Transportation

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University of Kentucky

Highway Safety Research, Development, and Technology Transfer

John A. Deacon
University of Kentucky

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INTRODUCTION

Late in 1987, the Federal Highway Administration assembled a seven-member panel which, guided by a primary contractor, Harrison Boyd & Associates, was charged with the task of developing a recommended five-year research, development, and technology transfer program for highway safety starting in the 1990s. As a part of the task, each panel member prepared an individual position paper to stimulate and focus panel discussions and, ultimately, to provide the basis for a consensus paper. This represents one such individual paper.

Although it is believed that significant safety gains can be achieved in the 1990s and beyond simply by more extensive implementation of known and proven crash countermeasures, this position paper focuses on research activity, the generation or extension of information related to the enhancement of road safety. Quantum improvement in road safety as a result of highly focused new research appears unlikely. Accordingly, in the quest to achieve significant additional gains, the recommended approach tackles the road safety problem on a broad front, examining a wide variety of factors contributing to travel hazard and building incrementally on existing knowledge. Furthermore, emphasis has been placed on activities likely to yield results that, if implemented, could be expected to generate short-term gains, perhaps within a period as short as five or fewer years.

Certainly no claim can ever be made that a specific research program will generate knowledge adequate to sustain high levels of travel safety over long periods of time. The recommended five-year research program is simply an immediate, short-term phase of a continuing process that seeks to retain or enhance a high level of personal safety in face of endless changes in human activity patterns and the highway systems built to accommodate them.

CURRENT STATUS AND EMERGING ISSUES

In this section, stock is taken of initiatives currently underway that are likely to have future safety repercussions and of trends expected to persist into an admittedly murky future which may likewise affect travel safety. The purpose of this assessment is to identify aspects of future mobility likely to alter the hazard of travel, emphasizing those of increasing risk that are possibly amenable to mitigation through implementation of the findings of new research initiatives.

CONTINUING SAFETY DEVELOPMENTS

A number of current initiatives--some based on prior research, some based on on-going research, and some based simply on good common sense--are expected to yield significant safety benefits in the years ahead. In a 1987 report, "Highway Safety
Priorities to the Year 2000," The Automotive Safety Foundation and the Highway Users Federation For Safety and Mobility listed a number of specific recommendations designed to reduce the motor vehicle death rate to 1.5 deaths per 100 million vehicle miles of travel by the year 2000. Perhaps only a few of these recommendations will ultimately be implemented, and perhaps the safety gains will fall short of original projections. Nevertheless, numerous activities are underway that can be counted upon to reduce the highway crash toll. The following are illustrative.

Drunken driving, responsible in part for up to half of all crashes resulting in fatality, is unlikely to increase and may well decline. Public awareness of the dangers of intoxicated driving is at an all-time high, most significantly among impressionable teenagers. Additionally, the courts are increasingly willing to impose stiff sanctions on those convicted of DUI. Not only is the offender being threatened with much stiffer fines and loss of driving privilege in many states, fatal crashes sometimes result in manslaughter or even murder charges. Enforcement efforts are encouraged by higher conviction rates, and special enforcement programs are targeted at potential offenders. Commercial drivers are increasingly unwilling to risk potential loss of livelihood for the "pleasure" of an occasional on-the-road drink.

Safety benefits are expected to continue to accrue, although at a decreasing rate, as a result of further increases in the use of occupant restraint devices. State laws have mandated the use of child safety seats as well as shoulder harnesses/lap belts. While enforcement of these laws is often limited, the net effect remains an increase in restraint usage. More importantly, the youngest generation has become habitualized to "buckling up" and prompting parents to do so as well. Recent reductions in insurance premiums have been offered for vehicles in which air bags are installed. As such incentives spread and as the costs of passive systems plummet, economics may soon make air bags a prudent addition to the new car investment.

Perhaps the most obvious example of the technological and practical feasibility of improved braking systems for both cars and heavy trucks is the anti-lock braking system, designed to improve traction by preventing premature wheel lockup. Such systems are commercially available for both cars and trucks and have been quite effectively used on heavy trucks in Europe for several years. Another example of proven technology is the automatic slack adjuster which reliably maintains proper adjustment of heavy-truck brakes. Heavy-truck braking is also expected to improve as a result of the mandate for working brakes on wheels of the steering axle. Regarding improved braking systems, the critical question seems to involve only the rate at which improvements will be introduced into the inventory: their eventual introduction seems assured. In any event, improved braking is expected to translate directly into enhanced safety.
Elimination of multistate licensure for commercial motor vehicle operators and development of maintenance standards for the reflectivity of traffic signs and markings are examples of the large array of other current initiatives for improving highway safety. Although the composite effect of these initiatives may not reach the ASF/HUFSAM goal of "1.5 by 2000," a net positive effect on highway safety seems certain.

FUTURE TRAVEL

The earth's supply of fossilized fuels on which motorized travel has been so heavily dependent and its ability to neutralize the potentially lethal atmospheric effects of fuel combustion are being exhausted, rapidly and perhaps catastrophically. Past failures in the search for viable fuel alternatives suggest that society will likely be forced to deal with the symptoms of this global disease well before a cure is found. Although a number of interim treatments will likely be implemented, one possible impact is a reduction in motorized travel.

While technology has largely failed to develop economic fuel alternatives for the motor vehicle, it continues to succeed in developing vastly improved communication and computation systems. The prospects of effective communication substitutes for travel--promised for such a long time--now seem very real, especially in a service-oriented economy and in a world strapped by fuel shortage and environmental degradation. At the same time, forces that have driven the spectacular increase in motorized travel--population growth, a prospering economy, developmental sprawl, the desire for personal mobility--are likely to continue, though perhaps with reduced intensity.

Although the net effect of the above factors on motorized travel is debatable, it seems clear that an absolute decline in travel within the next decade or two is possible and that, if not, a reduction in the rate of travel increase can reasonably be expected. Since travel is the dominant factor affecting crash frequency, highway safety may well be enhanced by changes in the host of factors that generate and sustain the desire to travel.

HAZARDOUS MATERIALS TRANSPORT

Rapid increases both in the production of hazardous materials and in their transport by motor truck are not expected to diminish in the near future. Petroleum fuels, other petrochemicals, armaments, nuclear wastes--necessary products for a modern society--can be extremely hazardous in highway crashes. Both the risk of crash and the consequences thereof intensify when more trucks carrying hazardous materials are routed through high density urban corridors.

Heretofore, the transport of hazardous materials has not
been a dominant factor in national highway crash statistics. Because the fraction of trucks carrying hazardous materials will continue to be small, this situation is expected to continue. Nevertheless, crashes involving hazardous materials are expected to become more frequent and more severe: renewed efforts to seek ways to effectively mitigate the danger seem justifiable. Continued development of effective emergency response procedures, while necessary, no longer is sufficient.

KNOWLEDGE BASE

What is known about highway safety stems largely from the process by which knowledge is acquired (that is, the initiation, conduct, and evaluation of research), the dissemination of that knowledge to practitioners, and its presentation to those being schooled in highway safety related disciplines. Despite a rich heritage of highway safety research extending over many years, the process of inventorying the current knowledge base reveals surprisingly large gaps, frequent inconsistencies, and little evidence of convincing scientific inquiry--at least in those components related to road and street design and traffic control. Researchers do not systematically build on the base of existing knowledge, and research findings are seldom called upon to bear the burden of careful scrutiny. Safety does not seem to be well integrated into the processes of design and traffic control. Designers are frequently unaware of the safety effects of their decisions and don't know where to turn for essential information.

In sum, despite the fact that many very critical safety areas have been extensively researched, there seems to be something fundamentally unsound about the way highway safety business has been conducted. Perhaps it is simply that the virtues of "safety" have allowed perceptions to predispose scientific inquiry or that practical difficulties of safety research have precluded definitive findings. In any case, however, continuing gains in the ability to engineer safety into highways and their traffic control elements demand much more effective means for developing, evaluating, disseminating, and preserving safety knowledge.

MORE AND LARGER TRUCKS

One of the more dominant trends in highway travel through the years has been the persistent increase in allowable truck size and weight and in the increasing numbers of trucks on the nation's highways, especially the Interstate system and other major trucking routes. These trends will continue into the foreseeable future.

Larger trucks mean greater productivity, driving down shipping costs and/or increasing profits for the motor carriers. Cost-effectiveness analyses have commonly concluded that the incremental costs which slightly larger trucks impose on the
public—in safety decrements as well as road wear—are relatively small in comparison to the savings realized by the private sector. Unlike aviation in which the aircraft industry has been forced to accommodate real barriers to airport expansion, regulators of motor trucks and providers of highways seem more content to let vehicle characteristics drive facility design. A compelling case for restricting further increases in truck size and weight has yet to be made.

Shippers are attracted by the advantages of motor freight, fast and ubiquitous delivery, reasonable costs, reliable service, etc. Certainly many bulk commodities will continue to flow on the waterways and over the rails, and air freight will continue to offer an attractive means for shipping precious and perishable goods. But there simply is no serious competitor in the markets where motor trucks now prevail and, hence, no reason to suspect that continual increases in motor truck travel will be curtailed.

Certainly, the lay perception is that more and larger trucks translate into increased travel risk. Although that perception may be an exaggerated one, there is little doubt that operating heavy trucks is much more demanding than operating cars and that truck crashes are much more damaging. Although considerable research has been devoted to better understanding heavy truck safety and in seeking ways by which truck hazard can be mitigated, much remains to be learned. In light of the future prospects for truck travel, considerably more research is warranted.

DRIVER AGING

Although the nation's population is rapidly aging, its effect on highway safety remains largely conjectural. Some related trends are evident, however. The older segment of the population will be much more dependent on the automobile in the future than in the past. Fewer older persons will live where alternative modes of transport can accommodate their travel needs, and a much greater proportion will have been conditioned to automobile travel as an essential component of daily life. Older persons will become healthier and more active and will be much less content to accept mobility restrictions with advancing age.

But advancing age does bring diminished skills essential for safe driving; vision dims, physical and mental responses slow, and fragility increases. Might not the irreversible demographic trend in aging greatly increase the frequency and severity of road crashes? In the past, many older drivers have recognized their limitations and compensated for them by driving less often at night and venturing less frequently into unfamiliar territories. The future population may well be less content to make these accommodations to their age-diminished physical capacities. The pace of older driver (and older pedestrian as well) research must quicken if uncertainties of the future are to
be narrowed, and ability to provide a safe highway environment is to be enhanced.

ROAD WEAR

With the major exception of development on the peripheries of expanding urban areas, very few roads on new alignment are now being built. For a variety of reasons including economic realities and continuing environmental concerns, the pace of new road construction is not likely to significantly quicken in future years. Emphasis will continue to turn more to reconstruction as the primary means for accommodating traffic growth and responding to capacity deficiencies.

Another trend of similar impact is the rate at which existing roads are wearing, both as a result of traffic loading and from destructive environmental forces. More maintenance work is being required, and rehabilitation has commanded a much higher priority within highway agencies.

The net safety effect of these trends is an uncertain one. More road users will doubtlessly be exposed to the greater risk of travel in work zones, and road wear resulting in pavement surface deterioration—for example, slicker surfaces and more frequent pavement edge dropoffs—may increase the normal risk of travel. At the same time, rehabilitation and reconstruction provide considerable—and possibly inexpensive—opportunity for ameliorating or eliminating road hazards at the same time that road wear is being treated and traffic capacity is being increased. Designers and maintenance personnel must learn much more about how to capitalize on this opportunity to improve highway safety.

URBAN CONGESTION

Not only is highway travel in congestion a fact of urban life, it is an increasing likelihood within heavily trafficked rural corridors. To the extent that congestion results in a slower moving traffic stream, it is likely to reduce the incidence of fatal crashes. At the same time, the flow is often sporadic and, with the closer packing of vehicles, the opportunity for conflict is intensified. The net effect may well be an increase in costs attributable to highway crashes.

In addition to the direct effects of congested travel, safety may be affected in other ways. Traffic law enforcement is difficult or impossible when traffic volumes approach capacity levels, and the strain of driving may increase the incidence of unpredictable and/or unlawful behavior. In addition, some of the measures undertaken to alleviate congestion may well increase travel hazard. Certainly, much more needs to be learned about both the effects of congestion on travel safety and on the means to mitigate any adverse effects.
RURAL SPEEDS

Despite a nationwide speed limit of 55 miles per hour, average travel speeds in rural areas have inched upward in recent years. Relaxation of the speed limit to 65 miles per hour on the Interstate system and certain other major highways is expected to accelerate this trend. One of the costs of being able to travel faster from city to city is an increase in the highway crash toll. Not only are more crashes expected but also the crashes that occur will be more severe.

Barring catastrophe, a future rollback of the nationwide restriction is not expected. At the same time, further relaxation of legal speed limits is likely to be quite limited. Although there will always be continued public pressure to allow faster travel, another major legislative battle in the immediate future is not foreseen.

SUGGESTED RESEARCH

Identified herein are some specific projects--grouped according to the emerging-issue categories identified above--that are proposed for consideration in development of the five-year research, development, and technology transfer program. The fact that no projects have been identified in the areas of hazardous materials transport and increasing rural speeds is indicative only of the time constraint in preparing this individual paper and not necessarily of a lack of relative importance of these emerging issues.

KNOWLEDGE BASE

Design of Safety Studies for Reliability and Utility

Background. Safety studies can be counted on to yield useful and reliable results only if the right kinds of questions are posed, the "experiment" is properly planned, data are accurately collected, and appropriate analysis is performed. Particularly troublesome are studies relying primarily on crash data. It is difficult in such studies to collect an homogenous data set sufficiently large to reasonably offset the rare nature of crash events and to isolate safety effects of the phenomenon of interest from those occasioned mainly by chance or from those due to the host of confounding variables--traffic, driver, roadway, environment, enforcement--influencing the pattern of crashes.

Regrettably much of the highway safety literature is composed of investigations not meeting the standards of reasonable scientific inquiry. Samples are often of insufficient
size, excessively large crash reductions are reported as a result of regression-to-the-mean effects, effects of confounding variables are seldom properly considered, and essential information is often unreported. In assessing the validity of research findings, it is often difficult to separate fact from fiction: misconceptions and inaccuracies, which quickly and easily enter professional practice, are difficult to later dislodge.

The genesis of the proposed study is that the quality of safety studies can be improved by education and information. Although a plethora of methodological information is available, much is of little use to the typical safety researcher, often trained in another discipline and operating under constraints of the real world with imperfect data and limited resources. The proposed study represents a refinement and extension of FHWA's pioneering "Accident Research Manual."

Objectives. The primary objective of this study is to develop a guidebook for highway safety investigators. The guidebook should help investigators structure safety research in such a way that usable findings are developed. It should identify typical questions to which answers are sought and should recommend experimental plans, sample sizes, analytical techniques, and statistical procedures designed to produce reliable results. Each technique and principle should be demonstrated by example. The guidebook is not expected to be a complete tutorial on statistical procedures. Nor is it expected to provide guidance for every possible matter confronting the safety researcher. It is expected to recognize that data sets are often imperfect and to recommend procedures for dealing with such imperfections. The study should specifically include an examination of countermeasures whose likely safety impact is small. It should recognize the practical difficulty of constructing a well-designed statistical experiment, the fact that many important variables are beyond the control of the safety experimenter, and the difficulty in distinguishing between correlation and causality.

Applications. The facts of highway safety can not be separated from the fictions without rigorous research and investigation. This study is designed to help investigators better understand the kinds of experiments that must be conducted to produce reliable and useful results. It will enjoy greater success than similar efforts of years past if the deficiencies of these prior efforts are addressed and if the environment within which highway safety research is conducted is fully considered in its development.

Modular Approach to Crash Modeling I: Non-Intersections

Background. Many types of models have been used in an attempt to quantify the influence of roadway and traffic control variables on the frequency and severity of crashes. Generally,
models applicable for extended roadway sections and those applicable for spot locations incorporate only a few of the same kinds of explanatory variables, those constant throughout an extended length such as lane and shoulder widths. Otherwise, section models often use composite variables such as number of driveways per mile, cumulative change in angular direction per mile, average roadside hazard rating, mountainous/rolling/level categories, etc. while spot models more often use specific measures such as offset distance to a roadside object, degree of curvature for a specific curve, gradient for a particular grade, etc. Measures of exposure to risk are often different as well. While section models often use vehicle miles of travel, spot models more typically use only vehicles.

The net result of these and other differences in crash models is that it is very difficult to integrate models developed by different researchers into a coherent statement of likely composite crash effect, and it is difficult to build upon previously published work. This study is directed to the task of developing a conceptual model incorporating a series of modules which could be developed and calibrated somewhat independently but would still contribute to understanding the whole.

Objectives. The objectives of this study are to examine and evaluate the methods that have been used to model crash effects; to develop standards by which such models should be judged; to develop a modular approach to modeling that would enable somewhat independent development of separate modules and be useful, if possible, for both spot and section locations; and to examine the likely range of candidate explanatory variables for each module. The study will recommend how spot locations should be defined, both in terms of the feature(s) to be included and the length of the spot. It will examine both frequency and severity models and will determine when it is useful to model subsets of the crash population separately.

Applications. Further quantification of crash effects of various roadway and traffic control parameters is essential if the ability to engineer safety into the roadway is to be advanced. The task is too monumental for a single effort: research will be incremental and progress will be gradual. Meaningful accomplishments will be realized only if there is a conceptual model into which incremental adjustments and refinements can be incorporated.

Modular Approach to Crash Modeling II: Intersections

The at-grade intersection demands special treatment in crash modeling not only because of the high incidence and unique nature of crashes at intersections but also because of the extreme variability among intersections and the complexity of potentially contributory factors. This study would be similar to that described above for non-intersection locations.
Refinement of Roadside Encroachment Models

Background. Recent attention that has been directed by safety researchers to roadside crashes has paid handsome dividends. On rural Interstate highways, for example, the side slopes are flatter, many hazardous objects have been eliminated, and guardrail reduces the threat by those remaining. But the safety dollar is of finite dimension, and costly improvements such as these must be evaluated against others that may have greater payoff. The key to cost effectiveness evaluation of roadside countermeasures is a roadside crash model, most likely based on encroachment concepts.

Roadside encroachment models have been available for many years, emerging in safety evaluations soon after the pioneering work by Hutchinson and Kennedy in examining encroachments within freeway medians. In the intervening years, however, little progress has been made in building on this early work: available models remain crude and of questionable validity. This is partly because encroachment models have been primarily considered as an adjunct to other safety investigations.

Objectives. The objective of this study is to develop, calibrate, and validate a roadside crash model based on encroachment concepts and applicable for rural travel on both two-lane and multilane highways. This study will examine existing roadside crash models and propose refinements to expand their utility and increase their accuracy. It is expected that existing crash records will prove useful in calibrating crash severity components of the proposed model and in overall evaluations of its validity. It is likely, however, that new data will be required for the main calibration effort, probably using "hits" on longitudinal barriers as the measure of interest and requiring a multiyear data collection effort.

Applications. Strong interest continues in efforts to reduce roadside hazard. In the absence of a validated roadside crash model, however, decisions are largely a matter for intuition and guesswork. For example, there is little objective basis for deciding when a guardrail should be installed in lieu of flattening a sideslope. Neither is there basis for judging whether the safety gains from lane widening might be offset if restricted right-of-way also requires that sideslopes be steepened. The results of this study should be useful in day-to-day design decisions and should eventually form the basis for developing justifiable roadside design standards and guidelines.
More and Larger Trucks

Accelerations - Truck Limits, Operational Needs, and Road Inventories

Background. Road design standards have generally been patterned to meet the needs of passenger cars and their drivers rather than those of large trucks. One critical difference between cars and trucks which is not satisfactorily addressed in existing standards relates to accelerative and decelerative forces. Large trucks accelerate much more slowly than cars, they require considerably greater stopping distances, and they roll over much more easily. For large trucks to be operated safely, forces demanded by the road environment must not exceed truck capabilities. The following typify areas of concern:

- The driver of a large truck, approaching a controlled intersection, must be able to see sufficiently far in advance to comfortably execute a required stop.
- The taper length of a ramp entering a high-speed facility must be sufficient to enable loaded trucks to accelerate to speed before a merge is required.
- Curve transitions must be sufficiently gradual and curvature sufficiently flat so that rotational and centrifugal effects don't induce rollover.
- A truck, previously stopped, must be given ample time to clear an at-grade intersection before being threatened by an approaching vehicle.

Objectives. The objectives of this study are to identify operational situations where limited accelerative and decelerative capabilities of large trucks are a likely threat to safety, to characterize the critical accelerative and decelerative capabilities of the existing truck fleet, and to develop means for "measuring" a road segment--either in service or under design--to determine minimum vehicular capabilities demanded for safe travel recognizing normal driver and environmental variances.

Applications. The following represent ways in which results of the proposed study would be useful. First, they would be useful in determining the routes on which specific classes of trucks could safely travel. Second, they would be useful to road designers--and those developing design standards--in effectively accommodating truck performance characteristics. Third, they might ultimately be used in determining the need for standards of performance for new trucks to assure that these vehicles do not present unacceptable safety risk when operated on the existing road system.
Truck Gradeability, Traffic Speed Variance, and Crash Propensity

Background. Although limited information is available about the traffic interaction effects of large trucks, most studies of their safety impact have relied on crash histories or focused on handling and stability properties. One interactive effect of much potential significance is the speed differential between large trucks and other vehicles in the traffic stream, particularly on long, steep upgrades. Existing knowledge of the effect of speed differential on crash frequency—based largely on work done almost three decades ago—pinpoints the danger of large speed differentials. This matter warrants re-examination not only to confirm or deny the previously developed crash relationship but also to examine characteristics of the truck population that affect the maintenance of speed on road segments of varying grade and, hence, that might affect the rate and pattern of crashes.

Objectives. The objectives of this study are to re-establish the relationship between the rate of highway crashes and speed variance within the traffic stream, to examine the capacity of the existing truck population to maintain speed, to ascertain the role of such truck factors as weight/power ratio and governors on speed variability, and to ascertain the extent to which vehicle regulations designed to reduce speed variability would enhance safety. Both two-lane and multilane facilities are to be considered.

Applications. Typically the weight/power ratio and other factors that affect speed maintainability of large trucks have been largely unregulated. As weight limits ease, particularly with a tightening fuel supply, the possibility for increased use of underpowered trucks seems real. The safety threat may be aggravated by increases both in traffic congestion and the number of trucks on the road. This study is expected to establish the degree to which uniform speeds are essential for safe operations under current traffic and roadway conditions. It is also expected to determine if trucks pose a special threat for which remedial action through vehicle regulation is warranted.

Conditions for Safe Operation of Large Trucks

Background. For decades, the operations of large trucks have been restricted to roadways on which they could be operated safely, where their weights could be carried without excessive damage to bridges and pavements, and where their presence would not violate economic or environmental sensitivities. In view of this long tradition in regulating truck operations, the difficulty in selecting the designated trucking system—dictated by the Surface Transportation Act of 1982—was somewhat surprising. Regulators simply could not agree on minimal conditions necessary for the safe operation of twin trailer trucks and the longer tractor-semitrailers. Typical of the many
questions was whether 8.5-foot wide trucks could be safely operated if the lane width was less than 12 feet.

The STAA pushed a new line of inquiry regarding truck size and weight regulation. It implicitly recognized that there was no inherent size or weight level beyond which large truck operation was unduly hazardous. Explicitly, it added an important new dimension to truck regulation, that of determining the conditions under which a truck of given size and configuration could be safely operated.

Economic pressures for still larger trucks are intense and will continue. A rational, knowledge-based capability for determining conditions under which these trucks can be safely operated must be developed.

Objectives. The objectives of this study are to identify those roadway, driver, traffic, and environmental conditions most likely to be critical to the safe operation of large trucks; to summarize current knowledge about how minimally acceptable levels of these conditions are affected by variations in truck size, weight, and configuration; and to recommend research necessary to develop a rational method for determining where, when, and by whom trucks of a specific type and size can be safely operated.

Applications. Decisions are being made continuously about restricting truck operations to reduce hazard to the motoring public. The degree to which these restrictions will enhance (or degrade) safety is unknown. Most of the decisions are based on intuition not fact. The proposed study will outline a systematic approach which will eventually permit more objective decisions. To assist in the interim, it will provide a summary of current knowledge, structured specifically to support such size and weight decisions.

Methodology for Assessment of Safety Consequences of Incremental Changes in Truck Size and Weight Regulation

Background. The gradual growth through the years in truck sizes and weights reflects a persistent quest by the trucking industry for ways to increase productivity. Concerns by competing private interests as well as by public agencies charged with protecting the public investment in highways and in promoting safety of the traveling public have assured that truck size and weight regulations are a perennial concern of state and federal legislative bodies. To maintain creditability, proposed relaxations in truck sizes and weights are typically small. Unfortunately, the safety impacts of small, incremental changes in size and weight can not be quantitatively determined: legislative bodies are forced to rely more on hunch and intuition, tainted heavily by emotional appeals, than on scientific evidence. A methodology is needed by which safety impacts of legislative alternatives can be evaluated with relative ease and on which future knowledge can be expanded.
Objectives. The objectives of the proposed study are to examine methods that have been applied in evaluating the safety impacts of incremental changes in truck size and weight regulation, to structure a methodology capable of providing reasonable evaluations for use by both state and federal legislative bodies and of assimilating both current and future knowledge, and to recommend research necessary to make the methodology fully operational.

Applications. No single method is likely to meet the needs of all agencies which prepare evaluations for legislative consideration. The diversity in circumstance is much too great. At the same time, all would profit from a scientific inquiry that assessed current capacity for making quantitative evaluations of incremental safety impacts, that developed a methodology for extending this capacity, and that charted the direction by which future improvements could be realized. Otherwise, any hope for rationally dealing with the cumulative effects of multitudinous, small changes is nil.

DRIVER AGING

The Transportation Research Board is currently completing a comprehensive study regarding the aging population. Entitled "Study on Improving the Mobility and Safety for Older Persons," this committee-directed effort has examined a wide range of issues related both to mobility and to safety, concentrating on movement within the highway system. One special task undertaken by the study committee was to identify research priorities having promise for enhancing the travel safety of older persons. Careful consideration of these recommendations should be extremely useful in developing a research program for the 1990s which incorporates a concern for the changing age distribution of drivers and pedestrians.

Other members of the current FHWA safety panel have highlighted needs for research focusing on driver behavior and on ways to make passenger cars safer, both in terms of crashworthiness and in terms of crash avoidance. In view of the changing nature of the driving population, such research must make special efforts to recognize characteristics common to the older population such as increased fragility, impaired vision, delayed decision making, weakened response, and restricted range and speed of bodily movement. Unfortunately, the older population is perhaps the most heterogeneous of age groups, and explicit concern for its safety will doubtlessly complicate and extend research activity.

The following study is proposed as a complement to others directed toward the aging population of drivers and pedestrians.
Intersection Control Displays

Background. At-grade intersections seem to pose a greater hazard to the older person. Crashes involving older drivers and older pedestrians are more concentrated at intersection locations, and older-driver violations typify those associated with intersections, failure to yield the right of way or failure to observe traffic signs or signals. Such tendencies may stem in part from concentration of older-person travel in urban areas, places with a correspondingly higher density of intersections than in rural locations. At the same time, they also likely reflect age-related diminution in vision, cognition, and movement. Required decisions at intersections are often complex: some must be quickly made. The difficulty of decision making is compounded by the mosaic of visual stimuli diverting attention from elements most critical to safe driving and walking.

Objectives. The objectives of this study are to determine the extent to which presentation of traffic control information at intersections affects driver response and crash patterns, to examine any special needs of older persons for traffic-control information at intersections, to determine the adequacy of existing standards in meeting these needs, and to identify needed improvements. All aspects of intersection control displays are to be considered including the location and design of advance warning features, street and route indicators, delineation, signs, and signals.

Applications. The Manual on Uniform Traffic Control Devices (MUTCD) governs the application, location, and physical design features of traffic control devices both at intersections and elsewhere. This study will evaluate the adequacy of existing standards and guidelines in meeting the needs of older persons. Needed improvements will be suggested for possible inclusion in the MUTCD. Although the focus will be on needs of older drivers, improvements can be expected to benefit others of the driving and walking populations as well.

ROAD WEAR

Contract Incentives for Quicker and Safer Construction

Background. Most current indications point to an exacerbation of the hazard of future road construction and reconstruction. Recent efforts to alleviate construction threat have concentrated on traffic-control measures, measures designed to alert the driver to the construction zone and to provide proper instructions for safe travel through it. Although refinement of traffic-control measures almost certainly will be continued, the prospects for significant additional gains are not great. Much more promising are attempts to reduce the exposure of traffic to construction activity. If the exposure were to be halved, for example, a concomitant halving of the crash toll
Exposure can be reduced by a variety of means, including construction on new location, limiting construction to hours of least travel, and application of techniques, equipment, and materials which lessen construction time. The proposed study examines the possibility that construction time can be reduced through contractual arrangements that place a premium on completion date, that recognize the tradeoffs between profitability and convenience for the contractor and mobility and safety of the traveling public.

**Objectives.** The objectives are to determine the likelihood that project completion dates can be significantly advanced through enlightened contractual arrangements, to identify the most promising of these arrangements, to estimate their likely effect on exposure of traffic to construction risk, and to determine the incremental costs/benefits that would accrue to road agencies and the traveling public by their use.

**Applications.** Despite the fact that contract incentives have often been shown to be effective in reducing construction time, they seem to be regarded as being appropriate only for especially critical situations. The proposed study focuses on contract modifications for everyday use. It seeks to critically determine their anticipated costs and benefits. It has the potential for triggering sweeping changes in the way our construction business is done on the heaviest traveled thoroughfares throughout the nation.

**Transparent Construction**

**Background.** Another promising means for reducing the threat of road construction and maintenance operations is to make them "transparent" to the road user. Capacity would be maintained, speed changes would be unnecessary, and detours would be geometrically consistent with the remainder of the road. Perhaps roadside hazards of typical construction could be reduced as well. The downside of such efforts is primarily that of increased cost.

**Objectives.** The objectives of this study are to determine the likely effect that traffic flow restrictions have on construction safety, to determine the extent to which highway agencies are making an explicit attempt to increase the transparency of construction and maintenance activity, to identify situations where the concept seems to offer the greatest potential and the means appropriate in these situations for maintaining speed and capacity, and to evaluate whether safety and other gains would likely outweigh the added costs.

**Applications.** To the extent that this study can assess the success of past attempts to maintain speed and capacity through construction and maintenance zones, it should be of great
interest to all highway agencies. It should also be of interest in helping them to better understand the true costs of construction and maintenance restrictions imposed on highway users. At the same time, its most promising contribution would be in the identification of situations most amenable to cost-effective alternatives to current practices for the accommodation and control of traffic in construction zones.

Resurfacing for Travel Safety

Background. Resurfacing provides the opportunity to improve safety by reducing or eliminating rutting, increasing skid resistance, correcting superelevation and/or normal crown deficiencies, providing proper superelevation runoff and/or correcting other deficiencies in the longitudinal rate of cross slope change, eliminating edge drops, providing minor widening, etc. It appears that very little effort is currently being made to assure that safety-related surface deficiencies are corrected during resurfacing and that, at the same time, opportunities to further enhance safety are maximized. Otherwise, design agencies, in addition to maintenance agencies, would be much more frequently involved in resurfacing projects.

Objectives. The primary objectives of this study are to examine the extent to which state agencies are exploiting resurfacing programs as a means for improving safety, to identify techniques for doing so, to identify the kinds of data and the methods of analysis necessary for informed decision making, and to evaluate the cost effectiveness of such techniques. The study should also examine the extent to which safety-related surface deficiencies are currently being considered in programming pavement rehabilitation as well as the safety gains likely from intensification of such practices.

Applications. Annual resurfacing programs, largely driven by concerns of users for mobility and of highway agencies for costs, affect large mileages of our street and highway system. The added cost of assuring that the repaved surface is not only smooth and structurally sound but also enhances motorist safety is likely to be relatively small. If this study identifies suitable techniques that can be routinely adopted for resurfacing projects and if those techniques are found to be cost-effective in enhancing safety, their widespread adoption by highway agencies would be expected.

Use of Travel and Other Cues in Road Redesign

Background. Despite the fact that more accurate and complete information is available concerning existing roads than proposed ones, the process of road redesign differs little from that applied to roads on new location. Conceptually, the designer ought to be able to use the enhanced information to more reliably build safety margins into redesigned roads than into new
ones. For example, measured speeds should provide useful clues to driver expectations, crash histories should pinpoint original design deficiencies, the types of vehicles in actual use should dictate turning standards, driveway activity should highlight the hazards of turning movements, and edge dropoffs or shoulder wear should indicate a need for curve flattening or pavement widening. Unfortunately, sources of guidance on which the designer has traditionally relied—textbooks, design manuals, and standards—make little or no distinction between design and redesign activities and provide the designer little help in exploiting the enhanced information base.

Objectives. The objectives of this study are to determine the extent to which road redesign is currently being influenced by existing traffic, roadway, and environmental information, to develop a set of guidelines by which the designer can systematically make better use of this information in redesigning safer roadways, and to evaluate the likely safety impact should these guidelines be routinely used in roadway redesign.

Applications. As reconstruction and rehabilitation garner an increasingly large share of the total highway budget, it is important to seek ways through which safety can be enhanced at the same time that mobility is being maintained. The proposed study, focusing on the process of redesign, represents one of several approaches that may be necessary to achieve this important goal.

Effect of Pavement Wear on Road Safety

Background. With some exception, effects of pavement wear on traffic operations (primarily speed) and safety are largely unknown. Pavements inevitably crack, settle, polish, disintegrate, etc. as a result of traffic loading and environmental stress. During repair operations, the risk of travel is greatly increased. But the extent to which rough, uneven, and/or otherwise worn pavements increases the frequency of crashes is largely unknown. Are mechanical failures accelerated by joint faulting, are undulating surfaces likely to induce instabilities in large trucks, how frequently does the swerve to miss a pot hole result in a loss-of-control crash? Or, on the other hand, does a worn surface induce drivers to lower their speeds to levels that counter the otherwise increased risk of travel?

Objectives. The objectives of this study are to summarize current knowledge of the safety effects of pavement wear, to develop models for estimating the crash costs of both pavement wear and repair, to ascertain the effect of pavement wear on traffic operations, especially travel speed, to determine the kinds of surface defects of greatest hazard, and to identify the vehicles and/or vehicle characteristics most sensitive to these hazards.
Applications. One of the great debates regarding the 3R program has been whether resurfacing without concomitant safety improvements would result in safety degradation because the improved surface condition would mask built-in geometric hazards. The question, which remains relevant and largely unanswered, highlights the fact that quantitatively little is known about the influence of maintenance and repair activity on traffic crashes. The proposed study seeks procedures for estimating the likely effect of deferred repair activity on safety costs as well as the likely effect of repair activities on the costs of construction/maintenance-related crashes. To the extent that it is successful, safety can be interwoven into pavement life cycle cost models and can become a meaningful consideration in both rehabilitation and maintenance programming. Less ambitiously, the study also seeks to identify pavement surface defects posing the greatest safety risks as well as vehicles or vehicle characteristics for which these risks may be exacerbated. Such information will be useful in pavement surveillance activities, condition surveys, and possibly sufficiency ratings. It may also prove useful in determining vehicle characteristics conducive to safe operations on real but imperfect highways and, hence, might impact future vehicle regulatory activity.

URBAN CONGESTION

Safety Effect of Sacrificing Lane, Shoulder, and Median Widths for Additional Lanes

Background. Pressures from urban congestion are increasingly forcing the traffic engineer to seek innovative ways for increasing road and street capacities through traffic control in addition to construction improvements. Capacity gains are virtually instantaneous on facilities where additional lanes can be created by restriping: this seems to be an effective, low-cost tool in the battle to stem the effects of urban congestion. At the same time, the extent to which the reduced lane, shoulder, and median widths accompanying restriping may add to the travel risk is largely unknown.

Objectives. The objectives of this study are to summarize the known effects of lane, shoulder, and median widths on the safety of multilane, urban arterials, to determine the likely safety effect of restriping programs which increase the number of lanes on urban arterials at the expense of these widths, and to identify any particular situations—such as heavy truck travel, high speeds, or curving alignments—likely to significantly increase the risk of travel on restriped roadways.

Applications. This study is expected to ascertain the safety costs that may be associated with an effective, low-construction-cost means for improving urban mobility. With its results in hand, traffic engineers could more confidently make decisions about the efficacy of restriping programs. The study
would also begin to address the broader issue of the safety effect of lane and shoulder widths on multilane urban arterials and would be expected to provide a basis for more extensive future investigation.

Impact of Travel Congestion on Driver Behavior

Background. For many years traffic engineers have believed that drivers, acclimated to travel in large, congested cities, behave differently than those accustomed to driving elsewhere. As one manifestation of this phenomenon, street intersections in larger urban areas can accommodate more vehicles than similar ones in smaller cities, a manifestation attributed to behavioral differences.

More recently, spreading congestion seems to have been responsible for some disturbing trends as evidenced by driver violence on the congested freeways of southern California and perhaps more frequent driver disobedience of traffic control devices (for example, failure to stop during red signal displays) and rules of the road (for example, failure to yield). If persistent congestion does, in fact, increase violence, risk taking, and violations, it can be expected to diminish highway safety. The stress of congested driving may compound other personal health risks as well.

Objectives. The primary objective of this proposed study is to examine the extent to which traffic congestion increases both the stress of driving as well as the extent of risk taking in the driving population and, as a result, poses a threat to highway safety and other aspects of personal health. Secondarily, it seeks to document differences in crash patterns observable with varying levels of congestion in the urban setting. Differences between unanticipated congestion (such as that due to a traffic crash) and chronic congestion (such as encountered in the daily commute) would be examined.

Applications. This study seeks to better understand the threat to public health and safety of traffic congestion. Although its findings might highlight particular circumstances that pose exceptionally high threat and that warrant preventive measures, the study is motivated primarily by the simple desire to know more about the extent and nature of health and safety risks from travel congestion. The effects of congestion on mobility (travel time and delay) are reasonably well known: effects on safety are not.

Law Enforcement in Congested Traffic

Background. Among the many potentially serious effects of urban congestion is the difficulty of enforcing traffic laws during the periods of greatest traffic volumes, particularly on freeways and expressways. Relying upon pursuit, enforcement
officials are increasingly unable to apprehend violators during peak traffic periods. Even when successful, ticketing is a risky proposition to other passersby, caught in the ebb and flow of the perturbed traffic stream.

Objectives. The objectives of this proposed study are to examine the extent to which enforcement agencies are experiencing difficulty in law enforcement during congested periods and the risks that may be involved including those to both enforcement personnel and innocent passersby, to assess possible safety implications of suspending active traffic law enforcement under heavy flows, to identify and assess alternatives to pursuit as a means for enforcement of traffic laws, and to address legal barriers to the implementation of such alternatives.

Applications. Many state laws and local ordinances prohibit automated enforcement of traffic laws without stopping violators on the highway. However effective these prohibitions may have been in the past, changing traffic conditions demand that they now be subjected to careful scrutiny. Technological innovation has almost certainly not only lowered the cost of automatic enforcement techniques but also reduced the risk of error as well. A well executed research investigation could dispel many of the doubts of legislators and other key public officials and, if properly documented, could generate widespread legislative change.

Crash Avoidance Technology

Background. In at least a qualitative sense, much is known about the relationship between the act of driving and crash avoidance. For example, the dangers of driving while intoxicated or fatigued are well known. These conditions severely impair the ability of the driver to make the reasoned and accurate judgments necessary to drive safely: accordingly, the risk of crash involvement is greatly increased.

At the same time, recent research investigations seeking means for helping the driver more safely perform what amounts to be a very complex control task have been largely limited to those related to traffic control measures. Little else seems to have been accomplished to explicitly aid the driver in the many years since brake lights and turn signal indicators became standard equipment. At the same time, driving on extensive portions of the nation's road and street system has become a much more exacting task. More vehicles, more distractions, and more traffic control exemplify the added complexity.

Although the potential appears enormous, help from recent advances in electronics and communications technology has been given only a passing glance. With road to vehicle communications, the driver could be informed of the presence of a hidden intersection or dangerous work zone or be advised to begin slowing for a safe stop at an upcoming traffic signal or to
safely negotiate a sharp turn. Vehicle to vehicle communications would expand the potential even further. Drivers could be alerted to the presence of threatening vehicles, rapidly approaching from a side road or stopped on the roadway ahead. It is time for a detailed investigation of the potential for crash avoidance systems which capitalize on the unique capabilities of modern electronics and communications technology.

Objectives. The objectives of this proposed study would be to identify traffic and roadway situations where advance "warning" or "advice" to the driver would likely result in significant safety gain, to assess the ability of modern technology to provide such information in a timely fashion, to estimate the costs of implementing the most appropriate technology, to evaluate the process by which such technology could ultimately be phased into the highway/motor vehicle inventory, and to identify additional activity necessary for the development of performance standards and for the development of a cooperative public/private enterprise.

Applications. Some on-board devices, such as brake lights and speedometers, are certainly essential for safe driving. Others with apparent potential, such as polarized lighting, have remained only neat ideas to be reexamined at some later and perhaps more appropriate time. Certainly there is no accurate way to determine whether electronic devices, yet to be devised, might prove to be of such worth as to warrant wide deployment. At the same time, the potential is sufficiently great to justify rather thorough research investigation.

OTHER SUGGESTED ACTIVITIES

Despite the rich tradition of highway safety research in the United States and the demonstration of some spectacular successes—such as our evolving understanding of the safety effects of access control and the development of breakaway sign and luminaire supports—prevailing knowledge about highway safety is largely qualitative and based on considerable measure on intuition and judgment. We understand that roads are neither safe nor unsafe, that the degree of safety each offers can be built into it. Yet we remain unable to fully engineer our roads for safety: we are unable to make necessary tradeoffs between the costs of safety improvements on the one hand and the benefits they provide on the other. We simply have insufficient knowledge of the most likely safety effects of the many design and control parameters which influence risks of highway travel.

This examination of promising directions for highway safety research provides an opportunity for reassessing the way in which research is conducted and implemented. Certainly changes seem possible, at least at the Federal level, which offer potential for more rapidly building up the safety information database. Identified herein are five possibilities, each designed to meet one or more deficiencies in prevailing practice:
Increased use of preliminary scoping studies is one promising way to assure that research objectives are attainable and meaningful and to stimulate creative inquiry.

Independent research review panels can help to identify research that has failed to meet acceptable standards of scientific inquiry and can help to eliminate self-serving findings.

Implementation of a highway safety design circular series would highlight significant research findings, widely disseminating them among the safety, design, and traffic control communities and encouraging their testing and further refinement.

Changes in procedures for developing design and operational standards—bolstered by the commitment of additional funding—could result in a much more business-like approach to standards development and assure that safety implications are properly incorporated into standards as knowledge accumulates through safety research.

Possibly in conjunction with the SHRP long-term pavement performance study and continuing sophistication of HPMS, creation of a selective, primary crash database is now a practical alternative for supporting long-term safety studies relying on actual crash data.

**SCOPING STUDIES**

RFPs for contract research are often terribly optimistic about the amount of work that is expected in return for the money that is available. Research goals are often beyond the reality of that which is achievable; there seems to be a failure to realize that the process of learning is most often an evolutionary one, testing the prior base and extending it incrementally. At the conclusion, the real failure is not so much the inability to reach the lofty objectives that were sought. Rather it is the opportunity that was lost in failing to achieve more modest, but attainable, successes.

The creative aspect of much contract research is incorporated in the proposal preparation stage. Acceptance of the proposal firms the final project objectives, sets the methodology to be employed, identifies the data to be developed, specifies the analyses to be performed, and, together with the RFP, sets the standards by which the contractor's work is to be judged. Unfortunately, few proposers are able to properly review the literature, identify alternate data sources, select the best experimental designs, etc. Proposal preparation is a hectic
time: decisions have to be quickly made, budgets must be prepared, and qualifications have to be demonstrated.

Scoping studies, adding a second, independent phase to contract research, represent one possible approach for alleviating these difficulties. Performed either by the contracting agency or by another under contract, such a study would precede the main research effort, detailing its scope and evaluating the likelihood that significant findings can be developed. It would entail a critical evaluation of the current knowledge base. Contract objectives would be sharpened, and methodology and databases would be tentatively selected. The scoping study would assure that proper attention was given to the critically important project preliminaries and would allow and encourage creative expression.

Whether scoping studies can, in fact, improve the quality of contract safety research is unknown. However, because they address a real need, they seem worthy of careful consideration and evaluation.

INDEPENDENT REVIEWS

If real progress is to be made in the advancement of safety knowledge, a much more effective means must be implemented for evaluating the reliability of contract research. For a variety of reasons, including self interest, neither the researcher nor the contracting agency is able to provide an unbiased evaluation, determining what is good and what is bad about the effort. In concept at least, results published in refereed journals have been subjected to rigorous evaluation. In practice, much potentially significant research remains unpublished, and the process of voluntary peer review in the highway safety literature has proven to be an unreliable test of validity and merit.

One approach to obtaining unbiased and critical evaluations of the scientific merit of safety research is for the FHWA to contract with independent agencies for such reviews. Effectiveness of such reviews would depend on an FHWA commitment to openly share their results.

HIGHWAY SAFETY DESIGN CIRCULARS

In 1963, the Automotive Safety Foundation published its "Traffic Control and Roadway Elements - Their Relationship to Highway Safety," a major compilation of what was then known about the link between safety and the roadway and traffic environment. The current version, a second revision titled "Synthesis of Safety Research Related to Traffic Control and Roadway Elements," was published by the FHWA in 1982. Although this publication has provided much useful information through the years, it fails to realize its potential as a meaningful guide for safety design and traffic control. Fact is not separated from fiction, nor myth
from reality. The most reliable models, the most strongly supported hypotheses, are not identified and highlighted. Quantification is not a compelling force in the synthesis, and information is quickly out-dated.

The designer, bent on engineering affordable safety into road designs, thus confronts a largely impossible task, that of extracting from the vast research literature a set of reliable safety relationships to guide design and traffic control decisions. The designer is ill-equipped to evaluate the integrity of research findings and is prevented from doing so by time constraints. Help is needed.

To fill this need—perhaps the most compelling in highway safety today—development of a serial publication devoted to highway safety design is proposed. An advisory board could help determine the subjects to be covered, a separate circular would be devoted to each. Revisions would be commissioned when new findings eclipsed prior knowledge. A premium would be placed on brevity but technical citations would be encouraged. The direction would be toward quantification, the focus would be on design and traffic control. Only the most strongly supportable relationships would be featured in each circular: a complete review of all prior work would not be attempted. Additional validation and further refinement would be encouraged.

STANDARDS DEVELOPMENT PROCESS

There is considerable consensus within the safety community that highway design and traffic control decisions often do not reflect practices which enhance safety. In part the blame is placed on ineptitude of the designer. Serious claims have been made that our institutions of higher education have failed to effectively incorporate safety in their transportation curricula, that employers have failed to provide suitable opportunities for their designers to stay abreast of developments in the safety arena, that designers do not know where to seek the latest and best information, and that the standards which guide the decision-making processes fail to adequately incorporate safety features. Some believe that the situation is likely to worsen in the immediate future as retirements deplete the ranks of competent design professionals.

While the ultimate goal is safety-conscious design—design which surpasses minimally acceptable conditions imposed by standards and exploits gains made possible by unique site-specific conditions—it is overly optimistic to expect that much more emphasis can be focused in the university curriculum on safety or that highway designers in general can have special expertise in all phases of their work. At the same time, it is reasonable to expect that design standards will reflect the most recent safety advances. Properly applied, such standards will significantly ameliorate potential hazards embedded in highway design and traffic control practice.
Because the process by which highway standards are developed in the United States is the product of many years of evolution, change will be neither quick nor easy. A study is proposed to assess the current process, to identify reasonable alternatives, to assess their monetary and other implications, and to recommend, as appropriate, process-oriented improvements. Assurance is sought that the process of developing design and operational control standards will consciously seek out the latest knowledge of safety impacts, that it will address whether added expense of more stringent standards is likely to produce justifiable savings in crash costs, and that it will enable tradeoffs of the effects of a dollar being spent on one safety and/or mobility improvement versus another.

SELECTIVE CRASH DATABASES

While numerous techniques are used by researchers seeking to more fully understand highway safety, ultimate validation of findings is most often sought in crash records. Fortunately, recent years have witnessed tremendous improvements in crash reporting and in the development of accurate crash databases. Not only is there greater uniformity in the types of data collected in the individual states, but there are also two extensive national databases, the Fatal Accident Reporting System (FARS) and the National Accident Sampling System (NASS). FARS is noteworthy by virtue of the fact that it represents a complete census of fatal accidents and NASS, by virtue of its in-depth studies of a statistically valid sample of all police-reported accidents.

Unfortunately, each of these nationwide databases has serious deficiencies, particularly with respect to the quest to better understand the association between crashes and attributes of the highway facility. Neither database records exposure to risk; FARS ignores non-fatal injury crashes, a much more extensive crash population and one likely to statistically strengthen the findings of crash studies; and NASS focuses on the vehicle and the driver. Of perhaps even greater concern to the safety researcher is the tendency of late for individual states to relax requirements for crash reporting.

The safety researcher seeking complete and accurate crash and exposure data for the entire nationwide highway system is simply fantasizing. The cost for developing the kind of database necessary for detailed crash studies is much too great. Much more reasonable are nationwide efforts (1) to develop detailed, short-term, project-specific databases--an example is the database assembled for evaluating the safety effectiveness of wide edgelines--and (2) to develop and maintain over a long period a general crash and exposure database on a selected sample of highways.

Proposed herein is a study to examine the effectiveness of
prior efforts to develop short-term, project-specific crash and exposure databases and to determine both the wisdom of continuing such efforts and ways in which future improvements can be realized. More importantly, also proposed is an immediate investigation of the feasibility of linking a safety component to the long-term pavement monitoring program of the Strategic Highway Research Program (SHRP). The SHRP sample will be unique in the kind and amount of information about traffic (certainly including heavy trucks), pavement condition, and pavement maintenance activity, each collected by nationwide sampling. The systematic integration of crash data may provide a minimum-cost opportunity to develop a long-term database which will be of great significance in assessing the safety impacts of both pavement condition and vehicle type and may be useful in many other types of safety investigations as well. Alternatives to SHRP as a means for establishing a long-term, crash/exposure, sample database should also be investigated.

CONCLUDING REMARKS

Weighed against a historical backdrop of spectacular achievement in highway safety is a continuing toll of human tragedy unmatched by other current threats to personal health and well being. This is but one of the many contradictions clouding the highway safety issue and fueling debate about the character and extent of future safety improvements.

The view expressed herein is that, because of a host of factors including the level of sophistication already reached on many of the nation's major highways and because of noteworthy enhancements in vehicle design, the rate of future safety improvement will be much slower than that realized in the past: future gains will require considerably more effort and will be much more costly. Future research must be more focused, more refined, and more critically evaluated. Although safety threats along a broad front must be countered, more care must be taken in channeling precious research funding into areas of greatest potential payoff. More effective means must be found for introducing research findings into professional practice. In short, the task ahead demands a fresh look at the way the nation's highway safety research business is conducted.