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The Automobile as Hazard: The Failure to Respond*

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Why are 48,000 deaths and nearly 2,000,000 injuries tolerated in the United States? Why are we not doing more than we can to reduce the hazard? We came to study these questions of auto safety as a case study in the context of the whole spectrum of technological hazards which society faces. We chose to study the hazard of auto safety because of the profound contradiction that it poses to both experts and lay people, to drivers and congressmen—the profound contradiction between what we know and what we do.

Our basic knowledge of motor vehicle hazards, compared to other technological hazards, is extensive and advanced. We can begin to demonstrate this by reference to Figure 1, which displays the work of one of our colleagues who is seven years old. She does not address driving directly, but rather a motor vehicle appropriate to her age—the go-cart. She begins with the issue of good drivers, then turns to the quality of the vehicle, and then to the nature of the highway, that she expresses as a ride that doesn't tip you over (she may also be referring to the cornering ability of the go-cart as well as the banking of the track). She concludes by again raising the issues of individual protection and safety education.

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*For more detail on the materials in the text see: T. Bick, C. Hohenemser, and R. Kates, "Target: Highway Risks," Part II; *Environment*, March, 1979.

What suffices for a seven-year-old in go-cart safety analysis suffices for a society as well. In Figure 2, we present a generic model of hazard structure applied to a simple auto accident sequence. The top line of the diagram indicates seven stages of hazard development, from the very earliest (left) to the last and final expression of hazard (right). The seven stages are expressed generically in the top of each box, and in terms of a sample motor vehicle accident in the bottom of each box. The stages have a complex structure and are linked by causal pathways, denoted by triangles. The middle line of the diagram indicates six control stages, linked to pathways between hazard stages by vertical arrows.

Each control stage is defined by an opportunity to intervene either to prevent or reduce hazardous events and consequences or to mitigate consequences after they occur. These are listed generically in Table 1 and in Figure 2 by the specific control actions that apply to the sample auto accident sequence. Thus, control stage 2 should be read: "you may modify techology 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 Department of Transportation* have structured the causal sequence of hazard. Three stages, denoted "pre-crash, crash, and post-crash" are envisioned, with various control actions and standards classified according to these. The fourth line shows the time dimension. This arrow 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 lead at a subsequent time to control actions affecting initiating events.

Combining this relatively well-understood theory of auto accident evolution with exceptional (by the standards of other fields) reporting data one can present a prescription for personal safety based on a distillation of a large amount of literature (Table 2). In using this prescription, one must immediately note that the various items are not mutually exclusive and some, indeed, may be contradictory. Simply adding them up may lead to the conclusion that not only has one eliminated the risk of death

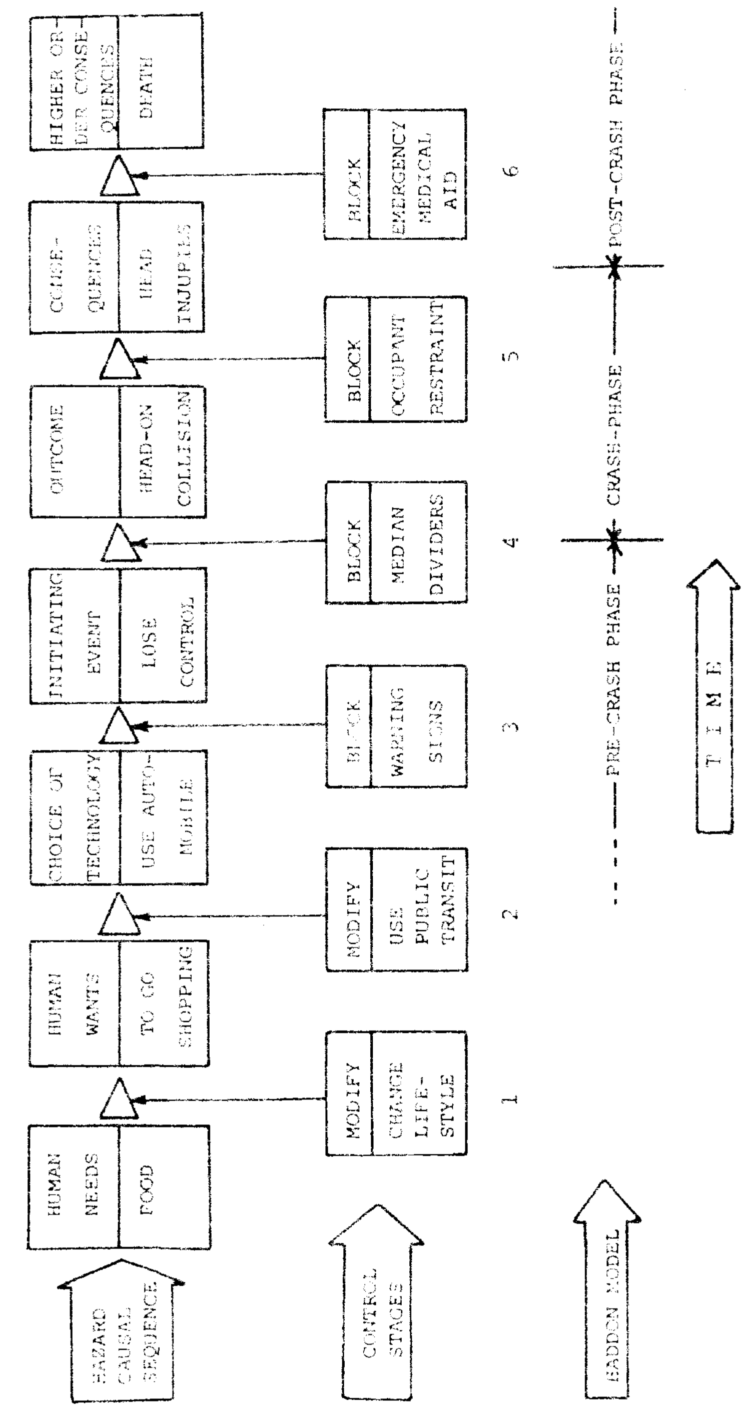
*W. Haddon, Jr., "A Logical Framework for Categorizing Highway Safety Phenomena and Activity," *Journal of Trauma*, Vol. 12 (1972).

Table 1.

Models of Highway and Vehicle Safety Management

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

Figure 2.



from a motor vehicle accident, but may have done so well as to be born again. Nonetheless, by following even a few of these prescriptions the individual can easily reduce the personal danger of death in an auto accident by a factor of 3 to 5.

A similar prescription comes from Washington and it deals with safety countermeasures related either to the highway itself, to regulating traffic, or to educating drivers (Table 3). The list omits making cars safer because that particular task was assigned to another agency. This ranking of countermeasures, by decreasing cost effectiveness and by the total fatalities that they would forestall over a ten-year period, is a controversial list.* Without arguing its merits here we can surely all agree that it demonstrates that we can think of lots of ways of improving highway and traffic safety, and, in some rough rank ordering, we can describe their effects both in terms of the benefits and fatalities forestalled and in approximate costs.

We can make these lists of what our group would call control adjustments because we basically understand the causal structure of automobile accidents. We don't understand that chain completely. We are particularly confused by the issue of motivation; for example, there is evidence that some deaths from motor vehicles that are classified as accidental may indeed be suicidal or even homicidal. Nonetheless, compared to the hazards of chemicals, the hazards of the auto accident are well understood. We understand the physics of momentum and energy, and, indeed, have come to understand it so well that a major prescription is to control the stopping distance in the last half-second before a human being impacts a non-resilient object. How well have we used our knowledge?

*The report (*The National Highway Safety Needs Report*, U. S. D.O.T., 1976) was based on an extensive literature search and consultation with the blue ribbon panel of 103 highway experts known as "Delphi Panel." From an initial list of 200 possible safety measures, 37 actions of "potentially high payoff" were culled and analyzed in terms of cost effectiveness. Because of the uncertain methodology used in arriving at cost effective estimates, many experts, including some transportation officials, continue to question its value. In particular some officials argue that the report is no better than the intuitive "commonsense approach" whereby highway safety experts 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."

Table 2.

Prescription for Personal Safety

	REDUCES RISK OF DEATH
DON'T DRINK OR TAKE DRUGS	50%
USE SEAT BELTS ALL THE TIME	25%
AVOID DRIVING AT NIGHT, ESPECIALLY FRIDAY AND SATURDAY NIGHTS	75%
BE A WOMAN DRIVER, OR DRIVE WITH A WOMAN	60%
BE OVER 35 OR DRIVE WITH AN OLDER PERSON	40%
DRIVE ON TURNPIKES AND INTERSTATES	60%
DRIVE LARGE CARS	50%

In absolute terms, not very well. In 1977, for example, motor vehicles accounted for 47,700 deaths and 1.9 million disabling injuries. There was approximately $12 billion of property damage. When the total cost of fatalities and injuries, measured in lost wages, insurance costs, and medical care, is added to the property damage, the resulting sum is $25 to $37 billion dollars depending upon the assumptions made. Since the introduction of the motor car in about 1900, there have been about 2.1 million highway fatalities. This exceeds all the United States war dead in the century by more than a factor of three.

As shown in Figure 3, there has been a steady increase in vehicles involved in accidents during each of the last 45 years; overall they have increased by a factor of fourteen. The total number of deaths per year, however, has increased less, only by about a factor of two since 1933.

To put it simply: we are dying in larger numbers because our population has increased, and we are driving more; but because of the increased safety of the driving, this in itself has not notably increased or decreased the risk. This increased safety is shown in

Table 3.

Ranking of Countermeasures by Decreasing Cost Effectiveness in Present Value Dollars Per Total Fatalities Forestalled-10 Year Total

COUNTERMEASURE	FATALITIES FORESTALLED	COST ($ millions)	DOLLARS PER FATALITY FORESTALLED
1. Mandatory Safety Belt Usage	89,000	45.0	506
2. Highway Construction and Maintenance Practices	459	9.2	20,000
3. Upgrade Bicycle and Pedestrian Safety Curriculum Offerings	649	13.2	20,400
4. Nationwide 55 mph Speed Limit	31,900	676.0	21,200
5. Driver Improvement Schools	2,470	53.0	21,400
6. Regulatory and Warning Signs	3,670	125.0	34,000
7. Guardrail	3,160	108.0	34,100
8. Pedestrian Safety Information and Education	490	18.0	36,800
9. Skid Resistance	3,740	158.0	42,200
10. Bridge Rails and Parapets	1,520	69.8	46,000
11. Wrong-Way Entry Avoidance Techniques	779	38.5	49,400
12. Driver Improvement Schools for Young Offenders	692	36.3	52,500
13. Motorcycle Rider Safety Helmets	1,150	61.2	53,300
14. Motorcycle Lights-On Practice	65	5.2	80,600
15. Impact Absorbing Roadside Safety Devices	6,780	735.0	108,000
16. Breakaway Sign and Lighting Supports	3,250	379.0	116,000
17. Selective Traffic Enforcement	7,560	1,010.0	133,000
18. Combined Alcohol Safety Action Countermeasures	13,000	2,130.0	164,000
19. Citizen Assistance of Crash Victims	3,750	784.0	209,000
20. Median Barriers	529	121.0	228,000
21. Pedestrian and Bicycle Visibility Enhancement	1,440	332.0	230,000
22. Tire and Braking System Safety Critical Inspection—Selective	4,591	1,150.0	251,000
23. Warning Letters to Problem Drivers	192	50.5	263,000
24. Clear Roadside Recovery Area	533	151.0	284,000
25. Upgrade Education and Training for Beginning Drivers	3,050	1,170.0	385,000
26. Intersection Sight Distance	468	196.0	420,000
27. Combined Emergency Medical Countermeasures	8,000	4,300.0	538,000
28. Upgrade Traffic Signals and Systems	3,400	2,080.0	610,000
29. Roadway Lighting	759	710.0	936,000
30. Traffic Channelization	645	1,080.0	1,680,000
31. Periodic Motor Vehicle Inspection—Current Practice	1,840	3,890.0	2,120,000
32. Pavement Markings and Delineators	237	639.0	2,700,000
33. Selective Access Control for Safety	1,300	3,780.0	2,910,000
34. Bridge Widening	1,330	4,600.0	3,460,000
35. Railroad-Highway Grade Crossing Protection (Automatic gates excluded)	276	974.0	3,530,000
36. Paved or Stabilized Shoulders	928	5,380.0	5,800,000
37. Roadway Alignment and Gradient	590	4,530.0	7,680,000

Source: *The National Highway Safety Needs Report* (U.S. Department of Transportation), 1976.

the decline of the death rate per 100 million vehicle miles in the last 45 years (Figure 4). At the same time, the risk to an average individual has changed little over the past 45 years; the death rate per unit population, despite fluctuations, has remained at a roughly constant average value of 20–30 per 100,000 people per year.

While a fluctuating rate between 20 and 30 per 100,000 population would generally hold little overall significance in comparison to the range of epidemiological statistics, the decline of the 1950s followed by the rise in the early 1960s has had profound political and social significance.

In 1965, when the number of motor vehicles numbered 90 million and traffic fatalities stood at 49,000 per year, a series of Congressional hearings was 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. 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. The Congressional hearings and Nader's book 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.

This "crisis" developed more than 40 years after Henry Ford first began mass-producing motor vehicles, and more than 30 years after the federal government became heavily involved as a highway builder. In retrospect, the preceding years had been a time when safety management, too narrowly conceived and administered in a highly decentralized manner and consistently evading the issue of automobile crashworthiness, had consistently lagged behind scientific knowledge. And while safety management had achieved a roughly constant traffic-mortality-per-unit-population (as vehicle numbers increased five-fold), this was no longer enough.

A new era began with President Johnson's introduction of landmark legislation in January 1966. This legislation was subsequently divided by Congress into two bills: the Highway Safety Act and the Motor Vehicle Safety Act. Both were passed overwhelmingly by Congress and signed into law nine months later.

Figure 3.

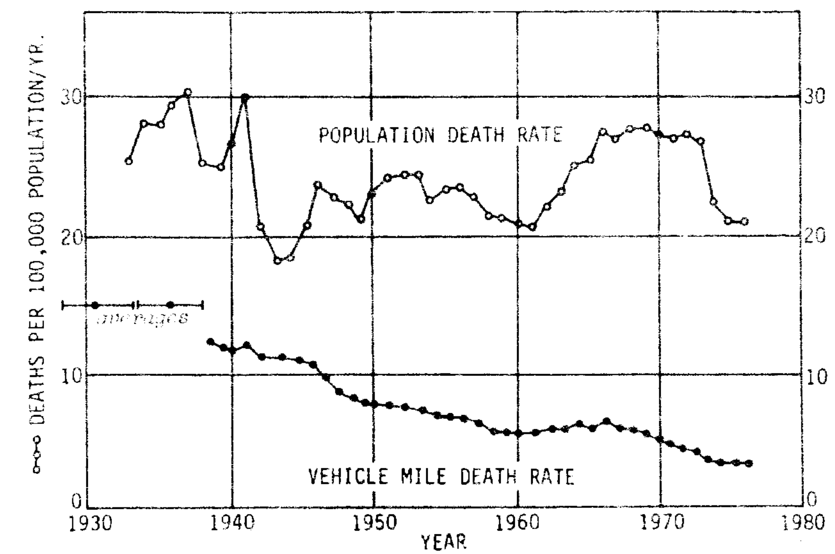
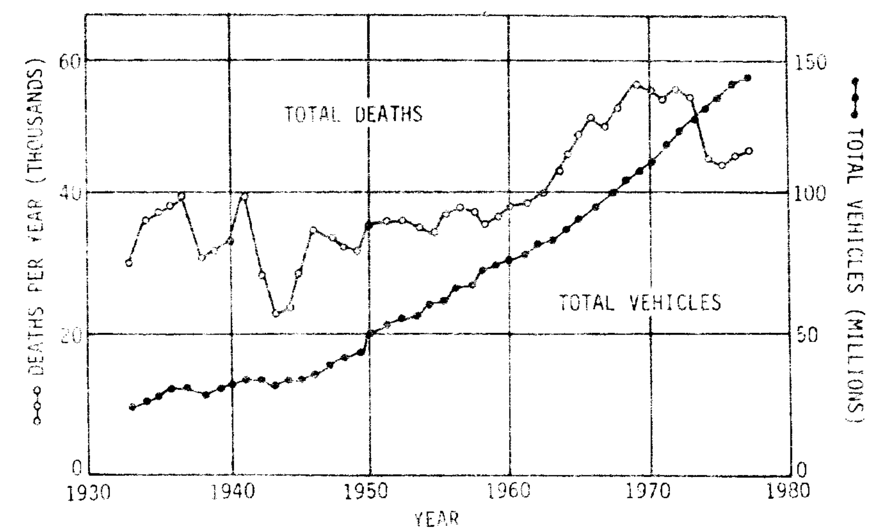


Figure 4.



With various amendments, these laws set the framework for a significant departure from the predominant emphasis on accident prevention, which had persisted for over 40 years. Particularly, the second 1966 law envisioned numerous managerial strategies—classified as preventing outcomes and consequences in our hazard model, and as the crash and post-crash phases in Haddon's schema.

In addition, the two 1966 laws initiated an enormous financial commitment to reduce the death and destruction on the nation's highways. From fiscal year 1976 to fiscal year 1977, the federal government has spent $6.6 billion toward this end. The cost to state and local government has been even greater. In fiscal 1977 alone, states and localities spent over $4 billion 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. For the first time in history, expenditures on specific safety became an appreciable fraction of highway and vehicle expenditures.

How effective has the 12-year effort since 1966 been? One measure is the trend of highway deaths shown in Figure 3. In a recent report NHTSA claims that a total of 150,000 lives has been saved since 1967 because of the reduction of the mortality rate per 100 million vehicle miles from 5.25 to 3.25. 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 can easily occur quite independent of the federal program. Thus, a decline during 1967–1977 would be predicted because of the rapid entry of women into the pool of drivers, the growing proportion of urban drivers, and the effect of the 55mph speed limit (mandated by oil scarcity rather than safety considerations). Also, an increase would be predicted based on the changing age distribution of drivers to greater predominance of young and old. On such mixed considerations, we estimate that gains specifically due to the federal safety program are considerably less than the 40 percent claimed.

But whatever the degree of credit claimed, our prognosis for future progress is limited. To illustrate, we consider the most attractive of physical countermeasures in Table 3, mandatory safety belt usage; one that according to the chart is designed to forestall an average of 8,900 deaths per year. Why is it that mandatory seatbelt use laws have not been enacted? There are two sets of reasons commonly given why such seatbelt laws have not been enacted. The first relates to its efficacy and the second to its desirability. The first argument asserts that even if the law were enacted it would not increase current use from the dismal 14 percent observed in a recent national highway traffic safety administration study or even the 25 percent who have expressed their employment in response to questions that they regularly use seatbelts. This is probably true, and we suspect that a compulsory law without enforcement would have little effect on seatbelt usage. But there is no reason to imagine that even modest enforcement will not have an effect. The 55mph maximum speed law is enforced sporadically, and it certainly is observed only indifferently. Yet, while not achieving its goal of reducing the average maximum speed to 55mph, there has been a substantial and significant overall reduction in average top speeds and an accompanying reduction in death rates. A further argument, sometimes asserted, is that even if there were an increase in a use of seatbelts, this would not prevent fatalities. This is not a generally accepted argument, because there is wide agreement that we would have substantial savings of lives, although estimates may vary by as much as between 7,000 to 12,000 per year.

A second line of reasoning runs that a voluntary campaign would be more preferable. While we might readily agree, we can appreciate the need for involuntary actions to pursue a common good. The survivors of auto accidents live with us for a very long time; they tax the health care system and a variety of public support systems for many years. It has been widely accepted in other areas of our national life that individual behavior can be curbed when it places an undue burden on the broader societal welfare. Indeed, countries as diverse as France, Australia, and Sweden have passed mandatory laws that are enforced and have led to between 70–90 percent reported seatbelt usage. A student of national character can only marvel at the diversity of these three countries, each of which seems to have overcome the standard objections that prevail in our country. A mandatory seatbelt law in America would probably be unpopular, but it is not clear that it is unobtainable. The majority of people asked in opinion polls say that they are against it, yet interestingly there is considerably higher approval for mandatory seatbelt laws than for voluntary buckling up. And one must question how political leadership differs from ours in the 26 countries that have such mandatory laws.

Finally, it is argued that a passive restraint system now mandated for 1981 makes the whole question moot. Yet the issue is far from settled, and there is a continuing legal battle in prospect. It may well be the 1990s before such a system comes into wide and current usage.

Why is it that individuals fail to use seatbelts and a large number of them oppose mandatory usage? My colleagues at Decision Research have studied this reluctance to use seatbelts in the light of research showing that safety behavior, or as they call it "protective behavior," is influenced more by the probability of a hazard than by the severity or magnitude of its consequences; and that people are not inclined to protect themselves against very low probability hazards.* The individual hazard is, in one sense, quite low. They calculate that the chance of a fatality each time one gets into an automobile is about 1 in 3.5 million, although a disabling injury is considerably higher, being about 1 in 100,000. With the odds in each trip being so low, it's not surprising that only one in four persons report that he regularly wears seatbelts. Nonetheless, if one uses a different standard, that of a lifetime of driving (50 years), the odds of having a fatal accident rise to about 1 in 100, with the probability of experiencing at least one disabling injury about one in three.

In addition to this element of rationality, that is, the small probability of a fatal accident, there is the sense that driving is a voluntary activity. There is some evidence that suggests that we have a double standard between voluntary and involuntary activities, that accepts greater risks in activities that are considered voluntary. In any event, whether voluntary or not, drivers all over the world evidence a belief in their own skill as drivers compared to the population at large, replying that they consider themselves in the upper percentile of skill. Finally, one can only speculate on those deep psychological wellsprings that ownership and operation of an automobile seem to tap.

Whatever our final explanations as to why mandatory seatbelt

*P. Slovic, B. Fischoff, and S. Lichtenstein, "Accident Probabilities and Seatbelt Usage: A Psychological Perspective," *Accident Analysis and Prevention*, 10 (1978), pp. 281–85.

laws are not passed, or if passed would not be heeded or enforced, they illustrate the special problem of making further progress in auto safety in the face of a strong reluctance by industry to provide *safety leadership*. The support and sometimes prodding that a concerned public provides to regulatory agencies is undermined by the fact that individual members of the public are willing to acquiesce to a loss pattern in death and injury for themselves which, when taken in aggregate, carries a very high price in required medical costs and lost productivity.

Our final prognosis is not a hopeful one. If our economy continues to expand, despite rising costs of oil and in the face of chronic inflation, driving will expand further, and the two-car household will become standard. Thus, much improvement in hazard management will be vitiated by increased driving, and may, because of the introduction of smaller, less crashworthy cars, even exceed our present projections.

We will have to work very hard just to keep the slaughter on the highways contained to the "acceptable" 50,000 deaths and 2,000,000 injuries. We will consistently favor technological fixes over behavioral adjustments because, while costly, they seem more dependable in the face of the gap between individual public behavior and aggregate desire for safety.

There are other scenarios, of course, that can lead to a less dour future: a more socially responsible industry developing a car that achieves major safety goals without prohibitive cost; or a major catastrophe, possibly involving trucks "that leads to renewed efforts to improve truck safety"; or a notable shift in the perception of driving from a voluntary to an involuntary risk. But these are not probable outcomes. The automobile, more than any other modern technology, is rooted so deeply in our economy, our lifestyle, and our psyche that even the anguished cries of two million yearly victims has only modest effect on well established trends and directions.