their cost, as long as they are "practicable," an undefined term in the act that gives broad discretion to the agency. To date, cost-benefit estimates are available for some vehicle standards, but the broad-scope approach that was mandated by Congress in the highway safety area has not been applied. Therefore, at this stage it is not wholly clear to DOT or its critics in what order vehicle standards are to be implemented or at what level implementation should stop because of diminishing returns, as illustrated for highway standards in Figure 4.

Passive Restraints

The complexity of DOT's vehicle standards program is perhaps best illustrated by the most important, and probably the most cost-effective, example of the fifty vehicle standards issued to date—that dealing with passive restraints. Passive restraints, with minor differences, have the same purpose and function as manually operated seatbelts: they assure that the stopping distance of front-seat passengers in frontal crashes is at least as long as that of the crashing vehicle.[26] The difference is that passive restraints do not require voluntary action by vehicle occupants. Instead, the restraint works without any intervention on the part of the occupant. Two popular forms of passive restraints are airbags, which inflate during frontal crashes on signal from an impact sensor, and passive belts, which move into place around the occupants of the front seat when they enter the vehicle.

Because of their functional similarity to seatbelts, passive restraints, if fully deployed, would save about the same number of lives—12,000-13,000 per year.[27] Their initial cost is estimated to be $27 and $120 (in 1976 dollars) for passive belts and airbags, respectively. Assuming a ten-year lifetime for new vehicles equipped with them, this means their respective cost-effectiveness is about $30,000 and $130,000 per life saved.[28] This makes them comparable to some of the most effective control actions listed in the 1976 Highway Safety Needs Report (see Table 3). Despite a higher initial cost than seatbelts, passive restraints have a high level of public acceptance. For example, a June 1977 Gallup poll showed the public favoring the installation of airbags in all new cars by 46 to 37 percent.[29]

What then is the reason that passive restraints, though fully developed technologically for at least ten years, have been installed in so few vehicles? The answer is a case study in frustrated hazard management which has probably cost about as many American lives as Viet Nam. The opponents of passive restraints in this drama run from the principal auto makers, to Richard Nixon, to a variety of conservative groups advocating a "government keep hands off" policy. The proponents are the Department of Transportation, Ralph Nader and allied public interest groups, and a number of private groups such as the Insurance Institute for Highway Safety.

The story begins in 1942 when Hugh DeHaven, working at Cornell Medical College, began publishing papers showing, first, that the human body is extremely resistant to transient decelerative forces if it is properly packaged and, second, that such proper "crashpackaging," if provided motor vehicle and aircraft occupants, would greatly reduce injuries and deaths. This insight was brought to the new highway safety program in 1966 by its first director, Dr. William Haddon. The restraint of vehicle passengers during crashes soon became one key part of DOT's packaging strategy. Vehicle Standard 208, adopted in 1966, required the installation of lap and shoulder belts in all passenger cars.

But, as already noted, since so few voluntarily used them, mere installation did not solve the problem.

Through the forceful advocacy of Dr. Haddon, it soon became clear to DOT officials that passive restraints were preferable to active ones for the simple reason that they do not depend on the cooperation of distracted or unwilling drivers. Accordingly, as early as 1969 DOT issued an advance notice of a proposed amendment to Vehicle Standard 208 that would require impact-inflating airbags in all new passenger cars by 1972. The notice specifically called for installation of "inflatable occupant restraint systems," but was soon changed to "passive restraints" in order to permit automakers to chose between airbags and passive belts, or any other system that would perform equally well.

From the beginning, though the technology was available "off the shelf," particularly at General Motors,[30] mandatory passive restraints were vigorously opposed by automakers for a variety of reasons, including cost, lack of reliability, and infringement on the right of the public to choose. Automakers took their case to the White House, to Congress, and, via a concerted media campaign, to the American people. Succumbing to this unprecedented lobbying effort, DOT in 1970-71 delayed the effective date of the rule three times. In addition, in 1971 NHTSA decided to give automakers a choice between passive restraints and ignition-belt interlock systems (which prevent cars from starting unless seatbelts are fastened). This, in effect, mandated the installation of interlocks in all 1974 cars, because interlocks were far cheaper than airbags.

Both the ignition interlock option and the last passive restraint delay may well have originated with the Nixon White House. The President's interest in the interlock system began soon after Henry Ford II made a personal visit to the White House to complain about the cost of government regulation and to extol the virtues of the interlock system as an alternative. Soon after Ford's visit, a White House meeting between then Secretary of Transportation John Volpe and presidential aides Peter Flanigan and John Ehrlichman was held, after which Volpe informed DOT officials that the President wanted DOT to defer the passive restraint standard. Soon thereafter DOT proposed the interlock option as an allowable substitute for the airbag.

In 1972 Ralph Nader and the Center for Auto Safety filed suit in Federal District Court to block the interlock option on the basis that it resulted from rule-making based on secret, *ex parte* communications, not included in the proper DOT rulemaking docket, between the White House and the Secretary of Transportation. The suit was unsuccessful, and all 1974 cars rolled off the assembly lines equipped with the interlocks.

Airbags or other passive restraints, if installed in all vehicles, could save 12,000 to 13,000 lives annually. Despite this, the implementation of a passive restraint standard has proved to be a case study in frustrated hazard management.

As might be expected from public rejection of "buckle-up" campaigns, the interlock system proved unpopular. This prompted skeptics, Nader included, to suggest that the interlock system was part of a devious scheme hatched in Detroit and supported by the White House to mobilize the public against *any* type of mandatory occupant restraint. If so, the scheme was a short-term success. Soon after the 1974 models began filling the dealers' showrooms, Congress responded to the resulting public outcry by not only repealing the interlock amendment but by reserving to Congress the power to veto within sixty days any DOT rule dealing with passive restraints.

The effective date of the passive restraint standard was indefinitely suspended. Further, DOT interpreted the public opposition to interlocks as a reaction against any mandatory seatbelt-use laws. It therefore scuttled remaining efforts in this direction, including a plan to award federal incentive grants to states which enacted such laws.

But the issue was not dead. Safety advocates continued to push for a passive restraint rule. In early 1976 Secretary Coleman decided to assume direct control over the controversial issue. He commissioned a special study and held a series of hearings to solicit the opinions of experts on both sides of the issue. In December 1976 he published his findings.[31] While concluding that passive restraints are cost effective and should perform about as indicated above, he decided not to require their installation in new cars but opted instead for a demonstration program to begin in 1978.

In 1977 Brock Adams took over from Coleman as Secretary of Transportation and immediately called for new hearings on the issue. Following these, he announced in June 1977 his decision to overrule his predecessor and to mandate automatic protection for front-seat occupants for all new cars beginning in 1981. Congressional resolutions to veto the new ruling failed, and Adams' order became "final" on September 1, 1977.

Yet the issue is far from settled. Both sides in the fight immediately responded with lawsuits. The Pacific Legal Foundation, a conservative group opposed to mandatory safety regulation, sued to overturn the order as an abuse of the DOT rulemaking discretion, but their suit was denied by a unanimous appellate court decision. On the other side, Ralph Nader and his group, Public Citizen, challenged the order for permitting unreasonable and unnecessary extension of the effective date. Meanwhile, congressional opponents of restraints, led by Representative Bud Shuster (R-Pa.), successfully attached an amendment to the 1979 DOT appropriations bill prohibiting the use of any funds for implementing or enforcing any regulation requiring the use of passive restraints systems other than belts.[32]

In summary, a more complete frustration of hazard management is difficult to imagine. Yet, the case of passive restraints, while the most widely disputed, is not exceptional. The pattern repeats itself in many other cases.

The Air Brake Standard

DOT Vehicle Standard 121, the Air Brake Standard, is premised on the simple physical principle that the more uniform the braking distances of all highway vehicles, the lower their collision rate will be, as well as on the need to prevent skidding. The basic requirement of the standard is that a vehicle equipped with air brakes be capable of stopping in a limited distance without leaving its traffic lane or locking its wheels. As such, the standard is aimed primarily at large trucks and buses. (In 1976, multi-unit trucks and commercial buses, which constitute less than one percent of all vehicles, were responsible for 6.5 percent of all fatal accidents.[33] To meet the antilock provision of the standard, manufacturers have developed electronic control systems for braking that cost about $1,200 per vehicle.[34] At that cost, a rough estimate of the standard's cost-effectiveness is $500,000 per life saved.[35] This places it well above the cost of passive restraints yet still below many of the control actions envisioned in the 1976 Highway Safety Needs Report (see Table 3).

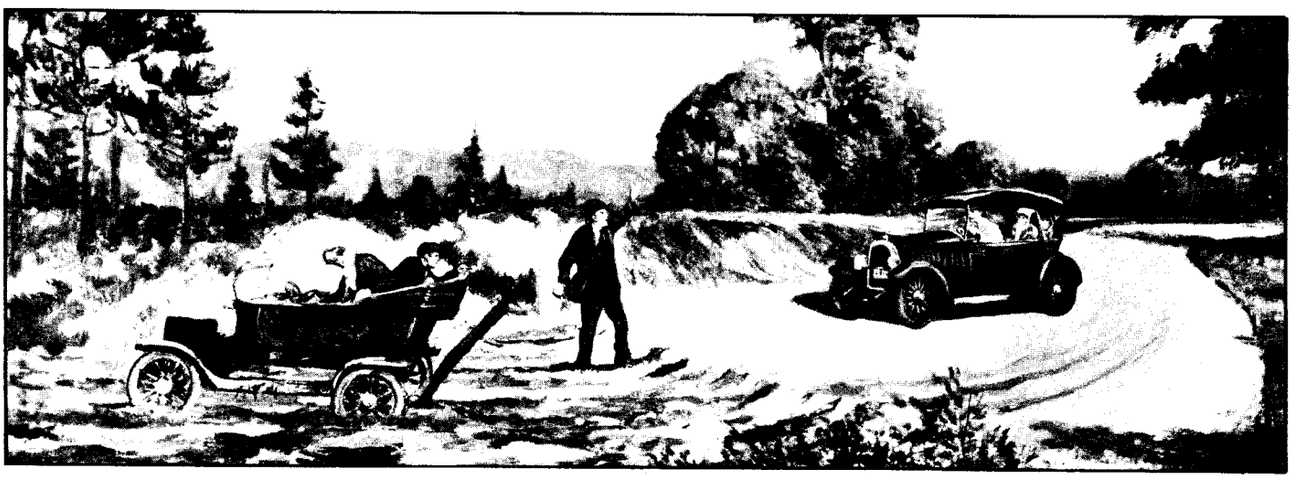
As might be expected from the high initial cost of the required equipment, opposition to the proposed standard has been intense. The standard was first issued in 1971, to become effective in September 1974. As the 1974 effective date drew near, industry's lobbying efforts to weaken the standard intensified. Despite pressure from industry, DOT went ahead with the standard, though it postponed the effective date until January 1975.

The controversy continued after the provision became effective. Trucking firms complained that the delicate braking mechanism frequently malfunctioned and, additionally, that it was extremely difficult to maintain. To respond to these concerns, and to stave off the political opposition underlying them, DOT relaxed the standard somewhat by lowering brake performance levels. The strategy seemed to work. Following congressional hearings, the House rejected industry's pleas for further relaxation of the antilock requirement.[36]

But the debate went on. As of January 1, 1978, the standard was to become applicable to buses as well as trucks. In response, bus manufacturers and operators joined the trucking industry in an intensive lobbying effort on Capitol Hill. On the other side, equipment manufacturers, drivers (including the Teamsters Union), and public interest activists lined up in support of the standard.

Reports that the antilock systems occasionally malfunctioned pitted manufacturers of the devices against the trucking lines. Within DOT, the debate generated an intra-agency squabble.[37] As in the case of passive restraints, the issue finally became so hot that the Secretary decided to assume control of it. Thus, early in 1978, Brock Adams issued orders which retained the standard for truck tractors but rescinded it for truck trailers, and refused any further delay for the application of the standard to buses, with the exception of school buses. Adam's position on the standard represented a major compromise. It pleased the trucking industry by modifying the standard to exempt trailers and it pleased safety advocates by including buses for the first time. In fact, early in 1978 it appeared that the steam had been taken out of the controversy.

But then came an unexpected court decision that surprised participants on both sides. A U.S. Appeals Court invalidated the standard.[38] The court apparently accepted the claim of the plaintiff representing the trucking industry. With the support of reams of technical documents, it was argued that vehicles equipped with antilock devices could actually be more dangerous than those without. The Supreme Court recently



MUD AT THE STATE LINE – 1916

THE DRAGON LADY

Joan Claybrook was appointed administrator of the National Highway Traffic Safety Administration (NHTSA) by President Carter in 1976. It is her difficult task to make automobiles safer during a period of more austere federal budgets and of mounting opposition to federal regulation. The automobile and tire industries, whose products Claybrook regulates, have dubbed her the "Dragon Lady" and "Big Sister." Although Claybrook came to NHTSA after being consumer advocate Ralph Nader's chief lobbyist on Capitol Hill, within a year of her appointment her former boss criticized her for not doing enough, fast enough.

Claybrook's actions as President Carter's chief auto safety advocate have included:

- *Passive restraints:* Cars of the 1980s will be required to be equipped with airbags or passive seatbelts. The performance standard issued in 1977, to be effective on a phased-in schedule starting in model year 1982, has been reaffirmed both in the Congress and the courts.
- *Fuel economy:* Claybrook has held firm on the 27.5 miles per gallon fuel standard for 1985 automobiles and a stringent program to increase the fuel economy of cars and light trucks from 1981-1984. It is estimated that the standard will result in savings of about 20 billion gallons of gasoline a year by 1985, and of $500 to the consumer over the life of an average 1985 car.
- *Auto safety defects:* In 1977 the automobile industry recalled more cars than they manufactured, largely at NHTSA's direction, and the Firestone Tire and Rubber Company is still reeling in the wake of the biggest tire recall in history of its defective Firestone 500 steel belted radial.

One indication of Joan Claybrook's effect on Detroit is the recent acknowledgement by Phillip Caldwell, new president of the Ford Motor Company, that auto safety and fuel economy can work to everyone's advantage, and that the auto industry ought to turn the challenge of government regulations into opportunities for new and better products. "There's been a lot of moaning and groaning about the burdens of government regulation on the industry, and a lot of people say Washington is killing the business and taking the fun out of it. I don't think so. On the contrary, I think the revolutionary changes in automotive design that the regulations have initiated are creating a great new market for our products."

refused to hear the case on appeal, thereby letting stand the appellate court decision.

A History of Failure

The stories of the passive restraint and air brake standards are thus tales of failure in hazard management. These failures testify to the ability of big industry to delay safety-oriented rule making, and to significant public opposition. Neither the passive restraint standard, first proposed in 1969, nor the air brake standard, proposed in 1971, are in effect today; nor are they likely to be by the end of this decade. By using the courts, the Congress, and the White House, the auto and trucking industries and their allies among the general public have successfully resisted what most hazard managers regard as cost-effective standards, capable of substantially reducing fatalities, injuries, and property loss.

The opposition of industry in these cases is perhaps easier to understand than that of the public. For profit-oriented industry, any "private cost" mandated by government is viewed with suspicion and, in the absence of a corresponding "private sense of responsibility," will be opposed on narrow economic grounds. Only strong public disapproval of such industry policy can prevent this response.

But why does the public exhibit such a widespread lack of concern with the country's enormous highway loss problem? Why do most ordinary citizens fail to buckle up, and why do 37 percent oppose passive restraints in new cars? The answer cannot lie in the process of government rule making and intervention as such, since the public readily accepts government regulation of air and water quality and a host of other areas. Rather, the answer must involve deeper questions of risk perception and acceptance as they relate to the automobile. While these considerations are beyond the scope of this review, they surely warrant further investigation.

Problems and Prospects

Why are 48,000 deaths and nearly 5,000,000 injuries caused by motor vehicles tolerated each year in the United States? Why are we not doing better? Our analysis suggests four major conclusions which partly answer these questions.

- Basic knowledge of motor vehicle hazards, compared with our knowledge of other technological hazards, is extensive and advanced. This basic knowledge, reviewed briefly in the first of these two articles, suggests that considerable improvement is possible. For example, by following our general prescription for hazard reduction (see box on page 35), risks could be reduced by as much as five times.
- Historically, there have been major improvements in the death rate per vehicle mile. Thus, during the years from 1926 to 1961, there was a steady decline in the number of deaths per vehicle mile. Yet, because of an even more rapid increase in the number of vehicles and miles driven, the total number of deaths per year increased slightly

over the same period. Beginning in the early 1960s, for the first time in decades, the death rate per vehicle mile began to increase (see Figure 2), probably as a result of the increasing number of young "baby-boom" drivers and record production of high-powered cars and of convertibles. The death rate per 100,000 population also rose substantially during the sixties. The political crisis which developed and which led to major federal intervention in 1966 was thus as much a crisis of increased driving and of demographics as a crisis of inadequate safety management.

- The crisis of 1966, together with accompanying major changes in bureaucratic organization, resulted in a significant shift in the scope of contemplated control actions. Compared to pre-1966 safety management, much more emphasis was placed on the later stages of hazard management. At these stages, which we designate as blocking of outcomes, consequences, and higher order consequences, and which Haddon terms crash and post-crash phases, the need is for preventive action after the crash itself has begun. Theoretically, this shift to a largely neglected mode of control should have brought remarkable safety improvements. Yet actual improvements in safety since 1966 have been far less than those theoretically achievable. This may be attributable in part to the demographic changes previously mentioned. When one relates traffic deaths to the number of vehicles being driven (so as to control for these demographic changes), it appears that some real safety improvements have been made during the past decade (see Figure 7).

- The failures since 1966 have been political failures. Thus, large sums have been spent on measures such as motor vehicle inspection and highway widening that serve the needs of bureaucracies and service industries but are believed by DOT to offer little in the way of reduction of the death and injury toll. On the other hand, measures such as passive restraints and truck brake standards, that are known to be highly effective, have been buried in a deluge of delaying tactics, political manipulation, and endless litigation in the courts. A complex mix of forces has orchestrated this defeat. Failure can be attributed not only to the weakness of the federal bureaucracy in the face of industry pressure, the direct interference of the President, and an indifferent public; it is also rooted in the persistence of the preconceptions that dominated hazard management philosophy in the pre-1966 era.

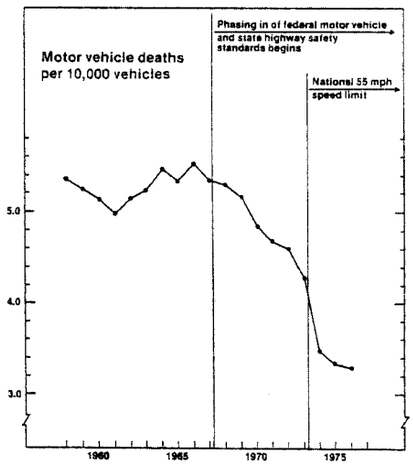


FIGURE 7. Beginning in the early 1960s, as the post-war baby boom came of driving age, motor vehicle fatalities increased markedly. When the death rate is given per 10,000 vehicles (so as to control for the growing driving-age population), it can be seen that the rate began to decline in the late 1960s following the implementation of the new highway and motor vehicle safety laws. *Source:* William Haddon, Jr. M.D., "Options for Prevention of Motor Vehicle Injury," Conference on Options for Prevention of Motor Vehicle Injury, Ben Gurion University of the Negev, Beer-Sheva, Israel, January 10, 1979.

Thus, while the science of motor vehicle risk reduction is highly advanced, the politics of safety management must bear much of the responsibility for the fact that we are not doing better. In addition, the change of direction in 1966 was conceptually so fundamental, indeed revolutionary, that its full implications are just beginning to make an impact on the immense inertia of the political process. The 1966 changes, at least in an optimistic view of the problem, may simply need more time to be absorbed. For this reason our suggestions for the future are based on making use of the framework provided

A Prescription for Individual Risk Reduction

- Before driving, avoid the use of alcohol and other drugs that reduce alertness. Half of drivers involved in fatal accidents have positive alcohol blood tests.
- Use seatbelts at all times. If everyone used seatbelts, the annual death toll would be reduced by 20 percent.
- Avoid driving at night, particularly on Friday and Saturday nights. The accident rate at night is twice the average rate, and 3.5 times the daytime rate.
- Avoid use of motorcycles and bicycles on major highways and roads. The fatality rate for motorcycle riders is four times that of automobile users.
- If you have a choice of driver sex and age, and all other things are equal (e.g., the degree of alertness, adequacy of vision, etc.), let women drive rather than men. On the average, women drivers have a fatal accident rate less than half that of men. And if the choice is between young or middle-aged men, let the latter drive, for the same reason.
- If you have a choice of roadway, opt for turnpikes and interstates. They have less than half the average fatality rate, and less than one-third the rate for rural roads.
- If you have a choice of auto size, and are not concerned about energy saving, choose larger over smaller cars. In multi-vehicle accidents, occupant fatality rates in mid-sized to full-sized cars are less than half those of subcompacts.

Implications of the Physics of Crashing

Vehicle design criteria:

- Increase energy absorbing capacity of vehicle exteriors
- Increase the strength of passenger compartment structures
- Decrease vehicle mass without decreasing energy absorbing capacity
- Provide for greater vehicle mass uniformity
- Provide for adequate and assured passenger restraint.

Highway design criteria:

- Remove roadside obstacles where possible
- Provide "soft" roadside obstacles where removal is not possible
- Install traffic patterns that prevent contact between multidirectional flows where possible
- Regulate traffic speed and provide speed uniformity
- Provide for highway designs that reduce exposure of pedestrians, cyclists, and other similar populations.

Neither the principles of risk reduction nor the guidelines derived from physical theory are all-inclusive or very precisely stated; they are presented here as illustrative examples only.

by the spirit, if not the letter, of existing legislation.

√ *Broadening control actions.* Though the spectrum of possible control actions has been hugely broadened since 1966, it is highly desirable to continue this process in the future. The insights that could be derived from risk studies and further application of physical analysis have so far been only partly converted to practical proposals for action. For example, the effects of large size differences in vehicles, the importance of crushability of vehicles, and the effect of increasingly large speed differentials among vehicles, though all factors recognized by researchers, find insufficient expression in hazard management practice. In addition, attention to the early control stages, such as modifying wants and choice of technology, is strikingly lacking in current management practice. A search could be made to find acceptable actions in this area which might have the effect of reducing the demand for motor vehicle travel.

√ *Cost-effectiveness.* Though beginnings have been made in establishing cost-effectiveness priorities, this has by no means become a routine approach. Without some consensus in this area, resource allocation will continue to be plagued by disabling controversy, leading ultimately to frustration of the management process. Cost-effectiveness is a useful tool for rational resource allocation even though it must often be based on rough projections from inadequate data.

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PNEUMATIC TIRE IMPACT TESTS – 1921

√ *Public financing.* A principal problem in implementing certain control measures could be overcome if some private costs were transferred to the public sector. This might require, for example, that tax-supported trust funds be used to subsidize, either directly or indirectly, some of the highly effective vehicle-related actions we have discussed. This action could help overcome resistance to those mandated controls which now require private expenditure and could achieve a more even distribution of costs.

√ *Research.* It is clear that motor vehicle safety management is particularly resistant to government regulatory action, even at a time when other areas such as clean air and water quality are not. Important for understanding this fact are not only the details of the regulatory process but also the method by which the public arrives at its own risk assessment. For the public's assessment of risk is eventually fed back through Congress into the regulatory process, in some cases resulting in the blocking of what would be highly effective measures. The basic problem is that, at present, individual members of the public are willing to accept a loss pattern in death and injury *for themselves* which, when taken in the aggregate, carries an extremely high price in medical costs, lost productivity, and property damage. Given that our society is already heavily burdened by the medical and welfare costs entailed by an increasingly older and unemployed population, the cost of highway losses at present levels may be more than society can or should bear, quite independently of the degree of personal suffering involved. Dealing with this issue will require not only a better understanding of how the public perceives risks, but, once achieved, this understanding must be followed by a concerted effort to educate the public, at least to the degree that some mandatory actions in support of the general welfare are accepted.

Despite these suggestions, which are based on an optimistic extension of the present legislative context, our final prognosis is not a hopeful one. If the economy continues to expand despite rising oil costs and chronic inflation, driving will also continue to expand, and the two-car household will become standard. Thus, much improvement in hazard management will, as in the past,

be vitiated by the risks created by increased driving and may, because of the introduction of smaller, less crashworthy cars, even exceed present loss projections. There are other scenarios, of course, that could lead to a less dour future: a more socially responsive motor vehicle industry might develop a car that would achieve major safety goals at an acceptable cost; or a major catastrophe, possibly involving trucks, could lead to renewed efforts to improve truck safety; or a major shift in our perception of driving risks could cause us to regard them as involuntary rather than voluntary. But these are not probable outcomes. The motor vehicle, more than any other modern technology, is so rooted in our economy, our lifestyle, and our psyches that even the anguish of five million yearly victims has had little effect on long-established trends.

ACKNOWLEDGMENTS

This article owes much to those individuals in the Department of Transportation and elsewhere who took the trouble to discuss major managerial questions with us. While it is impossible to acknowledge most of this assistance explicitly, the picture we have gained can be documented in another way, through references to publicly available reports and documents which we have quoted in our text. The article also benefited from the comments of Clark colleagues, particularly Roger Kasperson. For collecting much important background material, we thank Jeanne Kasperson. The study was prepared as a case study under NSF grant ENV 77-15334. Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not reflect the views of the National Science Foundation.

Pictures for this article were provided by the Department of Transportation.

NOTES

1. Facts and Figures, 1976, Motor Vehicle Manufacturers Association, Detroit, 1976.

2. National Conference on Highway Financing, U.S. Chamber of Commerce, 1936.

3. Motor Vehicle Traffic Conditions in the United States, U.S. Bureau of Public Roads, Washington, D.C., 1938.

4. Figures provided to the authors by the Federal Highway Administration.

5. C. Hohenemser and T. Bick, "Target: Highway Risks: I. Taking Individual Aim," Environment, January/February 1979.

6. Ralph Nader, Unsafe at Any Speed, Grossman, New York, 1965.

7. Interdepartmental Highway Safety Board, Special Report on Federal Policy and Program for Highway Safety, 1965.

8. Status Report, May 31, 1978, Insurance Institute for Highway Safety, Washington, D.C., 1978.

9. Figures provided to the authors by the National Highway Traffic Safety Administration.

10. National Highway Traffic Safety Administration, Highway Safety: A Report under the Highway Safety Act of 1966 as Amended, January 1, 1977-December 31, 1977, Department of Transportation, Washington, D.C., 1978; National Highway Traffic Safety Administration, Motor Vehicle Safety 1977: A Report on the Activities Under the National Traffic and Motor Vehicle Safety Act of 1966 and the Motor Vehicle Information and Cost Savings Act of 1972, January 1, 1977-December 31, 1977, U.S. Department of Transportation, Washington, D.C., 1978.

11. See note 10.

12. It is required by 23 U.S. Code Section 402(a) that standards address, though not be limited to, the following areas: improvement of driver performance (including driver education), pedestrian performance, accident investigation and reporting, vehicle registration, operation, and inspection, highway design and maintenance, identification and correction of high-hazard locations, traffic control, and emergency services.

13. It should be noted that the FHWA itself has established many standards for highway safety matters under its jurisdiction and has been increasingly active in recent years in pushing for their implementation on federally-aided highways.

14. See note 10.

15. Lyndon B. Johnson, Transportation Message, March 2, 1966, as quoted in Senate Report No. 1302, U.S. Govt. Prtg. Off., Washington, D. C., 1966.

16. House of Representatives Report No. 93-118, U.S. Govt. Prtg. Off., Washington, D.C., 1973.

17. The National Highway Safety Needs Report, U.S. Department of Transportation, Washington, D.C., 1976.

18. See note 17.

19. This statement must be moderated by recognition that part of the range in cost-effectiveness arises from the fact that costs are defined in an incremental or marginal way. To illustrate, consider the two measures "mandatory seatbelt use" and "median barriers," rated at $506 and $228,000 per life, respectively. The first includes only the cost of enforcement, and presumes the existence

(continued on next page)

of hardware. The second includes total construction costs required for modification of existing roads. If initial costs were included for seatbelts, the cost of mandatory use would jump fifty times, to about $25,000 per life. Which is the "correct" cost of mandatory seatbelt use? The answer really depends on the questioner's point of view. For the DOT hazard manager confronting the present situation, the incremental costs for seatbelts seem most relevant; for someone wishing to compare seatbelt deployment to another, equivalent measure, use of total costs is more logical. Thus, when using the figures in Table 3, the reader is advised to take some care in recognizing how they were calculated.

20. D. J. Rice, J. J. Feldman, and K. L. White, **The Current Burden of Illness in the United States**, Occasional Paper, Institute of Medicine, National Academy of Sciences, Washington, D.C., 1976; Barbara Moyer Faigin, "Societal Costs of Motor Vehicle Accidents," DOT Report—HS 802 119, U.S. Department of Transportation, Washington, D.C., 1976.

21. See note 17.

22. P. Slovic, B. Fischhoff, and S. Lichtenstein, "Accident Probabilities and Seatbelt Usage: A Pyschological Perspective," **Accident Analysis and Prevention**, 10 (1978): 281-285.

23. **Report on the Highway Safety Act of 1966**, House Report No. 1700, U.S. Govt. Prtg. Off., Washington, D.C., 1966.

24. See note 9.

25. **An Evaluation of the Highway Safety Program**, Report to Congress from the Secretary of Transportation, Department of Transportation, Washington, D.C., 1977.

26. See the discussion of physical principles in part one of this article (note 5).

27. The usual number given for the lives saved by passive restraints is 9,000. (See, for example, note 10, **Highway Safety**.) This does not include the number of lives saved by the present use of non-passive belts, which is about 3,000. Hence, once passive restraints are installed in all cars, the total lives saved as compared with no use of restraints is 12,000.

28. To obtain these estimates, take the total cost of equipping 140 million vehicles and divide by the total number of lives saved over a period of ten years.

29. **Background Manual on the Passive Restraint Issue**, Insurance Institute for Highway Safety, Washington, D.C., August 1977.

30. **Federal Regulation and Regulatory Reform**, Report by the Subcommittee on Oversight and Investigations of the Committee on Interstate and Foreign Commerce, U.S. House of Representatives, October 1976.

31. **The Secretary's Decision Concerning Motor Vehicle Protection**, 42 FR 5071, January 27, 1977.

32. The Senate rejected a limitation similar to the Shuster amendment, but a House/Senate conference committee restored it. At the same time, another amendment was added by the conference committee which effectively nullified the impact of the Shuster spending limitation. The latter amendment, introduced by Representative Silvio Conte (R-Mass.) specified that the DOT was not prohibited from using funds for any research and development activity relating to occupant restraint systems; this, in effect narrowed the Shuster amendment to a funding limitation on enforcement activities only. Since no enforcement was even planned in fiscal 1979, the Shuster amendment is probably meaningless.

33. See note 10, **Highway Safety**.

34. See note 9.

35. An estimate for the cost-effectiveness of the air brake standard may be obtained as follows. There were 1.25 million multi-unit trucks and commercial buses in 1976, all presumably with air brakes. These were involved in 3,000 highway fatalities (see note 10, **Highway Safety**). According to the latest NHTSA estimate, obtained through a study at the University of Michigan, the standard could prevent up to 19 percent of these fatalities, or 570 in 1976. Assuming that vehicles equipped with the new braking system have a ten-year life, and that the maintenance costs of the equipment are equal to the initial costs, 5,700 lives would be saved at a cost of $2,400 per vehicle, which is equivalent to $520,000 per life.

36. **Report of the Interstate Commerce Committee, May 14, 1976**, Report No. 57-006, U.S. Govt. Prtg. Off., Washington, D.C., 1976.

37. Manufacturers claimed that the antilocks were not being properly maintained by the shippers, a contention supported by organizations representing the drivers. The shippers, in turn, blamed the malfunction on inadequate design. To solve this difficulty required action by two agencies within DOT: NHTSA, which issues standards and can force installation, but cannot deal with maintenance problems; and the Bureau of Motor Carrier Safety (BMCS), which among other things is charged with maintenance enforcement. In the case of antilocks, NHTSA urged BMCS to issue maintenance regulations and to establish a program of enforcement. BMCS refused, claiming that since antilocks were still experimental, such regulation would be premature. NHTSA, in order to get results, finally overrode BMCS and took its case to Adams.

38. **Paccar Inc. et al. vs. NHTSA and the Department of Transportation**, 573 F2d 632, (Ninth Circuit 1978).

This is the sixth in a series of articles on technological hazards and their management. In earlier articles the burden of technological hazards was estimated and major generic issues in hazard management were raised [September 1978]. Following this, two case studies in hazard management were presented. The first focused on the Consumer Products Safety Commission [October 1978], the second on management of the chronic mercury hazard in ambient air [November 1978]. Last month the first of two articles dealing with the hazard posed by motor vehicles focused on the principles of risk reduction.

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