

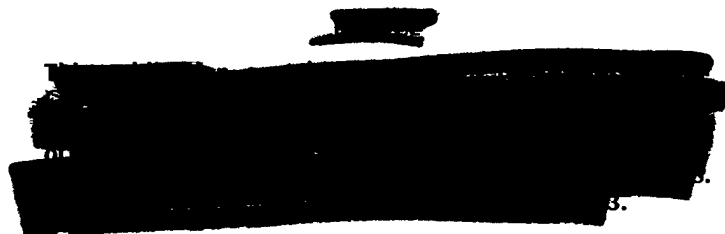
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Inadequate Self-Discipline as a Causal Factor in Human Error Accidents

D. Runcie
University of Alabama Project Director

D. A. Seaver
PNL Project Manager

March 1991

**Prepared by the University of Alabama
Tuscaloosa, Alabama for the U.S. Army
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INADEQUATE SELF-DISCIPLINE AS A CAUSAL
FACTOR IN HUMAN ERROR ACCIDENTS

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D. A. Seaver, PNL Project Manager

March 1991

Prepared by the University of Alabama
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Pacific Northwest Laboratory
Richland, Washington 99352

PREFACE

The present report is part of a coordinated research initiative sponsored by the US Army Safety Center. The University of Alabama research is examining the possibility of identifying those Army personnel who are at high risk for accidents because of their inadequate self-discipline. The project also investigated the effects of motivational programs on safety and made several proposals concerning motivational factors. The University of Alabama research team is also investigating related questions of the degree of accountability for those who have been involved in accidents, and an analysis of the most frequently violated Army procedures.

EXECUTIVE SUMMARY

Previous analysis by the U.S. Army Safety Center (USASC) has shown human error to be involved in a majority of accidents. About 45% of these accidents can be attributed to inadequate self discipline (ISD). ISD includes such factors as inadequate attention, poor attitude/motivation, overconfidence, avoidable fatigue, and use of drugs or alcohol. Of particular concern, however, are accidents in which individuals willfully and knowingly fail to use proper procedures. The objective of the present research effort is to assist the USASC in developing a program to reduce human error caused by ISD. To accomplish this objective the following tasks were undertaken: (a) a literature review of journal articles and technical reports dealing with human-error accidents in general, plus a special emphasis on articles that focus on the relationship between such accidents and Army demographic and behavioral data; (b) a comprehensive review of motivational factors which may influence ISD; (c) data which are contained in the Army recruitment file were cross-referenced with studies in the literature which have shown these factors to be associated with accidents; (d) a motivational system was developed, and (e) recommendations were made.

The literature review examined about 200 studies in the time period 1945 to the present. The best of the studies reviewed clearly how factors involved in accident research can be controlled so that better data is collected and more accurate conclusions made based on those data.

Cross-referencing available personnel-file data and the findings in the accident literature produced a list of factors which might predict ISD behavior in soldiers. The factors based on past behavior are given the greatest importance (e.g., previous traffic violations; previous accidents; DUI, drug/alcohol history; disciplinary offenses; criminal offenses; work record). In addition, the literature less strongly indicated certain demographic variables (e.g., early social/parental relations; intellectual ability/aptitude; socio-economic status/education; age; life events; peer relations.)

Selective use of motivational strategies in safety research is clearly indicated and would include: (a) point system; (b) the use of non-punitive motivational systems such as social reinforcement, tangible reinforcement,

competition, goal setting and feedback, and (c) the development of an organizational safety climate scale.

We recommend the use of both behavioral and demographic data to identify high-risk ISD individuals. The most cost-effective approach would be to examine such data in the records of individuals who have been involved in ISD-type accidents and compare it to data from an accident-free sample. The samples would be equated on dimensions such as accident opportunity, length of service, etc. We also recommend that the joint use of the motivational strategies (described in the previous paragraph) be tested in field studies.

The legal option noted no legal obstacles to: (a) the cautious and prudent collection of relevant data; (b) the application of validated traits which do not cause a disparate impact on constitutionally protected classes of recruits; or (c) the use of point systems for motivation of personnel as outlined in the body of the manuscript.

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INTRODUCTION

A review of the research literature from 1920 to the present provides a clear picture of growth and development in the techniques and methodologies used for studying accidents. In step with these evolving methodologies are the changing attitudes to human error and more sophisticated interpretations of data. It can be seen from the perspective of 60 years of research that the most realistic indicator of future undisciplined behavior is a history of accidents where inadequate self-discipline was a causal factor.

Early studies that attempted to understand the causes of accidents tended to be flawed. It was often assumed that some causal factor, such as accident proneness, might provide useful answers. Instead, due to confusion about the concept itself and the lack of a shared definition of the term "accident proneness" there resulted from these early studies much that was contradictory and of little utility in better understanding accident causation. A new look at the concept from a statistical perspective shows that accident frequencies follow a negative binomial distribution rather than the Poisson which would be expected if no factor other than pure chance were operative. This revitalizes the concept of accident proneness.

Many of the earlier studies tended to use a "shotgun" approach in which a large number of variables would be associated with accident frequencies. The absence of a theoretical framework linking these factors to accident causality and poor problem conceptualization resulted in many factors being suggested as causal factors in accidents. Subsequent research has shown many of these variables to be both inadequate and misleading in establishing an accident-prone index. In the present report, behavioral indicators available in military files are cross-referenced with indicators of inadequate self-discipline found in the literature. This approach holds promise for predicting those in the Army who will exhibit inadequate self-discipline based on a military history of indiscipline. Recent developments in the literature indicate improvement and further development of viable conceptual models. Building on what is seen as best in the literature this report assesses point systems as they could relate to the Army. The report concludes with recommendations for motivational and safety strategies that can be used by the Army. Strategies that have proven successful in other contexts and could have military application include goal setting, graphic feedback, team competition and tangible incentives. Motivation for safe behavior is strongly influenced by the safety climate of the organization; development of a safety climate scale and its possible application are discussed.

DETAILED SUMMARIES OF KEY RESEARCH STUDIES

General Methodological Studies

The Montag & Comrey (1987) research relates a modification of Rotter's Internality-Externality (I-E) Locus of Control Scale to driving behavior. The modified I-E scale was administered to 200 individuals who had been involved in a fatal driving accident, and 200 control subjects drawn at random from the driving population.

The study makes the case that those who show an internal locus of control (see events as being under their control) tend to be more cautious in their driving behavior. This, and other literature, suggests that internals are more attentive and adept at avoiding unnecessary risk, and are generally highly motivated to perform well in a variety of settings. In the context of the present study, the findings reported here have considerable face validity, as they fit nicely with what would be predicted from the general I-E literature.

Another feature of this research is the development of an I-E scale specifically for use with drivers. The more general Locus of Control Scale has sometimes not been effective in specific situations with the result that more specific scales have evolved to meet the needs of those working in circumscribed areas. This

I-E scale for driving reports Driving Internality to be negatively correlated with fatal accidents and Driving Externality to be positively correlated with fatal accidents. A problem remains is that those involved in fatal accidents may wish to attribute accidents to chance factors. The authors present some data that this is not the case; more research is currently being conducted on this question.

Shannon (1986) approaches accident data from an epidemiological perspective. The focus of the paper is to explore the plausibility of Risk Homeostasis Theory (RHT) (which states that conventional, non-motivational safety measures will fail to reduce the accident per unity time of exposure) from a methodological perspective. RHT postulates that in risky situations individuals will adjust to their level of acceptable risk. This is seen as a closed-loop process where acceptable risk operates as the reference variable; the number of deaths due to road accidents is a direct function of how much time is spent on the road multiplied by the acceptable amount of risk individuals are willing to assume.

A number of difficulties with RHT have surfaced, and while the discussion of RHT is itself interesting, the more general methodological issues dealing with accident reporting and data analysis deserve special attention. Some possible alternate explanations of RHT based upon methodological issues are considered.

1. The change in accident rate over time suggests that the level of acceptable risk must have changed over time. Conceptually this is difficult to accept, as homeostasis is defined by its property of resistance to change and of returning to some set-point.

2. It is also possible that individuals may be aware of total accidents rather than accident rates. This would suggest that with population increases there would be the perception of more accidents even though the actual rate may be decreasing. If the level of acceptable risk is based upon the perception of accident frequency a number of variables will influence that perception, including vividness and frequency of reports in the media. This would suggest short-term fluctuations, whereas in the data base being considered, fluctuations were gradual and over a 35-year period.

3. The quality and consistency of data have a bearing on the rates. At one time a driving fatality was recorded if the death was within 60 days of the accident, now a fatality is recorded only if the death is within 30 days of the accident. During the period of the study there have been changes in the way in which driving distances were estimated. There have also been notable improvements in emergency medical care for road accident victims.

While these factors clearly have an effect on accident rate data they do not appear to provide an explanation for the decrease in accidents. The changes noted appear at some particular point in time, whereas the decrease in accidents has been a continuous process.

4. A number of covariants may have also changed. The sex, age, and experience of drivers may have changed; with increased affluence, faster and more powerful automobiles may be purchased and driven in different parts of the country. The construction of freeways which separates motor traffic from pedestrians and cyclists may decrease accidents through good engineering, but may increase accidents because of increased usage and greater speeds. It is clear that only a very sophisticated analysis can deal with these issues.

5. The distribution of deaths for different classes of road use has changed (pedestrian, cyclist, motorist, etc.). This probably represents changing preferences for modes of travel. The pattern of change in fatalities for each mode of travel does not mirror the change in usage for each mode.

6. Finally, there have been a number of safety measures implemented over the period of this study; some of these have been of a non-motivational nature and some are difficult to classify one way or another. As these various measures have been introduced continuously over time it is the opinion of Shannon (1986) that they are responsible for the gradual and continuous decrease in accidents.

The McKenna (1983) paper examines the concept of accident proneness and attempts to explain why the history of this concept has been so controversial. If accidents were a random occurrence then they would be described by a Poisson distribution; if, on the other hand, there was a differential probability of certain individuals having an accident then a negative binomial distribution may be expected. Given that the negative binomial has historically given the better fit, it follows that the concept of accident proneness should be accepted. There are several difficulties in accepting the accident proneness concept on these grounds. In interpreting the negative binomial as evidence for accident proneness, it is necessary to control for such factors as differential occupational risk and biases in accident reporting across jobs. Even when these factors are adequately controlled, there is no reason for assuming that when a Poisson distribution is not found that the cause is some unknown personal variable. It is just as reasonable to assume that the cause is some unknown non-personal variable. In addition, some critics have pointed out that the negative binomial can be derived from assumptions that do not include differential initial liability to accident involvement. It has been shown that the negative binomial can be derived from assumptions of equal initial accident liability if the occurrence of an accident alters the probability of further accidents.

It has been stated in the literature that a few people are responsible for many accidents (e.g., 4% responsible for 36% of accidents). This claim has been refuted often, and the finding explained based purely on the laws of probability. There is considerable confusion as to whether accident proneness is a unitary concept or a mixture of various psychological factors. Furthermore, there is a lack of consensus as to whether it is a general characteristic which will generalize across different environments; there are some who subscribe to the concept of accident proneness while rejecting the generality notion. An additional, but related concept, is to regard accident proneness as an innate and unmodifiable characteristic. Those viewed in the above manner, are seen as carrying their accident proneness "hung like an albatross around each person's neck" (McKenna, 1983, p. 66).

It is clear that there is no universal concept or standard definition of accident proneness. What appears promising in clarifying the concept is the use of certain concrete operations which can be conceptually linked to a reasonable definition of accident proneness. It has been shown that locus of control, field dependence, ability to switch attention, and life events scores can be linked to a concept of accident proneness and that these measures show the possibility of improving our understanding of the psychological processes underlying human performance errors.

Klein (1976) in his paper dealing with social aspects of exposure to highway crashes, notes that with an increase in funding from governmental and private agencies that many sophisticated researchers have become market driven and have moved into the area of accident research. The problem, he observes, is that these investigators come from rather narrow disciplines and then apply their technology to an aspect of accident research that is amenable to that technology. The domain of investigation becomes restricted to the area where the researcher's technology and accident problems overlap. The social perspective is to view a highway accident and its resulting trauma as a public-health problem involving a variety of interactions among psychological, sociological, cultural, legal, political, educational, and other factors.

One by-product of this narrow view is unquestioned support of the status quo in accident research. This in turn results in a great deal of research being directed at attempts to modify driver behavior, and very little effort being directed at the driver's environment. Evidence is accumulating to demonstrate that programs directed at one aspect of driver behavior are seldom effective. There is little in the way of program evaluation, or cost-benefit analyses, and in cases where this is adequately performed the results have not been encouraging.

Klein contends that the driver and his environment are too narrowly defined. For example, research on passive restraint in motor vehicles has been superior in quality and overwhelmingly superior in quantity to research directed at public resistance to the use of these same passive restraints. Many programs of research and public action are directed at the average driver. It would be of greater value to identify those who are at greatest risk and then direct research and intervention programs at them so that limited resources can provide the most advantageous cost-benefit ratios.

It is suggested that investigators have noted the association between a number of variables and accidents. In this context it is not suggested that any of these variables be used to screen the accident prone, but rather to better understand the characteristics of those who are likely to be involved in accidents. This is based on the belief that automobile accidents are not isolated behaviors but rather one index of general tendencies "you drive as you live" (Klein, 1983, p. 216).

In order for the social perspectives approach to work, Klein feels investigators must get beyond their own technical specialties, show trust in the efforts of others from different disciplines, and adopt accident research as their primary affiliation. In many cases researchers see accident research as

a source of data to investigate a problem outside the area of accident research. Until investigators see themselves primarily as accident researchers and are able to educate the research establishment to the potential contributions that the social perspective can make we will have a fragmentary approach to the problem of human error.

Summaries of References - Task 2 and 3

A study of fatal and disabling private motor vehicle accidents in the Third U.S. Army included a review of the literature, an analysis of prominent characteristics of third army accidents, an identification of the personal characteristics of a sample of the accident-involved drivers, and a comparison of the accident-involved and a group of accident-free drivers on those personal characteristics (Beall, 1972).

The literature review indicated that prior criminal offenses, previous traffic violations, driver age, and drug and alcohol abuse were related to the accident involvement of drivers in general. Among the personal characteristics of accident-involved army drivers were years of military service, military rank, record of previous traffic violations, record of non-traffic disciplinary offenses, and several aptitude subscale scores. The analysis of the matched groups of accident-involved and accident-free army drivers indicated that these same personal characteristics significantly discriminated between the two groups of drivers.

Beshai (1984) analyzed data on accidents and on drivers convicted of alcohol-related traffic offenses (ARTCs) during a 4-year period in Los Angeles County and California. The indications were that, although ARTCs and accidents decreased across time, recidivism was higher for ARTCs than for accident involvement.

Clayton (1985) noted that participants at the symposium agreed without exception that young people are involved in more accidents and are overrepresented in fatal accidents. Among the factors identified in various studies, age, inexperience and gender were found to be significantly related to accidents. Also, the number of miles driven was useful in the prediction of accident rate.

In a study (Ferguson, McNally, & Booth, 1983) concerning the high accident rates for initial enlistees in the Navy, hospital admissions and deaths due to accidents were analyzed for a group of such personnel during the first four years of enlistment. Personal characteristics such as age, education level, and mental ability at time of enlistment were also analyzed. It was found that, when considered alone, each of the personal characteristics was significantly correlated with accidents; however, when considered simultaneously, education level was the only characteristic which related significantly to accidents.

Finn and Bragg (1986) attempted to use misperception of risk to account for the overrepresentation of young people in traffic accidents. A group of young male drivers and a group of older male drivers estimated the risk of accident involvement using several methods: A questionnaire about accident involvement, ratings of riskiness of photographs depicting driving situations, and ratings of riskiness of videotapes of driving situations. The results indicated that young people tend to misperceive the riskiness of driving situations, a failure which may contribute to their over-involvement in traffic accidents.

As part of a study validating two personality scales as predictors of industrial accident risk, a review of the literature relating accidents and personality characteristics was conducted (Hansen, 1988). The review revealed a consistent relationship between accidents, both industrial and traffic, and maladaptive behaviors as manifested in delinquency, criminal acts, marital and/or familial problems, and problem drinking, among others.

A group of repeat traffic violators in California was evaluated to determine whether subsequent driving record could be predicted psychometrically after a group intervention aimed at driver improvement (Harano, 1975). The results indicated that

driving record and criminal record were the best predictors of future driving record. Age was also a factor associated with collisions.

Jonah (1986) reviewed research concerning the risk of involvement of young people in traffic accidents and supported the contention that young drivers are at a greater risk of accident involvement than are older drivers due to their tendency to take risks while driving. Epidemiological data lent support to the hypothesis that young drivers are overrepresented in traffic accidents. Data from self-reports and observations of driving behavior supported the hypothesis that it is their propensity for taking risks when driving which is a primary contributor to the greater accident involvement of young people.

California has established a reexamination program (REX) for those drivers who accumulate two major traffic violations within three years (Kadell & Peck, 1984). A comparison of 6,000 reexamined drivers with 6,000 controls revealed that the REX information improved the prediction of future alcohol-related traffic violations over driving-record information alone.

As part of a dissertation analyzing accident proneness in fighter pilots, an extensive review of factors related to accident proneness was conducted (Koz, 1984). Among the

variables indicated by previous research to be related to accidents and accident risk were socioeconomic status, previous accident history, aviation aptitude scores, vocational interest test scores, and type of parenting.

As part of a study of the relationship between human factors and aircraft accidents and near accidents, 34 U.S. Air Force C-5 pilots were surveyed regarding possible human factors problem areas which could affect the flight experience (Majors, 1984). Among the areas noted were cognitive skills and information processing, fatigue, problems with attention, changes in moods and/or emotions, career and promotion difficulties, and life events and/or changes. It was also found that 17.6% of the pilots reported a history of significant behavioral, cognitive, emotional, and/or interpersonal problems or changes.

Personality factors which have been found to be associated with traffic accidents were delineated by McGuire, 1976. The accident driver has been described as tending to possess a more disturbed life history including such experiences as an unhappy childhood, delinquency, family disruptions, and an uneven work record. Age of the driver has also been found to be related to accident occurrence.

The concept of accident proneness was analyzed by McKenna (1983) and factors relating to individuals who are repeatedly involved in accidents were delineated. A review of accident literature indicated, among other things, that people who have more accidents at home tend to have more accidents at work.

The symposium participants examined data on young California drivers involved in traffic accidents and convicted of traffic violations (Peck, 1985). The analyses revealed that although young drivers are overrepresented in traffic accidents in comparison to older drivers, the factors which correlate with accident involvement and risk are similar for all age groups. It was found that the best predictor of accident risk was the number of 1-point traffic convictions.

A brief review of accident literature was conducted as part of a study of personality factors associated with traffic accidents (Pestonjee, Singh, & Singh, 1980). Previous research indicated that driver age, driving experience, marital status, and previous traffic conviction records were consistent predictors of accident involvement. A study comparing 20 accident-involved drivers with 20 accident-free drivers revealed a number of personality factors which differentiated between the two groups of drivers.

A questionnaire concerning alcohol and drug use and the occurrence of alcohol-related consequences (ARCs) was administered to 484 males and 552 females aged 14-15 years (Plant, Peck, & Stuart, 1984). Approximately 20% of the males and 13% of the females reported at least one significant ARC. Effective predictors of ARCs for both sexes were found to be factors associated with leisure activities and bar frequenting. In addition, drug use was positively correlated with accidents in general and with ARCs. For males, drug use was a significant predictor of ARCs whereas deriving pleasure from drinking was predictive of ARCs for females.

In this study (Risser, 1985) of the relationship between traffic conflict (TC) situations and accidents and the role of driver behavior in increasing accident risk, 201 drivers were observed in a standardized driving test. Subsequently, 196 of these drivers were interviewed about their driving experience and their record for the previous five years. It was found that TCs and accidents were positively correlated and that there was a positive correlation between driving errors and accident records and TCs.

The frequency of accidents was evaluated for 597 hospital employees representing 46 jobs grouped into 6 job levels (Sanders, 1964). It was found that there were more accidents for

lower level jobs than for higher level ones; however, there were no significant differences in the frequency of accidents within a given job level.

In this dissertation (Sipes, 1986), the psychological profile was studied as a means of identifying human factors which contribute to aircraft accidents. The literature review revealed that accident repeaters tend to experience problems with interpersonal relations, erratic work histories, and difficulty with authority figures.

Voicu and Nereuta (19985) examined the relationship between aptitudes and efficient work functioning for equipment operators whose tasks involve accident risk was evaluated using a battery of assessment instruments. Based on a sample of 35 operators it was found that factors such as intelligence (e.g., use of abstract ideas, reasoning), memory for numbers, attention flexibility, and speed of visual information acquisition, among others, were significantly related to efficiency of functioning.

The social interactive aspect of driving behavior was discussed by Wilde (1976), and a brief review of pertinent literature was conducted. It was found that level of education and the amount of beating and/or bossing around by parents were related to driver aggression.

Williams, Henderson, and Mills (1974) briefly reviewed the literature on factors related to traffic accidents revealed that

four variables are associated with the occurrence of traffic accidents: (1) youth of the driver; (2) the driver's attitude concerning risk and danger; (3) a pattern of maladaptive and strong emotions; and (4) the social irresponsibility of the driver. A study comparing 100 serious-offense drivers with 99 matched controls using a battery of assessment instruments indicated that socioeconomic status, occupation, and type of driver training were significant discriminators for the two groups.

Motivation and Intervention Studies

The Larson et al. (1980) research is important for several reasons: 1. The subjects were members of a paramilitary organization, i.e., police officers.

2. The targeted behavior is on-duty driving. Given the social structure of most police departments, driving violations by police are rarely reported or recorded, unless they result in an accident. As in certain military settings, the evaluation of police driving is complicated by the remoteness and isolation of the job activity. In addition, the results of both safe and unsafe behavior are inconsistent and rare e.g., safety awards, accidents, or reprimands.

3. Due to high exposure and emergency/pursuit driving, police have a high accident rate.

4. The Larson et al. study is methodologically sound.

These investigators studied the use of the tachograph--a clock-driven recording device which provides a permanent record of vehicle functions. Tachograph units were installed in 224 vehicles of a metropolitan police department (Nashville). Three sections of the department received the "Feedback" treatment at different time intervals and baseline length in a multiple baseline design. Supervisory personnel monitored (a) use of emergency lights (b) high rates of speed and (c) non-movement over 30 minutes.

Two treatments given to the "Traffic Section" after tachograph installation (no feedback and feedback from sergeants) as well as the installation itself had little or no effect. Larson et al. then introduced a "Feedback plus inspections" condition. Here tachograph records went directly to the Inspections Section of the department -- a unit responsible for compliance with rules, regulations and policies. When necessary, they requested explanations from the officer and his or her sergeant and also administered disciplinary actions.

In the traffic section, the Feedback/inspection treatment led to the virtual elimination of personal injury accidents and at-fault accidents were substantially reduced. The remaining two sections were given just the Feedback/inspections treatment condition after a baseline (no tachograph) condition with similar

results. The rate of officer related accidents during baseline was 1.47 per 100,000 miles, but showed a marked drop to .85 during the intervention. The data also revealed that the tachograph/feedback program was cost effective.

At the onset of the program, officers reacted negatively to the tachograph, which they termed the "iron sergeant". By the end of the data collection, however, tachograph use was accepted as routine.

Larson et al. attribute their results primarily to feedback. However, increased accountability and disciplinary actions obviously play a major role in this outcome. It should be noted that accident rate reduction only occurred when the Inspections Section monitored the procedures. Reliance on field sergeants alone to provide feedback was not effective. It may be that the sergeants' close working relationships with their subordinates undermines the effectiveness of the feedback procedures, at least without a strong "back-up" by higher authority. This factor should be considered in any military application of the tachograph/feedback technique.

The use of automated recorders on vehicles, combined with feedback, warnings, and point systems, might be applicable to Army safety. For example, the new flight data recorder for helicopters could provide information on unsafe flight practices, leading to feedback, warning letters, points, and/or hearings for

pilots. Also, if a pilot accumulated a certain point level, the recorder data might be sampled more extensively -- thus focusing on pilots showing a tendency toward inadequate self discipline.

The Haynes, Pine and Fitch (1982) study is selected for analysis due to the following reasons:

1. It is a good example of the organizational behavior modification approach.
2. It uses relatively low-cost techniques that are applicable to military organizations.
3. It focuses on outcome variables, i.e., accident rates, severity and cost.

Haynes et al. studied the effectiveness of an intervention package (feedback, competition, and incentives) in reducing accidents of mass transit operators. The setting was a regional transport authority in a large midwestern city. Despite prior interventions, e.g., a disciplinary code, safety awards, this authority continued to have the high accident rate common to city buses.

The experimental design consisted of two facets (a) bus drivers were randomly assigned to a control group (N = 325) or an experimental group (N = 100). The experimental treatment was also evaluated through a within-group reversal design.

For the experimental group, four operators were selected as team captains and four supervisory personnel as team sponsors. Twenty-four team members were then randomly assigned to each of the four teams.

Accidents were defined as any contact between the bus and a vehicle or fixed object, regardless of fault or extent of damage and/or when a passenger reported on the operator observed injury. A number of built-in reliability checks were used to enhance the reliability of accident reporting.

Prior to the intervention, baseline accident data was collected for 15 months. The intervention strategy was then administered to the experimental group for 18 weeks. It consisted of three components. Haynes et al. (1980, p. 411) describe them as follows:

Performance Feedback. Performance feedback charts were posted in the operators' lunchroom and updated on a daily basis. Each team's chart consisted of the name of each member on the vertical axis and the date for each day of the program across the horizontal axis. Green dots were placed next to the operator's name under the corresponding date for each accident-free day; a red dot when the operator was involved in an accident.

Team Competition. Accidents were assigned points based on their classification. Avoidable vehicle accidents were

assigned 3 points, passenger accidents 2 points, and unavoidable accidents 1 point. Accident classification was made by management personnel who were not aware of the names of operators who participated in the program. Teams competed for the lowest number of total accident points per 2-week period. Each member of the winning team(s) received his/her choice from a menu of available incentives. All teams started over again with 0 points at the beginning of the next 2-week period. (team competition, a common strategy for behavior change, moves the focus of reinforcement contingencies from the individual to the group.)

Incentives. The incentives that were available to each member of the winning team averaged \$5 in value and ranged from cash to free gasoline to free monthly passes on the bus system. Team captains and sponsors, along with incentive group operators, were encouraged to suggest desirable incentives. A double bonus was added for teams that were involved in no accidents for the entire 2-week period. In addition to the monetary incentives, each of the winning team captains was personally congratulated by the director of operations, and the team sponsors were congratulated by the general manager of the transit authority. When meetings were impossible to schedule because of time conflicts, personal letters were sent to the winning captains and sponsors.

Following the intervention, the incentive program ended and the feedback charts were removed. Data were collected for an additional 18 weeks (Baseline I).

No differences were found for accident rates during the two baseline phases, as expected. However, during the last 10 weeks of the intervention, the experimental group showed a statistically significant 35% lower accident rate than the control group. Also, accident costs differed substantially during the intervention phase (experimental = \$35; control = \$116) and to a lesser extent in Baseline II (experimental = \$28; control = \$76).

Another interesting effect was seen during the intervention phase. Experimental group drivers were involved in 39.7% fewer "avoidable" accidents and 23.7% fewer "unavoidable" accidents. It appears that even certain of those accidents classified as "unavoidable" may be affected.

Furthermore, the benefit-cost, ratio appears quite favorable, being approximately 4.6:1. and at least 3:1.

Interviews with experimental-group drivers revealed that they tried to minimize the risks they took. Thus, it appears that the intervention motivate drivers to reduce high-risk behaviors.

Given these results and considering relative simplicity and how cost of the intervention, the procedures used by Haynes et al. are worthy of consideration.

Zohar's (1980) research on safety climate is selected for several reasons:

1. It delineates theoretical and applied implications of the organizational safety climate.

2. Zohar's data helps define the organizational safety climate.

3. The study is a good illustration of a useful methodology to construct and validate a scale of this type. Zohar defines organizational climate as a summary of perceptions which organization members share about their work environments. These perceptions serve as a frame of reference for guiding adaptive (and sometimes maladaptive) task behaviors.

Schneider (1975) has proposed that specific climate measures be used in an area of research. In the safety area, Zohar (1980) has developed and validated an organizational climate scale. Also, reviews of the literature (Zohar, 1980; Cohen, 1977) defined six key organization characteristics which differentiate high versus low accident-rate companies. These were as follows (for successful companies):

1. A strong management commitment to safety, e.g., safety officers had a higher status in low-accident companies.

2. Strong emphasis on safety training.

3. Open communication links and frequent contacts between workers and management, e.g., frequent safety inspections.

4. General environmental control and good housekeeping.
5. A stable workforce with less turnover and older workers (this may reflect good personnel practices).
6. distinctive ways of promoting safety, e.g., counseling, recognition, etc.

Based on reviewed literature, Zohar decided that the safety climate questionnaire would contain the following dimensions:

1. perceived management attitudes toward safety
2. perceived effects of safe conduct on promotion
3. perceived effects of safe conduct on social status
4. perceived organizational status of safety officer
5. perceived risk level at work place
6. perceived effectiveness of enforcement versus guidance in promoting safety
7. perceived importance and effectiveness of safety training

Scale construction involved using seven Likert-type items for each of the seven dimensions. The scale was then administered to 120 factory workers. Factor analysis revealed eight factors, including the original seven factors. The final safety climate scale contained five items per factor.

In order to validate the scale, Zohar administered it to twenty factories in Israel. Five factories each were randomly chosen from the four areas of: metal fabrication, food processing, chemicals, and the textile industry. The average

safety climate score varied significantly across factories. In general, chemical plants had the highest scores, whereas food processing plants have the lowest scores--a finding which seems to reflect the high risks involved in chemical production.

Safety inspectors also ranked the factories within each area as to safety practices. Correlation coefficients (Rho) between climate scores and inspectors safety rankings were .90 (metal), .80 (chemical) and .50 (food). Given the small Ns, these coefficients should be interpreted with caution.

Zohar's research points the way for a similar approach to assessing military safety climate. Initial factors and items could be selected on the basis of the research of Zohar (1980) and Lindsey et al. (1983). A sample of 200-300 Army personnel from several units would be given the Army Safety Climate Scale (ASCS). The data then would be factor-analyzed and the final scale constructed.

A validation study would entail administering the scale to samples of personnel from a number of Army Units (e.g., 30), then correlating ASCS scores with objective measures of safety, e.g., accident rates, from the USASC database. Care should be taken to match of weight accident data for different types of units, exposure rates, and other key variables. Another possibility would be to run correlations only across units in the same category--e.g., ASCS scores correlated with accident rates in 15 transportation companies.

TASKS II & III

Recruitment File Factors Related to Accidents

Within a trait (or personal characteristics) model of accident prediction/prevention, a ready made approach to assessment and classification lies in the review of recruitment and incumbent files of Army personnel. The current review -- cross-referencing available personnel file data and the findings in the accident literature--holds promise. Directions for pilot studies can be discerned. Caution should be noted, however, in that trait models are inherently limited in their ability to explain behavioral outcomes. Second, most studies relate to driving outcomes. Third, some studies are themselves somewhat vague in their definitions of personal characteristics or events. Finally, recent studies comprise a patchwork, non-theory-based approach to the problem of accidents (or safety). The trends that seem worthy of preliminary application and further study comprise six (6) realms containing 20 factors (see Table 2).

These realms include:

- I. Driving behavior (4 factors)
- II. Military Service (2)
- III. Drugs/Alcohol/Disciplinaries/Crime History (3)
- IV. Social/Intellectual/Achievement (4)
- V. Demographics (4)
- VI. Life Events/Peers/Work History (3)

Within these larger constructs, the factors which appear to have the most consistent frequent support in the literature are as follows:

1. Previous traffic violations (5 studies)
2. Previous accidents (3)
3. DUI, Drug/Alcohol History (*)
4. Disciplinary offenses (4)
5. Criminal offenses (3)
6. Early social/parental relations (4)
7. Intellectual/Aptitude (5)
8. SES/Education (mixed results) (4)
9. Age (mixed results) (9)
10. Life events (*)
11. Peer relations (2)
12. Work record (2)

The use of such factors in decision-making may include screening out, directing to low-risk assignments, or providing markers for follow-up. A limitation (and needed remedy) to the current studies, however, is the absence of job analyses that would indicate risk factors endemic to the particular setting or task. It should also be noted that the trait factors cited in this review do not account for fluctuating events/stressors that might influence safety-oriented behavior.

Validation or follow-up should select some or most of the factors cited in the Table. Such studies would include the possibility of measuring a sample of recruits on each factor, determining risk-factors of their assigned MOS, and following their accident/safety performance for a period of months/years. A parallel retrospective study might be designed using data from incumbents records.

In addition to recruitment file factors, psychological measures of attitudes and personality traits could be used as predictors. However, as the literature review indicates, such measures may have low predictive validity. The most likely candidates for further study are the following:

1. Driving Internatlity/Externality
2. Immaturity
3. Adventurousness/Risk Taking
4. Egocentricity
5. Aggressiveness
6. Emotionality
7. Impulsivity
8. Overconfidence

Recruitment File Factors Related to Accidents*

Reference	Previous Traffic Violations	Previous Accident History	Driving Experience **	Type of Driver Training **	Military rank	Years of Military Service	DUI, Alcohol, and Drugs	Non-Traffic Disciplinary Offenses	Criminal Offenses	Early Socialization and Parental Relations **	IQ and Aptitude	Socioeconomic Status **	Education Level	Age	Age at Enlistment	Job Type and Level	Marital Status	History of Life Events and Changes	Negative Peer Relations **	Uneven Work Record
Beall (1972)	X				X	X	X	X	X		V			X						
Beshai (1984)						X	X							X						
Clayton (1985)			X																	
Ferguson et al. (1984)											B		X		X					
Finn & Bragg (1986)														X						
Hanson (1988)							X	C	X					X				D		
Harano (1975)	E								X					X						
Jonah (1986)														X						
Kadell & Peck (1984)	E																			
Koz (1984)		X								X	F,G	X							X	
Majors (1984)								H											X	
McGuire (1976)								C		J,J				X						X
McKenna (1983)		X												X						
Peck (1985)	K													X						
Pestonjee et al. (1980)	X		X											X			X			
Plant et al. (1984)						X														
Risser (1985)		L																		
Sanders (1964)																X				
Sipes (1986)																			X	X
Voicu & Nereuta (1985)											M									
Wilde (1976)										N			X							
Williams et al. (1974)				X								X		X		X				

* Factors denoted by the letter X are generic in that they are no more specific than the factor names themselves. However, factors denoted by the letters A through N refer to elements which are more specific than the factor names.

** The factors could be obtained from enlistment interview or obtained from "request for waiver disqualification" form. The other factors come directly from the recruitment file. This information was obtained from an Army Recruitment Office.

Related to Information in Recruitment File Factors

and to Accident Involvement

(Associated with Attached Table)

- A. Subscale scores: arithmetic reasoning, radio code, and clerical speed
- B. General Classification Test (mental ability)
- C. Delinquency
- D. Marital strife
- E. Driving record
- F. Aviation aptitude scores
- G. Strong Vocational Interest Blank
- H. History of behavior problems
- I. Unhappy childhood
- J. Family disruptions as a child
- K. Number of 1-point convictions
- L. Previous traffic accident history
- M. Speed of receiving information test; verbal intelligence test; Raven's Progressive matrices; Kohs Cubes; WAIS memory for numbers subscale; attention flexibility; motor reaction time.
- N. Amount of bossing and beating from parents

TASK IV

Recommendations:

Motivational Strategies and Safety

A. Point System

1. A point system for safety violations should be instituted in the U.S. Army. The initial version of such a system should be tested in the Aviation branch.

Given our recommendation that a point system be field-tested, the specifics of the system are described as follows:

1. Field-testing the Point System in Army Aviation Units.

The initial version of the point system will apply to pilots and co-pilots in Army aviation. Four types of units should be represented in the field-test sample: Assault/Utility, Cavalry, Assault Support/Chinook, and Fixed Wing.

This study involves the implementation and field-testing of the point system. The effectiveness of the system in reducing ISD-type behaviors and related accidents will be determined. Possible refinements to the system, based on the field test, will be considered. Test results will be used to develop recommendation concerning Army-wide implementation.

The estimated cost of this field testing is \$100,000.

2. Publicity.

The point system will be publicized as follows:

- a. A written description of the point system will be distributed before initiation of the system.
- b. A talk by CDRs on the point system will also be given before initiation of the system.
- c. A written reminder will be distributed 6 months after the start of the system.

3. Point Guidelines.

A Unit Safety Committee composed of the CDR, the Safety Officer, and the individual's Platoon Leader will assign points according to the following guidelines:

- a. Class IA-type violations: 5 points

These violations are defined as:

Any unsafe action which is a knowing, willful, and flagrant, violation of Army regulations or rules. Furthermore, this action put aircraft and personnel in danger.

- b. Class IB-type violations: 3 points

These violations are defined as:

Any unsafe action which is a willful and knowing violation of Army regulation or rules. Such actions are potentially (or actually) dangerous.

- c. If Class IA and Class IB violations cause an accident, an additional 5 points are assessed.
- d. A booklet containing specific examples of approximately 20 Class IA violations will be distributed to commanders. These examples will be taken from USASC records of violations which resulted in accidents.

For example:

<u>Violation (IA)</u>	<u>Example</u>
1. Unauthorized low level flight	a. A Huey pilot made an unauthorized low-level flight over a bay to show passengers "some beautiful scenery." The aircraft crashed due to a wire strike.
<u>Violation (IB)</u>	
1. Improper maneuver	a. Pilot tried to fly out of an uncommanded right turn by using his own method (a power reduction) rather than using all available left pedal.

2. Improper maneuver

- b. Pilot attempted a series of tight turns in order to quickly reverse course. This maneuver is non-standard and not found in the Aircrew Training Manual. Pilot also failed to respond appropriately to co-pilot's request to terminate such maneuvering.

4. Extenuating circumstances:

- a. The commander can reduce the points assigned by 1 point, if he justifies in writing the extenuating circumstances.
- b. This option is available only if the violation did not cause an accident and is classified as a IB violation.

5. Warnings.

The number of points assessed should be specified by the Unit Safety Committee directly and also in a warning letter.

- a. Warning letters should be sent every six months specifying the number of points. Such letters serve as valuable cues for avoiding unsafe behavior.

6. Tracking.

The points assigned and a record of the violation and accident, if any, will be placed on the Form 759 for the appropriate time period.

After 3 years, personnel who have no at-fault accidents violations will have Class IB (3 point) safety violations removed from their records. Class IA violations and at-fault accidents will be removed from their records after 5 years.

7. Point Reduction Incentives.

- a. Each one year period free of violations and at-fault accidents reduces the point-count total by 1 point.

Administrative Actions

Ten points, whether from one or nine HR episodes, will trigger an administrative action for the evaluation of that individual, if the 10 points are acquired within any one year period. Fifteen points within any two year period also will trigger board actions.

Experience over time will allow refinements on point requirements for board actions. After further study and evaluation, the computer will be programmed to alert the Commanders of personnel who acquire the number of points within the time limitations. It will also alert MILPERCEN and/or other agencies responsible for management of the system. When Commanders are so notified that an Administrative action for an individual is due, the Commander will convene the appropriate board within three weeks.

Following the Board action, the disposition of the case must also be entered into the data base within three weeks, or the appropriate MILPERCEN agency will be alerted to follow up onto the action and close the loop.

Evaluation Board actions may include a number of disciplinary actions. However, we recommend, at the very least, temporary flight restrictions and loss of flight pay for 30-60 days.

During a one-year time period following administrative action, major favorable personnel actions should be highly restricted, e.g., selection for promotion.

It should be noted that the point system should serve as a supplement to the systems in place, rather than a replacement.

B. Non-punitive Motivational Strategies

1. We realize that certain of these strategies are already being used in the U.S. Army, for example, extensive safety training, safety awards, etc. However, given the success of a variety of motivational strategies in civilian organizations, research in this area appears warranted.

2. We propose a study using three to four Army transportation and/or aviation units. These units should be large enough and their duties hazardous enough so that they have relatively substantial accident rates. However, if baseline rates are too low, observational data on HR behaviors could serve as a criterion.

The research design will be a multiple baseline design. Due to the U.S.A.S.C. database, baseline data already will be collected at the start of the study for outcome measures, that is, one to two years of prior accident and injury reports.

Three to four strategies seem appropriate to include as our "safety intervention package." They include goal setting, graphic feedback, team/unit competition, and tangible incentives. The units involved should participate in the design of the team/unit competition and the selection of incentives. Outcome criteria will be measured to determine the effects of the intervention, that is, accident rate, costs, and injuries. Recorded observations of high risk behaviors, if possible, would be valuable.

The intervention phase of the study will take one year (a longer-term study is also possible). During that time, the "safety package" will be initiated at different 2-month intervals for each unit. After the tenth month, the data will be analyzed and a cost-benefit analysis done.

3. We realize that this proposal does not focus on personnel with inadequate self-discipline. However, such people (a) may be hard to identify; (b) when identified, will be targeted by other countermeasures, for example, a point system; and (c) should react to elements of the safety package, for example, incentives, peer pressure generated by competition, etc.

C. Recommendations: Organizational Safety Climate

1. Motivation for safe behavior is strongly influenced by the organizational safety climate. An important report on safety climate in Army aviation units was published by the U.S. Army Safety Center (Lindsey et al., 1983). Similar research on the organizational characteristics of Army ground units with excellent safety records should be undertaken, and the findings well publicized. That is, a report detailing those qualities characteristic of Army units with excellent safety records should be distributed.

2. An Army organizational safety climate scale would be useful for diagnosis and evaluation. A scale of this type should be constructed and validated. To facilitate acceptance of this scale, as well as to gain other valuable data, the safety climate scale might be integrated into a broader "Organizational Climate Scale." This latter scale could deal with the perceptions of Army personnel as to a unit's effectiveness or motivation climate and/or other areas of interest to the Army.

Indicators of Inadequate Self-discipline

A Recommended Validation Study

Basically, the general research strategy is to use the 20 recruitment file factors/indicators as a predictive scale--Safety Indicators Scale (SIS). The SIS would be constructed and validated as follows:

1. Phase I: About 800 personnel would be used as subjects, including 400 subjects identified as causing IA (and IB if needed) accidents. Accidents would be sampled from jobs/tasks indicated by our research to result in costly and frequent accidents, e.g., combat vehicle drivers, etc. Four hundred subjects with no at-fault accidents would serve as controls. Control and experimental subjects would be matched on relevant variables.

The total sample would be split in half with 200 ISD personnel and 200 Control (C) subjects. Recruitment files would then be used to get data on each indicator. Standard techniques would then be used to weight each indicator as to its value in predicting in which group (ISD or C) the subject would be placed (Similar to the construction of a weighted application blank of biodata form. See Appendix C).

The total SIS score would then be used to predict membership in each group. Given reasonable and statistical success, the next phase would begin.

2. Phase II. Since characteristics of the original sample might affect the specific weights, the remaining 400 subjects would be used in a cross-validation study. SIS scores would be computed and used in an "Off-the-shelf predictive validity" design to classify the remaining 200 ISD and 200

subjects. Correlational analyses and the percentage of individuals correctly and incorrectly identified as to group membership would be calculated. These data would be used, in combination with accident base rates and costs in these specific jobs, to predict key criteria, e.g., "false positives," cost savings and fatality reductions.

Further Considerations. A major problem in the accident prediction is the low base rate of accidents. Even if the SIS predicts ISD-prone personnel reasonably well, it will still predict large numbers of "false positives." This, in itself, is not a major problem if the consequences of such predictions are not very negative, e.g., being briefly detained by an airport metal detector.

Thus, we would recommend the SIS, if valid, not be used as a recruitment selection device. However, it could serve as a placement tool for Army jobs in which accident rates are high and/or costly.

Cost. The estimated cost of this basic study is \$100,000.

Implementation and Possible Benefits

Assuming the SIS is valid, it could be easily filled out on a computer data sheet from a simple key and computer scored.

An example of the potential use and benefits of the SIS is given below, using data presented at the Feb. 2 USASC briefing. For a five year period, there were 1915 accidents for combat

vehicles in FTX's, costing 25.7 million dollars and 66 lives. Of these accidents, 38% were due to ISD (cost = 9.77 million dollars; 25 lives).

If we could identify a suitable cut-off point on the SIS that would bar even 20-25% of ISD types from combat vehicle training (they could still participate in other training, hopefully for lower risk jobs), considerable savings would occur. Just in the one area of combat vehicle FTX's, the savings over five years would be over 2 million dollars and 13-15 lives.

Add to this total other combat vehicle accidents and improved Army readiness and efficiency, and the potential benefits are considerable.

One further note--this example is based on only one area. Applied to several of the high-accident areas, the potential benefits would be striking.

LEGAL OPINION

This legal summary does not address the administrative remedies available to civilian personnel who might also, in time, be affected by incentive and disincentive programs along the lines proposed in the study. Such personnel are subject to the basically different employment regime erected by the Civil Service Reform Act of 1978 and the federal Personnel Manual. While relations with civilian employees are necessarily affected by institutional considerations not found in the military superior-subordinate framework, the civilian framework is equally complex and is believed to include sufficient flexibility so that the same broad purposes of increasing safety can be achieved.

The authors find no legal obstacles to: (a) the cautious and prudent collection of relevant data; (2) the application of validated traits which do not cause a disparate impact on constitutionally protected classes of recruits; or, (3) use of point systems for motivation of personnel as outlined.

Appendix A
Literature Review

TASK I

Literature Review

Years 1945 - 1969

In an Aviation Medicine article authored by Kalez and Hovde (1945) the authors boldly state that most aviation accidents analyzed "...were attributed to pilot error irrespective of the underlying contributing factors of the pilots temperament or capability", i.e., (p. 370) their temporary psychological compulsion is essentially an error of judgment. Pilots involved in nearly all such accidents present a long history of nonconformity as evidenced by their flight-training jackets. Occasionally they are below average aviators in every respect. These same analysts (1946) suggest also that accident-prone aviators can be assigned a pilot-error classification, a dangerous group with average or below average flight training records.

An interesting study conducted and reported by Horn (1947) identified the interval between accidents as being critical to assessing whether pilot error can be identified as the factor involved. The closer the time interval between accidents, the greater the probability that the second accident can be attributed in part to pilot error. The explanation offered by Horn considers whether the pilot has regained the required level of confidence, thereby reducing the chance of accident based on pilot error.

Acknowledged by the Editor of Aviation Medicine as the first

scientific analysis of the role of pilot error in military flight accidents, the data show that "...the accident rates are five times greater in the first month for those with one accident than the general service expectancy, and that it takes about a year for the accident liability group to return to normal..." (Horn 1947, p. 449).

In a study of 50 industrial plant employees conducted in the late 1940s, Harris (1950) found that "accident repeaters", as opposed to a matched group (n=250) of non-accident employees, tend to change jobs more frequently, have better health, have fewer children, are more interested in gambling and sports (based on biographical information from questionnaire), consider themselves to be nervous, and are inclined to be quick and sure in their actions (based on personality items). No differences were found between the two groups in terms of their responses to multiple-choice Rorschach items or the Rosenzweig Picture-Frustration items. The results of this study suggest, according to Harris (1950), that "...accident proneness, implying a psychological predisposition to get hurt, may [be]...greatly overrated" (p. 459).

The results of a study of two groups of 240 enlisted army personnel conducted by Beall and reported by Beall and Blumenfeld (1972) indicate that the non-accident and the accident groups differ (statistically significant at $p < .05$ level) on only five of 30 characteristics, including number of years of military

experience, record of disciplinary offenses, previous traffic violations, arithmetic reasoning score, and clerical speed score. It is also noteworthy that the authors state that their results "...probably will not generalize to civilian samples inasmuch as the military situation allows for the control of many more variables, thus acting in some ways as a moderator variable" (p. 628).

The use of a Drivometer, a device for measuring and recording driving behavior, served to generate some interesting data to test the hypothesis that drivers with different driving histories exhibit measurably different characteristics when tested on the same route in an instrumented car. Greenshield and Plott (1967) used various simulated road conditions and driving techniques to record events for a sample of high accident (n=40), high violation (n=20), and beginning drivers (n=40) which served as the experimental group. The control group was comprised of driver education teachers (n=17) and low-accident experienced drivers (n=23).

The purpose of this project was to identify "...some function of a set of driving variables that would discriminate between drivers of the different classes" (Greenshield & Plott, 1967, p. 207). Of a total of 12 variables five were found to be significant discriminators between the classification of drivers: traffic density, running time, accelerator reversals, macro steering reversals, and micro steering reversals.

Multivariate analysis was selected to test the hypothesis that drivers with different accident experience and driving records exhibit different driving profiles in ordinary driving. A pattern revealed a high degree of confidence in the discrimination between the different groups ranging from 67 percent for the high accident category to 100 percent for the high violation drivers. These analysts (Greenshield & Plott, 1967) surmise that the reason this high level of success occurred is "...that the higher the demands on a driver in performing a certain task, the greater the likelihood of driver failure with attendant higher accident probability" (p. 210). The authors go on to state:

Undoubtedly there is some balancing effect from recognition by the driver that the more difficult the task the greater is the risk and, hence, motivation of the driver to perform at his best. But there is a limit to a particular driver's performance ability (p. 210).

Using a general attitude survey and a driver attitude survey, a three-year follow up study of California drivers (n=1,700) tested in 1959 (Schuster 1968) found that previous driving record is a useful factor for predicting future driving record; specifically, accidents and moving violations. Using driver attitudinal, personality, and biographical variables, the item analysis, regression tests, and cross validation were based

on a subsample of 400 male and female drivers from the Los Angeles area. For males the post-test demonstrated a higher predictability for moving violations than accidents. For females, a nonrepresentative group in terms of accident experience, the percentage of accidents predicted correctly was 75%. The best prediction for either moving violations or accidents, according to Schuster "...was the appropriate attitude scale combined with previous driver record of moving violations and accidents." (Schuster, 1968, p. 21)

Such findings are encouraging, but Schuster's evaluation of California drivers counters somewhat the findings reported previously by Webb (1956). In a review of the prediction of the aircraft accidents literature compiled during the 1940s, Webb (1956) concluded: "The studies to date give strong evidence that accidents may not be predicted from preceding accident behavior" (p. 142).

The second group of eight studies reviewed combined aptitude for flight training measurers with pilot accident records. Again drawing heavily on research conducted during the 1940s, especially the World War II period, comparisons between pilot error accident groups and accident free control groups did show some differences, but these were not statistically significant at

conventional levels of measurement (e.g. .05 or less). Similar findings were reported for two flight accident performance studies conducted during the early 1950s where it was confirmed that "...faint and dubious relationship between the pilot stanine [pilot aptitudes for flight training] and accidents ...showed the relationship at approximately the 10 percent level of confidence" (Webb, 1956, p. 143).

Reporting on yet other studies Webb states that no significant relationships had been found between pilot error, aircraft accidents, and levels of education, work records, special interest, previous vocation, or the use of alcohol as stated by the subjects. The only significant relationship found was that of being physically scarred and accident proneness. Other important issues such as mood, inattention, temporary physiological states or levels of training and their relationship to accidents have not been explored according to Webb. The latter insight may not be surprising since such information generally is not reported in accident reports or other records made available to analysts engaged in predictive studies. What is clear, however, is that approximately 70 percent of the accidents are attributable to pilot actions or to individual differences in reaction time, while aptitude and capacity appear to be much less important (Webb 1956).

It is also noteworthy that Webb based his conclusions not on the review of extant literature alone, but also on the basis of existent measures. Perhaps more recent efforts and the more positive findings used to assess whether it is possible to select out accident prone or inadequately self-disciplined persons is a result of such refinement in our current measures.

Years 1970 - 1979

Contrary to the numerous reports which support the commonly accepted notion that a small number of civilian drivers or military pilots account for most accidents, Ferreira (1970) argues that the vast majority of accidents involve a large group of drivers with low accident likelihoods. These findings are based on statistical probabilities concerning a future hypothetical population of accident involved drivers, based on their present involvement. This report is of particular interest for two reasons. First, the statistics of choice were not useful for predicting the worse drivers. Second, examination of the six-year driving records (n=7,842 drivers) determined that drivers who averaged one accident a year during the course of the study actually accounted for only one percent of all accident involvements. Moreover, more than half of the drivers who recorded an accident during the first year of the study did not record another accident during the subsequent five year period. On the other hand, 88% of the total number of accidents for years

2-6 were recorded by drivers who were accident free during the first year.

Analyzing variables generated through project TALENT, a survey of approximately 400,000 high school students, Asher and Dodson (1971) evaluate whether driver training is effective in lowering automobile accidents and which of the 375 socio-psychological variables can be used to predict automobile accidents in the year following high school. A total of 7,996 subjects were compared based on two groupings: nonaccident group ($n=4,892$), and a group comprised of those who were the driver of an automobile that had been involved in an accident during a one-year period following graduation from high school ($n=849$). The total sample included 3,560 females and 4,436 males.

The variables analyzed consisted of a range of test topics including core curricula areas, intelligence scores, aptitude, achievement scores in abstract reasoning, language, and creativity, visualization in two and three dimensions, respondent background, plans for the future, study habits, health, career aspirations, and a socioeconomic-educational index. The statistical method employed was the Pearson correlation.

The results of this analysis suggest that a total of 40 predictor variables can be identified for males and 34 variables for females. Of these predictors, a total of 10 and 8 were found to be statistically significant ($p < .01$) for males and females respectively. Driver training did not prove to be a significant

predictor variable for automobile accidents; the results suggest that no differences exist between the male and female drivers involved in this study. The variables which did prove to be significant predictors, namely age at first learning to drive, occupational aspiration, whether one spoke Hebrew or Yiddish, kind of abode, how late one stays up on weekends, access to a car, socioeconomic-education index, sporting enthusiast, electrical items in home, and age of first date, were not evaluated by these two analysts who seem to be content to argue that driver training is not a relevant factor in preventing accidents.

Failure to observe (or look) and excessive speed were two errors which accounted for almost 54% of English road user errors reported by Clayton (1972). Using a sample of 210 accidents involving 348 road users, this analyst attempted to evaluate the driver error issue taking into account the role of the driver, environmental factors, vehicle factors, and what he described as complex interrelationships between these three elements. Several instruments were used in this evaluation including eye test equipment for visual factors, a highway code, and a three-stage decision model as well as on-site investigation of accidents. Most (85%) road users evaluated were drivers. Interestingly, 3.1% of the sample of road users were pedestrians, primarily from rural areas. Driving experience was significantly related to errors, a finding which was attributed to the relationship between age and driving experience.

Some road users, it was suggested, are incapable of monitoring two sources of stimuli, especially two traffic flows, at the same time. The issue of misperception error was considered to be more prevalent than a visual defect. Most errors of perception were also found to occur under environmental conditions of unfavorable or inadequate lighting or ambiguous situations involving road signs and road design. Where excessive speed was found to be a factor, the research team also determined that this factor was associated with road conditions (bends or crests in roads), sight distance, or vehicle defects (inadequate brakes or steering). Errors of panic reaction were also found, but these errors were attributed primarily to overreaction as opposed to rational response to the situation.

The "Spell theory" developed in 1963 by Cresswell and Froggett and described by Milosevic and Vucinic (1975) suggests that spells (periods of time during which people's performance in complex tasks is liable to be substandard so that during these spells they are more likely to incur an accident) may induce temporary accident proneness. Such spells are associated with fatigue, stress or sickness. Other psychological conditions are inferred as well, but are not delineated.

This theory, according to Milosevic and Vucinic (1975), is more consistent with the results of advanced research which goes

well beyond the theory of accident proneness first posed in 1919. But Spell theory also promotes the importance of human factors and the concomitant need to evaluate these factors. In their study of the observed distribution of accidents recorded by 134 train drivers for a five year period, these analysts suggest that the observed distribution can be explained with slightly differential power using Poisson, the negative binomial, or Short theoretical distributions. Thus, the human factors issue argued as being important was not taken into consideration.

This is not intended to suggest the report is (Milosevic & Vucinic, 1975) unimportant. To the contrary, the findings are quite important, suggesting that correlation statistical procedures may be more reliable than the distribution method and that support is still found for the accident proneness hypothesis created by Greenwood and Woods (Greenwood & Woods, 1919). On the other hand, the results do not advance previous reports intended to enhance the state of knowledge of accident-prone driver characteristics, nor are these effective for identification or as screening methods for selecting out such drivers prior to their incurring accidents.

A more recent statement published in Aviation Safety (April 1, 1984), however, is more encouraging regarding the human factors issue. Based on an ex-post-facto survey of flight surgeons who had served as members of aircraft mishap boards of

review, this unauthored statement reported that a study of 478 Navy aircrew members involved in mishaps (248 at fault-fliers and 230 not-at-fault fliers) differed on nine stressor variables often evaluated in the psychological literature. Two life events were: a) getting engaged to be married, and b) making a wrong career decision. The other seven stressors have to do with coping with stress including marital problems, trouble with supervisors or disciplinary action, trouble with peers or others, inadequate assessment of troublesome situations, difficulty in interpersonal relations, inadequate professional approach to flying, and immaturity-instability. In sum, stress does make a difference in flying behavior and the study is useful in that the findings can be used to develop predictive models of human performance.

Such findings and the implications suggested are supportive of the brief theoretical statement authored by Ware (1964). Although Ware's publication should be placed within an historical context, he made several important observations. The first refers to the inadequacy of methods of measuring and predicting performance. More importantly, perhaps, Ware addresses the complexity of individual and situational variables which affect human performance. Some of these variables are direct causal factors whereas others are thought to intervene and have an interactive effect on task performance.

Individual factors as well as situational factors when taken into consideration, according to Ware, should be considered in any systematic evaluation of performance. The utility of this argument has, we believe, been partially demonstrated in a vast literature developed around the post-traumatic stress concept and the more general assessment of the relationship between stress and abnormal behavior.

An enthusiastic report on a driver improvement program evaluation authored by Peck (1976) and published in Human Factors did not serve as the basis for "... a continuous stream of replicated experiments" (p. 503) simply because of the more advanced statistical and evaluation procedures later employed by the California State Department of Motor Vehicle's Research and Development office. Nevertheless, Peck does identify a major methodological problem, that of how to evaluate the "no shows" or non-respondents, which he states has been a source of difficulty in past evaluation efforts. It is noteworthy, however, that a similar kind of problem was identified in several of the studies conducted by this same R&D office during the early 1980s. The grandiose scheme reported in this interesting article did serve as the basis for the research and evaluation activities of this particular office.

An extensive co-authored study reported by Harano, Peck and McBride (1975) in the Journal of Safety Research is presented as

supporting remedial restrictive action against drivers who receive a certain number of moving violation convictions. In essence, the findings, based on use of a regression model and cluster analysis, when used together, show that previous traffic convictions significantly predict future accidents.

This report is a substantial review of the literature in the area of driver violation and accident involvement. A summary statement by the authors of one's driving ability, various socioeconomic factors, and certain personality and attitudinal factors, all represent statistically significant predictors of accidents.

The purpose of this report is unclear, if only because the methods and findings replicate the effort which has been conducted through the research component of the California State Department of Motor Vehicles. The authors state (p.19) that the purpose of their study was to evaluate the role of human factors in accident involvement, and to move beyond the various inadequacies of design and analyses of previous studies. In addition, the analysts included a battery of tests, also to overcome what is defined as a lack of previous comprehensiveness which they insist constricts the usefulness of all other research.

Numerous problems can be identified. First, as identified by the authors (indirectly at least), their study is flawed by

the very nature of their control and experimental groups. That is, the accident-free group (n=231) is compared only with a group composed of three plus accidents (n=196). Second, the subjects were from one large California county only. Third, on page 20, the authors state that their accident-free group was, in reality, only 80% accident-free. Nineteen percent had one or more accidents and one percent had three or more accidents. However, the researchers suggest that this methodological failure is acceptable because "subjects in this group with one or two accidents were also tested but were not included in most of the analyses (p. 20, emphasis added).

Although important steps in the procedures used to conduct this study are missing, the reader is nonetheless treated to information regarding the use of a DMV mobile trailer with sound proof walls and the fact that the air-conditioning unit was regulated at 70 degrees. The interviews were conducted by graduate students who were instructed (24 hours worth of training) in the aspects of personal interviewing and how to get a signed statement from the subjects.

A combination of paper and pencil tests, personal intervals, and tasks generated a vast amount of information including verbal skills, personality profile, Embedded Figures test, childhood experiences with parents, eye-hand coordination tasks, eye test and a physical check list, attitude and opinion scales developed

by the authors, reaction time, and a driving simulator test. Ninety variables out of 270 available from a cluster analysis were used in the multiple regression-covering the gamut of every conceivable kind of biographical, physiological, and socio-psychological information. The findings of various statistical runs are made comparing not only the control and experimental groups, but data are also presented for an "intermediate group" of 103 female drivers (see their Table 3 on page 27) and data for tested respondents are compared with nonrespondents (what does this mean?) are shown in Table 4 (page 28).

In sum, this is a most confusing exercise to follow. The findings are reported in an inconsistent manner, the test groups are confused, no theory is tested, and whatever findings were found to be significant serve as the basis for this report. The information reported is extensive, but the actual meaning of this exercise is lost in a quagmire of tables, figures, and discursive discussion of the "findings."

Attempting to establish the relationship between attitudes and accidents, Levine, Lee, Ryman and Rahe (1976) devised six scales based on a 22-item questionnaire. Use of the factor analysis technique produced six clusters of the 22 items upon which these scales were created: logic, adventurous, discipline, focus on immediate, and brashness. Only the four-item adventurous scale, measuring risk-taking, correlated significantly with accidents for a group of enlisted naval air wing personnel (n=156) based on an aircraft carrier.

According to Levine et al. (1976), a previous project conducted by Dunbar, the results of which were published in 1943, found that strict family discipline and a very religious upbringing were a part of what Dunbar described as an accident prone personality. The next highest statistical correlation with accidents found in the Levine et al. study was the logic factor among aviators ($p \leq .075$).

Consistent with the message promoted by Klein (1976), Clark and Prolisko (1979), replicating a study based on a Driver Role Scale, found that driving accidents are related to a model that places peer pressure to drink, drive and engage in risk-taking behavior in the forefront. Accident proneness again surfaces as a central concept. However, the results are strongly suggestive that those who hold little or no respect for the law, are easily influenced by their peers, and are not prone toward the roles of others, tend to be more prone to accidents. The authors suggest that any success in changing this response would undoubtedly be more successful provided such efforts were directed toward peer groups as opposed to individual drivers. Family relationships, as well as level of emotional maturity and family disruption, also are important factors.

Klein (1976), published an interesting, complex paper entitled "Social Aspects of Exposure to Highway Crash." The "data" reported are based on impressions and the logical

evaluation of social and economic events and characteristics which may have some effect upon a declining number of road fatalities documented and attributed to the previous imposed and recently rescinded 55-mph speed limit. Of particular interest is Klein's evaluation that despite a vast literature in the area of accident research, none has been documented as having had an effect in establishing a viable public policy to reduce accidents.

Although this particular report is dated, the ideas are noteworthy. One point developed is that the increased effort and funding dedicated to finding solutions may have unintentionally led to developments in the research which actually mask the true nature of the problem. That is, increased professional activities and what Klein describes as a parochialism in the field by specialists, may have led to symptoms of the problem being defined as the problem. According to Klein (1976):

it was almost inevitable that they would concentrate on what they [research institutes or bureaus] perceived as 'the problem'--that is, the driver, the vehicle, the highway, or an interaction among them--instead of perceiving highway crash and its resulting trauma as a public health problem involving complex interactions of cultural, social, political, legal, economic, ecological, psychological and other factors. (p. 212)

Parochial points of view also should be taken into consideration when the reported results of road violation and accident data are evaluated. According to Klein, the interests of specialized professionals and corporations (e.g. insurance companies) tend to skew the research methods as well as the nature of the data reported. Klein is also critical of those who seek both funding and then the use of data to test specific hypotheses which are found within a certain academic discipline. He is also critical of those (see p. 213) who, despite findings to the contrary, insist that techniques such as license revocation, driver safety education programs, and the media be used to modify driver behavior.

Funding agencies do not escape the critical assessment offered by Klein. The search for a better mousetrap, per Klein, suggests that analysts are encouraged to seek answers to the same problem using the organization's definition of the situation (the mousetrap).

The author's criticism of past efforts is both stimulating and challenging. But he also has recommendations to offer which should be given serious consideration. First, Klein argues that rather than focusing on the interaction between the driver and the environment, he proposes the use of a public-health or social problems approach, thereby taking into consideration individual

differences over time and among individuals. Citing his own previous findings, Klein further argues that severe crashes are not randomly distributed. Therefore, the research focus on average or typical drivers is inappropriate.

The sociological perspective, from Klein's view, also has something to offer. Drawing from the worker satisfaction literature Klein appropriately observes that the problem may not lie with specific portions of the driver's environment for which highway crashes may only be a symptom of the problem. The cause, then, is found somewhere in the vast array of interacting factors which lead to crashes. Symptoms then are often identified as the problem. Using sociological explanations allows the problem to be viewed in a broader context of life as a whole, including the array of activities, pressures, and stressors affecting individual drivers.

Other aspects of this important report include identifying the appropriate population(s) at risk, the search for sociological explanations, and sound long-term policies intended to reduce the fatality rate per 100,000 population, as opposed to per million miles of exposure, of the population at risk.

An interesting editorial published in the Journal of Safety Research (Benner, 1978) is focused not on generating statistically significant data to explain accidents, but on generating hypotheses which take into consideration multilinear

events. The method proposed by Benner, a safety researcher, is a simultaneous and sequential ordering of event sets. Application of probabilistic estimates of the frequency of occurrence of such events would, according to Benner, allow accident phenomena to be predicted with greater accuracy than has occurred through the general approach of using individual conditions or isolated events. Data would be generated, but as every researcher knows, the kinds of data gathered depends on the kinds of research hypotheses and questions generated.

Years 1980 - 1987

Borowsky's (1981) study of whether naval aviators who have accidents early in their flying career exhibit a higher future accident liability than pilots who do not have early aviation accidents is nonconclusive. Pilots who experience an accident during their first 1,000 hours did demonstrate a greater potential for accidents, but those who actually had a subsequent accident were small in number.

This study suffers from serious methodological flaws. Although the focus was on pilot-related error and the intent was to identify those who might be accident-prone, variables such as weather conditions, type of operation, operational decisions, and mission profiles were not used. Moreover, a well-defined control group, other than not having had an accident in the first 1,000 lifetime flight hours, was not used. The findings reported for this study tend to be limited in their utility.

In a continuation of the process to identify the characteristics of drivers involved in fatal accidents Garretson and Peck (1982) compare a group of fatal crash drivers with a group of drivers from California's general driving population. Similar to the results previously reported, drivers who had been drinking prior to the accident and those with worse driving records in term of road violations and/or accident records were differentiated from the general driving population.

The intent in this study is to identify the high risk fatal accident drivers through their distinctive characteristics. Males were found to differ from females in having more violations, accidents, and official DMV licensing actions. The fatal accident group as a whole did in fact differ from the general California population, especially in prior violations. The question is: why do these differences exist? The analysts do not provide an answer to this question and their use of discriminate analysis was not helpful in isolating useful predictor variables for useful discriminating the fatal accident driver.

A study of 2,576 Michigan State accident involvement and traffic violations record conducted by Evans and Wasielewski (1982) was intended to discern whether headway, a measure of driver risk, could be used to differentiate the involved from the non-involved driver. The authors conclude that "...accident-

involved drivers and drivers cited for violations exhibit higher levels of risk in everyday driving than accident-free and citation-free drivers."

This study is consistent with most common-sense interpretations of the relationship between driver, his/her vehicle, distance, and other vehicles. These individuals were observed, documented (by camera), and then had a record check through DMV (their license numbers were also documented by camera) and state files. Through a series of procedures the researchers were able to discern any discrepancies between the records and documents available to them and the information recorded on their photos which had been transformed into projected transparencies.

The results of a series of tests provide some evidence to support the contention that accident-involved drivers and traffic law violators, when compared to drivers with cleaner records, exhibit higher involvement and they also tend to engage in higher levels of highway risk driving.

Current traffic law violations can be successfully predicted, while current accidents cannot. These are the conclusions posed by Miller and Schuster (1983) after conducting a Driver Attitude Survey, a personality test linked to poor driving behavior. The purpose of this study was to establish long-term predictability of driving accidents and traffic violations using a complex data set which included driving record

and a measure of personality traits. This seven part Driver Attitude Scale had been used previously by one of the evaluators as a valid predictor of driving behaviors in short-term studies. The overall intent was to extend the predictive qualities of the previous effort.

The effectiveness of previous driver behavior in correctly classifying accidents ranged from 51% for Iowa drivers to 61 % for the random group. Two conclusions are drawn. First, there is a relationship between previous violations and current violations, but a similar relationship could not be established for accidents. Second, portions of the Driver Attitude Scale were useful in predicting current violations but were not useful for predicting current accidents.

The California experiments conducted by analysts employed by the State's Department of Motor Vehicle seem important and the results of these evaluations are encouraging. For example, in a brief statement written by Helander (1983), it is reported that one experimental group exposed to program reexamination, accident-avoidance sessions, and self-testing, "...demonstrated reductions in subsequent accidents in excess of 20% relative to comparable control groups." (p. 13). And, in a 1984 report on a negligent operator study by Kadell, in which the results of efforts at education of drivers, "conviction masking" are discussed (n=5,600), the reduction in both accidents (12%) and

convictions, and the cost-benefits ratio reported was in excess of \$5,400,000 annually (see also, Peck and Kadell 1983).

However, the analysts were unable to demonstrate whether the educational media used or the so-called "masking" of a recent offense actually contributed to their findings. Any actual reasons offered are too speculative to warrant discussion in this report. One question which can be raised, however, is who actually benefits? That is, when referring to the cost-benefit, the beneficiary of any proposed savings is who? The insurance company? A state insurance lottery?

Although the California experiments are of interest and the results reported are encouraging, no comparable findings are found to establish the reliability of these experiments. Indeed, in a later report, Kadell (1984) states the reasons for the effectiveness of the stimuli or incentives used are unknown. Moreover, Gebers and Peck (1987) conclude on the basis of a random sample of 161,509 licensed California drivers that although the accident frequency of individual drivers cannot be accurately predicted from knowledge of the prior driving record, drivers with deviant records, as a group, have much greater accident-involvement rates than clean-record drivers (see also page 8). In other words, "... prior accident frequency is not a good predictor of an individual's subsequent accident frequency. (p. 12). However, "... it can be concluded that, as a group, such drivers are more likely to be accident-involved than are

drivers with no convictions." (p. 16). Yet in another California study reported by Harano, Peck and McBride (1975), it was concluded that socialization, social conformity, and risk-taking are the dominant personal-centered factors underlying accident liability or accident causation. Many other previous reports tend to support these findings, including that of Hakkinen (1958) who found that attentiveness and behavioral stability are the best predictors of accidents.

The concept "accident proneness," according to Frank McKenna (1983), is replete with "conceptual confusion." This confusion, caused by definitions that are based in large part on exclusion, does not negate the importance of the general estimate which is that 90% of accidents can be attributed to human error. As stated by McKenna (1983), "...[such] data have not been controversial. Their interpretation has." (p. 65).

In this intriguing and interesting paper McKenna (1983) traces the conceptual and empirical evaluation of accident proneness, beginning with its introduction in 1919 by Greenwood and Woods, (1919) and the subsequent use of "accident proneness" to assess individual differences in accident liability. His evaluation of the reaction to findings by researchers and perhaps those who hold vested interests pertaining to the control of exposure to risk factors, provides a useful basis for assessing the issues of the two hypothetical distributions under

evaluation: a) the Poisson distribution--the equal chance to have an accident vs., b) the negative binomial distribution--or unequal initial liability to accident involvement. In the first instance, when the results of research are other than expected, analysts, in their attempt to explain the findings, will offer the negative binomial as a possible alternative distribution. If, on the other hand, the negative binomial distribution is used as a plausible explanation for accident proneness, then those charged with controlling the factors including nonpersonal factors that lead or expose one to risk to accidents become concerned. Thus an unknown personal factors as well as unknown nonpersonal factors could, it is argued, cause greater exposure to risk to accidents.

The analysts responsible for the original work in the area of accident proneness (Greenwood and Woods, 1919) also examined the reliability of accident involvement over time. That is, those who are prone to having an accident at one point in time also should be prone to having accidents during a subsequent time period. According to McKenna (1983), however, the generally low correlation coefficients resulting from studies conducted to test the accident proneness hypothesis do not provide much empirical support. Still, the methodological reasons explaining why low correlations are found, provide another good basis for understanding the confusion over the concept accident proneness.

In a summary effort intended to review the literature which associate several concepts with accident proneness, McKenna (1983) responds to five major issues, each of which has generated conflicting research results: a) most accidents are caused by a few people, b) accident proneness as a unitary personality trait, c) accident proneness as a general characteristic, d) accident proneness as an innate and unmodifiable characteristic and, e) accident proneness as both (tautological) a descriptive concept and as an explanatory concept.

In sum, McKenna (1983) argues that "...one of the reasons for the failure of accident proneness has been the lack of unanimity of its meaning" (p. 69). To move beyond the initial findings of 1919, McKenna further argues that the concept is best discarded and in its place should be substituted the concept of "differential accident involvement." According to McKenna (1983):

The advantage of the term [differential accident involvement] is that it denotes the study of individual differences without the historical confusions. It has the added advantage that it does not prejudge the issue in the way that accident proneness does. It is an area of study not a set theory. The central issue from this approach is to consider whether it is possible to predict or distinguish on the basis of psychological test those who are involved in accidents and those who are not. (p. 69)

In this new focus, then, McKenna's concept "differential accident involvement" would build on a literature that emphasizes factors such as reaction time, visual acuity and dexterity as well as switching of tasks. In addition, the stress literature which supports the thesis that those who experience more life events (cumulative stress or events) are more involved in accidents (temporary stressful state) also could be used. He also notes, with emphasis, that by using this analytical approach the traditional assumption that accident involvement is necessarily a stable (condition) phenomenon would not be made. Rather, a theoretical view of differential accident involvement would lead to an understanding of the psychosocial processes and factors underlying human error. And, as suggested by McKenna, this understanding could lead to further training where appropriate, selection when necessary, and redesign of the environment if possible.

The reorientation suggested by McKenna offers one other major difference. Rather than attempting to create statistical models of accident proneness, which allow comparisons to be made based on information gained from numerous studies, differential accident involvement is based on psychological testing. The rationale for McKenna's (1983) argument is as follows:

The concept of accident proneness is arrived at through a process of exclusion. An attempt is made to control all

factors relating to risk exposure, accident reporting, etc. If a result then occurs it is attributed to something else-- this something else is accident proneness. Accident proneness is thus defined not by what it is but what it is not... [if] the statistical approach were completely successful then the result would be that we would still know literally nothing about the psychological antecedents of accident involvement. The alternative approach being advocated, if successful, both demonstrates differential liability and provides some information on the antecedents of this differential liability. (p. 70).

A Technical Report, authored by Ferguson, McNally and Booth (1984) is a reprint of "Individual Characteristics as Predictors of Accidental Injuries in Naval Personnel" published during 1983 in Accident Analysis and Prevention. This cohort study relates individual and occupational characteristics to accidental injury rates. The purpose is to identify high risk groups. A cohort of male enlisted personnel (n=87,549) were followed throughout the four-year period of their first enlistment to determine the rate of hospital admissions and deaths from accidental injuries.

Using death records and medical history files, demographic and service history information was extracted, including age, occupation, rank or pay grade, and mental ability classification

at the time of enlistment. Hospitalizations were considered to be injury related for diagnoses such as accidents, poisonings, and violence, following the category established for the International Classification of Disease, Adapted for Use in the United States (8th revision). All other forms of death were excluded from the analyses. To account for attrition, the four-year enlistment was divided into seven intervals.

When evaluated singly, individual characteristics such as age at enlistment, education, and mental ability were found to be significantly related to injury. When these variables were considered as a cluster, however, only education was found to have an effect on injury rate. That is, the higher the level of education, the lower the injury rate.

According to Ferguson, et al., previous studies suggest that highly technical occupations, which require high intelligence scores, have lower accidental injury rates than other occupations. The results of this study tend to support these previous findings. Youthful age at enlistment, especially young high school dropouts, who reflect immaturity and unfavorable social adjustment, experience many problems, including unsatisfactory job performance and injury. For different reasons, older enlisted personnel also were found to suffer higher rates of injuries depending on the nature of their work environment.

An unauthored report, which appeared in the Journal of American Insurance (Vol. 60. No. 3. 1984) published by the Alliance of American Insurers, suggests that defensive driver training does not result in fewer accidents. The individual benefits to be derived from driver training programs, such as reduced moving violations, is not at issue. What is questionable, according to this insurance report, is whether such programs reduce accidents. While no data are shown, the report argues strongly against the assumption that defensive training is highly correlated with a reduced accident rate.

Developing a description of driving offenders (mopeds, motorcycles, and cars), Mischiels and Schneider (1984) identify only sex, age license was obtained (driving experience), and type of offense, comparing these variables within the three driver category groups during a three-month period. Seventy-three percent of the sample was male among the drivers of cars, 75% of the moped drivers under age 21 were males, 86% of those between the ages of 20-63 were male, and 97% of the motorcycle accidents were attributed to males. Germane to this report these analysts state (Mischiels & Schneider, 1984).

Without wishing to reopen the traditional (and tired) debate on proneness, some remarks are in order. Chance variability cannot explain the number of drivers who commit no or very

many offenses... All these facts support the hypothesis that number and type of offense are linked to the characteristics (psychological, medical, social, etc.) of persons driving (in particular traffic conditions). However, the traditional concept of proneness implicitly assumes it to be stable, consistent and long-lasting. This stable quality is not borne out by our data, except for those drivers who commit no or very few offenses. (p. 236-237)

The findings of this study are:

- Males commit masculine type offenses where assertiveness and competition play an important role.
- Older and more experienced drivers are prone to drink too much, drive over the speed limit, and ignore red lights.
- Experience (or inexperience) is a more important variable than age.

At this point in our discussion it seems appropriate to introduce the idea of the Klutz Syndrome. Coined by Richard Restak (1986) in an interesting article first published in the January 26, 1986 Sunday Outlook section of the Washington Post, Restak's interesting discussion of the Klutz Syndrome or neurobehavioral impairment (NBI) was reprinted in the Spring, 1986 Research Notes (pages 3-4) published by the Research and Development Office of the California State Department of Motor Vehicles.

According to Restak, NBI affects individuals who are either very young or very old. These people are poorly coordinated, some temporarily; such as users of prescribed drugs and alcohol, and some permanently. Typically those who suffer from NBI do not have any diagnosable brain disorder, but their behavior is suggestive of neurological impairment. Restak (1986) describes such persons as "... awkward, clumsy, klutzy, ungainly, erratic and unpredictable in their movements" (p. 3). Some may have accidents, but Restak is concerned also about NBI's being responsible for those, who in their attempt to avoid situations created by an NBI, actually have an accident. Symptoms of NBI among young drivers less than 25 years of age are hyperactivity, attention difficulties, erratic responses, and learning problems. Among older drivers, a fall-off in reaction time and brain-eye-hand coordination are fairly prominent. Although tests are available to detect drunk drivers, Restak suggest the creation of a test to detect all forms of the NBI or Klutz Syndrome.

In a recent article entitled "Internality and Externality as correlates of involvement in fatal driving accidents," Montag and Comrey (1987) report that among two groups of Israeli drivers a random sample of normal cases (n=200) and individuals previously involved in a fatal driving accident, (n=200), driving internality is negatively related to involvement in fatal

accidents, while driving externality is positively related to such involvement (1987). Based on Rotter's (1966) classic Internal-External Locus of Control Scale, Montag created two specialized scales (a Driving Internality (KI) scale and a Driving Externality (DE) scale) designed to evaluate driving behavior and personality type. Externality, according to Montag and Comrey (1987), is related to a lack of caution and a failure to take precautionary steps to avoid the occurrence of unfavorable outcomes, whereas internals are highly motivated and perform better than do externals in a variety of situations (page 341). These research results are encouraging in that those prone to have accidents or inadequately self-discipline persons could be screened using the Montag Scale. Those who score high on the externality portion of the scale could then be further examined or evaluated through background checks and further testing.

Highlights of Findings for Selected Reports, 1961-1984

Some additional reports dating from 1961 through 1984 are highlighted in the following statements.

-A Special Report No. 56-11 drafted by Martoccia and Nelson (April 24, 1956) state "There appeared to be no relationship between instructor prediction of student accidents and the subsequent occurrence of such accidents in Naval Air Basic Training.

-In professional Paper 5-69 by Wallace W. Prophet (February

1969), published by The George Washington University Human Resources Research Office, three topics regarding the prediction of aviator performance were discussed: a) performance in flight training, b) performance in combat and, c) performance with respect to career decision. The only statement of importance to this review of the literature has to do with Prophet's statement of the stress model; "the stress model predicts that under combat stress, the effectiveness of a man's performance is a function of both his skill and his basic attitude of confidence in himself when in dangerous situations."

-In December 1970, a Department of Transportation report authored by Lategola, Fiorica, Booze and Folk examined status variables of airmen, which these analysts consider to be age, height, or weight, comparing these variables among accident and non-accident groups of airmen. The intent of this project was to identify "...some common denominator from the population of accident-involved airmen in order to narrow the focus for further study within the board spectrum of human factor causes" (Lategola, et al., 1970, p. 1). The ostensive rationale for assessing these "status valuables" was, according to the authors, that excessive body weight should be explored as a pertinent item within the category of human factors associated with aviation accidents. A null hypothesis, encompassing these three variables, was tested using FAA medical records for the years 1966 and 1967. A total

of 12,119 records of accident airmen were compared to the 563,174 records of non-accident airmen. It is also noteworthy that these analysts combined "ground accidents" and "in-flight accidents" categories, arguing that their preliminary chi-square tests of these two groups failed to produce

differences in the proportions of ground accidents and in-flight accidents with respect to the five [not three] status variables. In all cases, the chi-square analyses indicated no significant differences in these proportions. Therefore, subsequent analysis did not treat ground accidents and in-flight accidents separately (page 2)

I think it imperative to acknowledge that the chi-square test of significance is not intended to be used in the manner these analysts employed this test. In addition, the effect of this methodological strategy not only incorrectly combines two distinctive groups, but it confuses a number of other factors including the criteria of selection for aviation status in the military. That is, age, height, and weight criteria are not similar for flight qualification vs. ground duty. With respect to inadequate self-discipline, risk taking, or accident-proneness, the results of this project are at best difficult to evaluate.

- Testing the hypothesis that women are more conservative than men in performance involving risk, Hudgens and Fatkin (February 1984) conducted a simulated mine field study using varying numbers and patterns of artillery launched mines represented by dots in the field. The subjects were to decide whether or not to send a tank across the field based on their judgment of the chances of their successful crossing. The result of this two phase project was that men and women do not differ significantly in their abilities to estimate probabilities of success in the first phase or on their total scores for decision making in either of the two experiments.

- A Technical Report (TR 83-7; July 1983) assesses the "Lessons Learned from FY 82 US Army Aviation Mishaps." Written by Lindsey, Rickertson, Jr., Reeder, and Smith, 96 aviation mishap cases are evaluated in a portion of this report. Human error was, similar to many other reports, identified as the common factor in these 96 Class A, B, and C aviation mishaps. Fifty-six lessons learned are identified of which 86 percent (n=48 lessons) were attributed to human error. It is also noteworthy that "human error" in this report does not necessarily refer to military personnel. The conclusions of this report are:

1. Seventy-one percent of all aircrew task errors involved three tasks; namely, emergency, approach and landing, and hovering.

2. Seventy-five percent of the mishaps were caused by three factors; namely, lack of self-discipline (45 percent), supervisory error (19 percent), and inadequate design (11 percent) of aircraft engines, tail rotors, and drive trains.

Highlights of Findings for Technical Reports, 1955-1985.

Among the series of papers and technical reports made available to the research team dated March 21, 1955, through December 17, 1985, the following abstracted statements are germane to this review of pertinent literature:

- The selection or identification of accident-prone individuals "... is not possible on the basis of existent aptitude or performance measures nor possible on the basis of aircraft accident histories," and that some portion of pilot-error accidents will be unpredictable (Webb, January 27, 1956).
- The effort to predict aircraft accidents using variables such as moods, inattentiveness, temporary physiological states, or changed levels of training have not been adequately explored (Webb January 27, 1956).
- The major factor in predicting the potential for pilot error may be the "state of readiness" to respond which, by the very nature of this situation, may be transitions in

that the state of readiness may be related to depression, anxiety, anger, boredom, distraction, tension, lack of knowledge, or incompatible training (Webb, January 27, 1956).

- In an unpublished meeting paper Zeller (1961) reported on the accident potential among Air Force jet fighter pilots. This is essentially an effort to demonstrate that experience is important. The author's stated purpose is to evaluate the influence of current flying (recent) on accident experience, comparing an accident group with a non-accident group, each with comparable amounts of flying time (100,000 hours) during the same period using the same types of equipment. This analyst refers to rates, but the accuracy of his analysis cannot be evaluated because the reader is not informed as to how the "rates" were computed. Perhaps the most important feature of this report is its emphasis on the time factor, hours flown within a six month period, hours in transition flying, and amount of experience with types of aircraft.
- In a report released by the National Transportation Safety Board on August 10, 1967 at 3:00 p.m., it was reported that: (1) "older pilots tend to be as safe, if not safer, than younger pilots on a proportionate basis and," (2) "Pilots under 30 tend to be slightly less safe than their elders, even though their scarcity in certain certificate groups affect the percentages." (page 1)

- In another convention paper prepared by Zeller and Weil (1969), it was reported that no statistical support is found to suggest that bomber flying experience in any way affects accidents in jet fighter aircraft.
- A government document, USAARL Report No. 75-1 (July 1974) developed by Sanders, Hofmann, Hunt and Snow reported that based on Cattrell's Personality Factor Scale pilot-error accident groupings were classified correctly at 86 percent, while a dynamic decision making task test was not effective in predicting a similar grouping. In particular, three of the Personality Factor Scale items were useful statistically to discriminate between the pilot-error accident involved and the pilot-error accident free groups. These three factors (out of 21) were: group dependent vs. self-sufficient; practical vs. imaginative; forth-right vs. shrewd.
- A summary of a "High-Risk Aviator Study" disseminated in 1983 indicates that the purpose was to review the literature published between 1919 to 1981 related to accident-proneness. The following statements, drawn from this summary, are based on a review of fifteen of these studies:
 - a) the major finding of these unidentified studies is that if accident proneness exists, it is very complex and there seems to be no clear way to identify such individuals.

- b) of those aviators who experienced one accident, only 11 percent had a second accident, two percent had three accidents, and only .003 percent had four accidents.
- c) of the aviators committing errors due to "inadequate self-discipline", who had one accident (n=154), only four percent (n=6) had two accidents.

- In a USASC Technical Note written by J. Thomas Denney (January 1985) it is reported that inadequate self-discipline was responsible for 40 percent (n=615) of all pilot-error mishaps from fiscal years 1976 through 1983. Other major causes of pilot error were inadequate unit training/experience (n=176 or 11 percent) inadequate supervision (n=159 or 10 percent), inadequate written procedures (n=153 or 10 percent, and inadequate design (n=100 or 6 percent). During the 1976 through 1983 fiscal year a total of 1519 pilot-error causes of Class A-C aviation mishaps were recorded. The analysts state that the pilot-error problem "...is aviators who know what to do and how to do it but elect not to do so." In Denney's summary statement he concludes "...that there is no research concerning inadequate self-discipline which can be profitably undertaken. There is a need, however, for institutionalizing accountability for pilot-error mishaps..."

Accident Proneness and Inadequate Self-Discipline

Assessing the potential for predicting the relationship between accident proneness and adequate self-discipline requires a consideration of the psychological and social factors in accident prevention. As noted by DeBobes (1986), these factors include personality differences, level of intelligence, emotional stability, group personality differences, motivation and peer pressure, job satisfaction, safe working conditions (including a safety program), conflicting motives and frustrations, attitudes and values related to human needs, and environmental factors, such as the length of the work day. In some instances, the condition per se may not be a factor contributing to the accident rate. The absence of safe working conditions, for example, is considered to be a contributing factor to an increasing accident rate. Vernon and Desilva (no year cited, found in DeBobes) found that female employees tend to be more prone to accidents than male employees (almost 50% more accident prone) and that the rate of job related accidents among females increases dramatically after seven hours on the job. Some support is also found in the research literature for establishing that individual proneness to accident increases under conditions of artificial lighting and noise (Boyle 1980), and temperature and humidity.

Early in the 20th century, Newbold (1926) (according to Boyle 1980, p. 54) found that accident rates in the teens and

early 20s are highly related, while Hale and Hale 1972 (again in Boyle, 1980, p. 54) found that "...early in a person's job history accident rates are relatively high (irrespective of the age of starting) and that the rates fall rapidly with increasing experience..." Although numbers of hours work seem to be a factor in the risk of accidents, in a comparative study of shifts in the same plant, Boyle (1980, p. 58) reported that "...variations in duration of exposure to risk cannot fully explain the variation (observed) in accident rates." The intent of this study was to determine whether differences in risk levels existed between day and evening shifts (think of artificial lighting).

The results of Boyle's report strongly suggest individual differences do exist "...with respect to their accident rates even when there are controls for such factors as ambient risk levels, period of exposure to risk, age, and job experience." Known as accident proneness, Boyle argues that the concept presents theoretical and empirical problems primarily because of definitional inadequacy and its application (measurement) in industrial research. In essence, the nature of this methodological problem is grounded in individual interpretations of the accident proneness concept, which means that the occurrence of different definitions is frequent (McKenna, 1982).

In a comprehensive review of the driving accident proneness literature developed prior to 1980, McKenna (1982) identified numerous issues and characteristics. One of the most insightful among these is the driver's ability to identify road hazards. Individuals who are able to detect road hazards score much higher on the Embedded Figures Test than do accident prone persons, a group which is also more apt to be risk takers. Persons who do well on this test also tend to be better prepared to predict the road situation.

Traumatic life events affect behavior and emotions. According to McKenna (1982), Selzer and Vinokur (1974) found that drivers who experience more traumatic life events such as financial and marital problems, especially divorce, are more likely to be involved in an accident. Focusing on life events, McKenna argues this "differential accident involvement" approach has several advantages. It provides a basis to study individual differences while avoiding historical confusion; it is a value free approach (as opposed to the concept accident proneness); it is based on psychological testing rather than statistical modeling and statistical distributions; and perhaps most importantly, this approach provides a basis for theoretically evaluating the antecedents of differential liability. Moreover, McKenna believes this approach to predicting who will be most likely to be involved in accidents "would make it possible to

design the environment to minimize human error... (and) to train those abilities which we then knew (sic) to be necessary for error-free performance in that environment."

The evidence that alcohol use and accidents is highly correlated is clear. However, Selzer and Vinokur (1974) and Zylman (1975) suggest that the effects of alcohol per se may be slightly over-estimated. Zylman's further suggestion that alcohol use which interacts with other factors such as aggression, fatigue, (Naatanen & Sumala, 1974; 1976) and female menstruation especially in terms of a lowered judgment, forgetfulness, and slow reaction time (Whitehead, 1934; Dalton, 1960; Liskey, 1972) provide the basis to generate hypotheses for study. Thus, the foci for minimizing human error would take aggressiveness and mental if not physical fatigue into consideration. McKenna (1982) states that a lack of good theoretical understanding of human error inhibits our ability to design training programs intended to reduce accidents. This problem is responsible in large part for what McKenna calls naive alternatives to driver improvement which focus on modification of the environment. But to modify the environment successfully requires dependable knowledge of the nature of human error. Thus, information about those at risk to accidents is a necessary although not sufficient requisite to decrease human error.

Taking the tangible personal benefits out of risk taking may lead to accident reduction (Murdock & Wilde, 1980). Maximizing the quality and quantity of information to pilots and drivers may also sensitize these individuals to the importance for avoiding situations or engaging in risk taking activities which exceed their ability to control, thus placing the burden for accident avoidance on the operator. A systems approach would consider that travel space (air or terrain), the conveyor (helicopter or other aircraft, and land vehicles), and the environment represent a complex interacting system which operators must be constantly aware of. Emphasizing a systems approach to accident prevention has a great potential, especially when operators are exposed to reinforcing training seminar's, discussion groups or films.

The Relationship of Stress and Coping Ability to Accidents

A study of college football players conducted during the 1970s and reported by Bramwell, Masuda, Wagner and Holmes (1975) in the Journal of Human Stress indicates that the risk of accidents is directly related to the accumulation of life change events. Arguing that accidents can be self-perpetuating, the authors of this report found that the stress originally associated with accident potential can increase in the aftermath of the accident (Stuart & Brown, 1981). The findings from a

sample of college students reported by Stuart and Brown suggest that prior knowledge of an individual's stress is useful to explain a portion of accidents. Knowledge of their ability to cope with stress was not useful, however.

A study of high risk accident vehicle drivers conducted in 1978 by the California Department of Motor Vehicles (McConnell & Hagen, October, 1980; Report No. 76) in which DUI and speeding conviction records were evaluated ($n = 250,000$) successfully created categories of homogeneous high risk drivers. The purpose of this project was to establish a method for predicting accident prone individuals prior to accident involvement and to use this predictive model for a driver improvement program. It is noteworthy that when reviewing the data, these analysts recognized that "...nearly all drivers who are involved in an accident in 1 (sic) year will not be involved in an accident the following year" (McConnell & Hagen, 1980, p. 2). It is also noteworthy that

There is a substantial random component to traffic accident occurrence. Behavior which is widely considered to be unsafe (e.g., tailgating, driving under the influence, speeding) will seldom result in an accident, while other behavior that is normally safe (e.g., crossing an intersection with a green light) will occasionally result in an accident. Given this random component, the best

that can be done is to identify specific measurable characteristics that are associated with accident involvement, and to estimate the likelihood that drivers who demonstrate these characteristics will be involved in an accident.

This statement may be useful for evaluating the characteristics of U.S. Army accidents as well. It is important to note, however, that the empirical findings on high risk drivers is equivocal. Finkelstein and Robbins (1978) found that most drivers who are accident involved had not established themselves as high risk drivers during a preceding period of time. And, according to Selzer and Vinokur (1974), the view that high accident liability may be a permanent characteristic of those who have accidents can be questioned.

McConnell and Hagen (1980, p. 59) caution that programs that are not directed toward the general population are inevitably going to miss those drivers who are involved with the majority of accidents. The premise that specific measures should be directed towards certain groups of drivers who engage in dangerous road activities (e.g. DUI and speeding) assumes these drivers are more likely to be prone toward having an accident. It is also more socially acceptable, according to McConnell and Hagen, that these groups of drivers be targeted. In this regard socially

accepted facts and actual reality do not always correlate highly when information on high risk accidents is used to develop predictive models.

In a life events and subjective stress study reported by Selzer and Vinokur (1974), transitory life events and stress among 532 males were found to be highly correlated to traffic accidents. With the exception of aggression, the subjects, both alcoholic and general drivers, could not be neatly classified on the basis of personality and sociodemographic characteristics. That is, only low statistical correlations have been reported in support of the premise that certain characteristics of high risk drivers, who have accidents, can be used to predict. However, as reported by Selzer and Vinokur (1974), certain mediating factors, such as stress, life events and changes, and the subsequent depression caused by job change, divorce, marriage, for example, may be useful to establish the etiology and accident probability of the high risk operator.

Selzer and Vinokur (1974) had more success when multiple correlations and a step-wise regression between traffic accidents and life change and subjective stress variables were computed. These analyses found that for all the demographic, personality, and miscellaneous variables available

the best combination of predictors of accidents . . .

included income . . . aggression, physical stress

responses (smoking, insomnia, headaches, and/or ulcers),

serious disturbance with parents and/or in-laws, serious disturbance or pressure in school, concern with broad social and ecological issues . . . and number of drinks per setting (Selzer and Vinokur 1974, p. 906).

In sum, countering the premise that demographic, personality, and social maladjustment variables are useful to predict the high risk operator, these analysts point to the important effects which life change and subjective stress have in predisposing certain individuals to be involved in accidents.

A study of accident proneness of factory departments reported by Kerr (no date or reference for this 1943 study by Willard K. Kerr) offers some additional insights which, in principle, may be useful for understanding military accidents. According to Kerr (1949 or 1950, p. 169):

The tendency for departments lowest in promotion probability to be high in both accident severity and frequency may be of considerable psychological significance. It is plausible that when promotion is too unlikely, the typical employee may develop accident prone attitudes of relative indifference to the work environment. A reasonable chance to get ahead may constitute an incentive which not only stimulates the employee to do better work but may make him more alert to avoid hazards which may detain him in his progress.

And, in a study conducted by Williams, Henderson and Mills (1974) which replicated the findings of twenty years earlier, it was shown that persons involved in motor vehicle accidents can be characterized as egocentric, aggressive, socially irresponsible, and antisocial in their attitudes. They were also found to have experienced negative life events within a month preceding the accident. Suggesting that some personality characteristics of traffic offenders appear to exist, Williams et al. (1974) also argue that any attempt to apply such findings should be viewed with caution because:

standard personality measures have only low predictive ability with much of the behavioral variance being accounted for by the situation rather than personality traits as traditionally conceived. (p. 107)

Decision Freezing as a Causal Factor in Accidents

Decision freezing, another theoretical concept germane to this discussion, is defined by Kruglanski (1986, p. 48) as a truncation of "...the information-search phase of the decision-making process, during which a person actively considers all available options before making a final judgment...certain informational and motivational conditions affect the tendency to freeze at a particular moment." Three motivational forces or psychological pressures--namely, the need for a positive conclusion, the need for cognitive structure, and the fear of invalidity--appear to operate in distorting the flow of

information which may lead to tragedy. Wishful thinking, convenience, and/or specified outcomes can promote freezing decision freezing, according to Kruglanski, particularly if a decision is expected or required. The need for a decision may prompt one to believe that any decision is better than no decision. And, in order to avoid the stress resulting from indecision or ambiguity, bad or improper decisions may be made prior to adequate information being available.

Decision freezing seems particularly useful in understanding the improper decisions of individuals who have been conditioned to respond to various stimuli in a particular manner. Premature decision freezing, the point at which a final decision is made without all the potentially available information becoming available, could explain why some military accidents occur.

Kahneman, working with others, has demonstrated the importance of being able to reorient quickly to continuous stimuli and how this ability is important to driving and accidents (Kahneman, Ben-Isha, & Lotan, 1973; see also Mihal & Barnett, 1976). Extending this thesis, Kahneman et al. (1973) investigated the hypothesized relationship between their selective attention test and the prediction of accidents among professional drivers. Based on the findings these investigators concluded that use of the selective attention test could aid in selecting out individuals who are most likely to be accident prone.

The basis of this discrimination is three types of errors:
(1) the number omissions in part 1 of a message; (2) the number of intrusions from the irrelevant ear in part 1 of the message; and (3) the number of incorrect reports in part 2 of the message. Comprised of digits and unconnected words, the messages were presented by earphone and the subjects were requested to repeat all relevant digits as soon as these were presented during the 25 minute test. Although the experiment was intended to be predictive, the analysts state that the estimates reported should be viewed with caution because their study was postdictive. However, estimated effects predicting three driver rejection rules (accident-free drivers, intermediate group, and accident-prone drivers) do seem to provide a potentially effective means for screening military personnel.

Test results of a perceptual-information model of driver decision making in which three factors (perceptual style, selective attention, and choice, complex reaction time involving both perceptual and motor movements) were hypothesized as being related to accidents are mixed. Mihal and Barnett (1976) found drivers considerable support among three groups ($N = 75$) of utility truck (no accidents, one, and two or more accidents) for the predicted relationships involving perceptual style and selective attention and accidents. Partial support was found for the hypothesis that complex reaction time was significantly

related to accidents, but a similar relationship did not hold for either initial or simple reaction time. Corollary hypotheses in which perceptual style was predicted to be related to complex and choice reaction time, to selective attention, were only partially supported by the data. That is, the Portable Rod and Frame Test of perceptual style and the Embedded Figures Test of selective attention used in this project were significantly correlated only to complex reaction time and the Selection Attention Test respectively. (Note: It would be interesting to look over the test items to explain these correlations.) In summarizing the results of their project, Mihal and Barnett suggest that both perceptual style and selective attention are significantly related to accident involvement, thus supporting the findings previously reported by Kahneman et al. (1973). Based on these findings, the authors suggest that perceptual information processing as a partial conceptual framework be used for devising predictors of accident involvement.

Biorhythm Theory

Only equivocal evidence exists to support theories relating to the influence of biorhythm on accident occurrence and performance. In an article by that same title, Khalil and Kurucz (1977) reported that biorhythms are related to normal life events such as accidents, a finding which was confirmed by Persinger,

Cooke, and Janes (1978) in their study of mining industrial accidents (N = 400) and by Wolcott and McMeekin (1977) in an analysis of 4000 general aviation accidents filed with the National Transportation Safety Board during 1972. Wolcott and McMeekin (1977) state that the "...data do not indicate a plausible role for biorhythm as a causal factor in aircraft accidents" (p. 291). However, the inconclusive evidence argued as disconfirming the theory of biorhythm is based in large part on a single statistical technique, namely a chi-square test of significance in which the expected frequency of an event (theoretically) is compared with the observed occurrence of that event.

Introduced in the early 1900s and popularized by the media during the 1960s and 70s, the theory of biorhythm suggests that certain positive behaviors and negative or undesirable behaviors are associated with three cycles; a physical cycle involving 23 days, an emotional cycle of 28 days, and a 33 day intellectual cycle. Drawing upon the work of Thommen (1968), Persinger et al. (1978) conceptualized the two dimensions of the theory as:

Half the days of each cycle, i.e., 12-1/2 days, 14 days, 16-1/2 days, are above the horizontal axis, the ascending phase or "up" days, while the other days are below the axis, the descending phase or "down" days. Positive behaviors associated with each cycle presumably occur more frequently during the down days. The days upon which the rhythms cross

the axis are called "critical days" during which time accidents and related behavior are supposed to be more probable. There are two critical days in each cycle.

Popular claims have been made that traffic and industrial accidents are more likely to occur during a person's critical days and that the biorhythmic model can be used to prevent these accidents. (p. 423)

As noted above, researchers have challenged the validity of this theoretical statement primarily because of methodological and experimental issues, i.e., intervening factors which cannot be controlled and a failure to distinguish between conceptual issues such as biorhythm and biological (Persinger, et al. 1978).

Intended for use in accident prevention, the biorhythm concept does not hold when evaluated empirically.

Perceptual Factors as Accident Causes

An important project, reported by Loo (1978), in which twenty-eight females, ages 19-27, were tested on their verbal reaction times, personality factors, and driving record established that: (1) perceptual field-dependent subjects had longer reaction times to embedded traffic signs and more traffic accidents than did perceptual field independent subjects, and (2) extraverts had longer reaction times to the embedded traffic signs, more accidents, and more traffic citations than introverts. The focus of this research was the perception of traffic signs.

Capitalizing on the fact that approximately 90 percent of all accidental traffic deaths are caused by human error and 95 percent of all vehicular accidents are due to human error (Brown 1986), Loo hypothesized that individual differences in the perception of traffic signs may explain this problem. This hypothesis resulted from previous research which concluded that the ability to distinguish relevant from irrelevant cues is a factor in accident liability. Loo (1978) suggested that "...field-dependent drivers may fail to separate the relevant figure(s) in the driving situation from the environment; that is, the organized background" (p. 66), (e.g. traffic signs and emergency situations which require driver reaction). Conducted in a laboratory setting, Loo used standard verbal and symbolic traffic messages or signs and a number of measurements including the Eysenck and Eysenck's Neuroticism and Extraversion Scales.

Building again on previous research in which it was found that "...extraverts are less socialized and consequently less bound by rules, and as a result are more likely to have traffic accidents and violations" (p. 67), Loo's intent was to investigate the relationships between field dependence/independence, extraversion, neuroticism, driving experience, and age with perceptual reaction times in group embeddedness conditions. Loo's findings support previous

research. He found that greater field dependence was associated with longer reaction times to the embedded traffic signs, indicating that field-dependent persons do not react as quickly as those who are field independent in detecting but not identifying relevant stimuli in embedded contexts.

Correlating traffic accident data with the above, Loo also found a significant relationship "...between number of accidents and reaction times in the embedded condition, indicating that those who had more accidents also had longer reaction times to the embedded signs" (p. 73). Differences were also noted in the correlations for age and previous driving experience. In supporting previous research, such findings among females suggest the importance of evaluating individual differences in cognitive style and personality for both males and females.

Danger Compensation on "Risk Homeostasis"

Safety features intended to reduce injuries to drivers involved in accidents also has undergone scrutiny. A body of literature has recently evolved around the "danger compensation principle" also known as the "Peltzman effect", which suggests that whatever benefits could be realized through the use of seat belts and motor vehicle safety equipment may be diminished because of increased risk taking among certain drivers who consciously respond to these features. However, in a related study by Evans, Wasieleski, and Von Buseck (1982) 4,812 drivers were evaluated; the analysts found no evidence to support the

Peltzman effect. The differences between the Ontario, Canada study conducted by Evans et al. (1982) and previous studies in which the danger compensation principle is not supported may be whether seat belt use is compulsory or not, especially when driver attitude toward risks are considered. Still, the principle may hold important implications for evaluating military accidents since the research findings in this area are not consistent. To illustrate this point, Waller (1987) argued that drivers who use seatbelts also tend to be more cautious in their driving behavior.

In a review of the literature on the prediction of accident liability and accident proneness, Harano, Peck, and McBride (1975) developed a research strategy intended to assist in formulating better screening techniques and remedial programs for high-risk drivers. In this report the authors identified the demographic, sociopsychological and psychomotor variables as a pre-condition for successfully predicting accident prone characteristics and risk potential through the use of mathematical models.

In this extensive literature review, Harano et al. (1975) found that high accident individuals can be characterized as irresponsible, as having psychopathic tendencies, by immaturity, by lack of self-discipline, that they are outwardly emotional, and discontent. In terms of psychomotor differentials, high-accident drivers tend to be inattentive and impulsive, and to

experience rigidity under stress inducing conditions. The remainder of the literature review points to the wide-ranging findings reported and a critique which is focused on the inadequacies of the research design and analytical deficiencies of these discrepant reports.

The purpose of the Harano et al. (1975) project was to evaluate the relationship between seven categories of variables: (a) biographical and driving-related data, (b) attitudes and personality factors, (c) parental relationships, (d) perceptual-motor skills, (e) physical condition, (f) criminal record, and (g) simulator performance. For their sample, three groups were used: (a) an accident-prone group ($n = 196$; 3 or more accidents within a three-year time period), (b) an accident-free group ($n = 231$; no accidents during the same three-year period), and (c) a contrasted sample of female drivers ($n = 107$; this group not discussed in the 1975 article). After a lengthy discussion, Harano et al. (1975) state: "the findings clearly support the hypothesis that drivers possess traits that differentially predispose them to accidents." (p. 41). Elaboration on this statement suggests the authors anticipate being able to predict with 70% accuracy the classification of accident prone drivers as well as accident-free drivers. Citing this effort as a notable contribution to predicting accident drivers, the authors nevertheless had to rely on data referring to traffic convictions

and accidents starting these are "...significantly correlated with many psychosocial variables..." and that "...traffic convictions and accidents are functionally related" (p. 42).

Such findings are not surprising for several reasons, including the sample size of the groups studied. The finding that low socioeconomic status and being unmarried is related to accident involvement again is not surprising. Although these results can be questioned on methodological grounds (e.g., type sample, lack of repetition), a summary of findings are nevertheless important for any attempt to develop a rigorous predictive model.

Aptitude and Efficiency

Voicu and Nereuta's (1980) study of the relationship between aptitude level and professional efficiency among operators of sophisticated industrial equipment is germane to the task at hand. With a focus for evaluating failure and accident producing risks surrounding the use of complex equipment, these analysts reported that the results of aptitude tests are significant predictors of "...the work efficiency of the operators in [an] average social and professional environment...taking into account such kind (sic) of information when selecting the personnel may contribute to diminishing the rules of failures and accident occurrence due to human factors in technical systems employing operators" (p. 137).

Most reports portend some unique characteristic of the

research intended to solve the problem of accidents, or at least to develop a model which will allow program officials and policy-makers to predict with some degree of accuracy what can be done to lower the rate of accidents/increase safety. Lave (1987), however, offers neither of these. Instead, he discusses, from an economics perspective, the utility of increasing safety through understanding and informed free choice. Recognizing that rules intended to increase safety and which are so restrictive as to inhibit freedom generally are doomed to fail, advocates of the economic perspective argue that efforts to attain an efficient level of safety is preferable. This preference is based on the tradeoff between greater safety and greater cost or loss of some desired outcome, such as a lowered accident rate. The issue is one of individual choice and the freedom to make a different choice, even a bad choice that will increase risk, and to what extent society should go on protecting individuals against their own failures and mistakes. Information alone is insufficient according to Lave (1987), to control undesirable decisions and behavior leading to accidents. Rather, "fairness and efficiency require that individuals be reasonably informed about the consequences of their decisions" (p. 32).

Another key element in moving toward the proposed efficiency model would be the enhancement of incentives for safe behavior and the enforcement of extant penalties for those who fail to do

so, especially if other individuals are placed at risk. However, this emphasis would be successful only if the rules and regulations are considered to be sensible and fair. Harsh or unfair rules may only exacerbate the problem and vitiate the benefits which could be achieved. But from an economic standpoint, a practical goal may be a desirable level of safety rather than zero risk and an acceptable level of accidents would be based on a systems approach in which persuasion and information interact with other aspects of the organization, such as risk management training, regulations, and perhaps penalties inherent in military and civilian law.

Effects of Stress

Stress is the non specific response of the body to any demand made upon it. This general definition would include events such as heightened arousal during athletic competition, intellectual excitement during a chess match, in fact any activity which moves the body from its homeostatic set point would be seen as stressful (Selye, 1983). In the field of aerospace psychology stress has been classified as (a) physical (b) cognitive, and (c) affective (Nimick & Sloan, 1985). Physical stress results from factors such as excessive fatigue, noise, vibration, temperature, and so forth. Cognitive stress arises under conditions of excessive intellectual demands upon the individual affected, which suggests an excess of demands over capacity for an

individual at a particular time. It is clear from such a definition that "capacity" is difficult to define in advance of future circumstances and impossible to define independently of the human performer. Affective stress is difficult to confirm independently and remains a private, subjective experience. It is interesting to note that affective stress plays no part in the Soviet view of emotional fatigue but is attracting increasing attention among western investigators (Nimick and Cooper, 1984). The present review will touch on the three classifications of stress outlined above and in addition will supplement these broad areas with brief reviews of select issues. It is assumed that all classifications of stress interact and that their joint effects are both additive and cumulative. That is, physical fatigue and excessive mental workload would combine to increase vulnerability to affective stress; over time these conditions would have a cumulative effect and increase an individual's vulnerability.

Affective stress is influenced by historic factors and personality variables in the person affected. In its extreme form affective stress can occur suddenly and result in complete loss of decision making ability. Aitken (1969) noted that among military pilots 71% had experienced significant affective stress and he suggested further that among civilian pilots the percentage may be even higher. Green (1985) notes:

Examination of RAF psychologists' reports also suggests that acute stress potentates further error. For example, a Phantom (F4) aircraft was lost after suffering an alarming, but not necessarily disastrous engine failure during take-off. Though the pilot would almost certainly have coped with this situation in a simulator, he failed to manage the real emergency and the aircraft was lost. Similar anecdotes could be given about several other two-engined aircraft which have been totally lost after failure of only one of the engines. Some aircraft have been lost after only a spurious warning (e.g., a Buccaneer after a spurious fire warning) or a relatively minor emergency (e.g., a Hawk lost after a brief and benign appearance of noxious fumes). It is not possible to be confident that all these aircraft were lost because of the pilot's affective response rather than, for example, an increased level of workload resulting from the original emergency. Nevertheless, the pattern of response is sufficiently common to provide reasonable evidence that many pilots

lose control of their aircraft as a fairly direct result of an increase in arousal or reactive stress. (p. 639)

The cases described above clearly suggest an interaction between mind, body, and environment. Military pilots by virtue of the type of career they have selected tend to bring with them a certain type of coping style and while in training they acquire others. Because pilots are self selecting (career choice) and because entrance and training criteria further select pilots; they are viewed as an homogeneous group having certain very evident strengths in coping with stress. Strengths in certain areas may imply weakness in others. Ursano (1980) found that aircrew members showed many similarities in personality characteristics. Pilots were seen as a relatively homogeneous group. They enjoyed extremely good health, were more interested in changing their environment than themselves, were more interested in immediate than long-term goals, show high need for achievement, responsibility, novelty and personal initiative. Pilots tend to be intelligent but non-intellectual, direct in their approach but emotionally avoidant. Ursano suggests that pilots tend to have difficulty in dealing with emotional problems which arise as a consequence of their private lives. When under stress, pilots seek external solutions, become active, and utilize humor. It is suggested that pilots will have great

difficulty in dealing with emotional problems because of the inherent problems. When such a confrontation with emotional problems cannot be avoided pilots have few mechanisms in their repertoire to deal with that type of problem.

It is probably not necessary to point out that pilots in most instances are extremely effective in dealing with emergency situations. However, pilots who normally function effectively can be subjected to emotional pressures which will reduce performance efficiency. Green (1985) reports the effect of a deteriorating marriage on a pilot. The pilot recalled an angry exchange with his wife before he left for the airport, and goes on to say, "I realized afterwards that the total loss of concentration was caused by the fact that my mind was entirely filled with the continuing emotional conflict of the argument with my wife. Later we separated and as soon as the separation took place I could almost feel the mental tension and build up draining away from me and I felt marvelous about my flying again." (p. 640). The author then notes that this type of evidence is not likely to surface in cases where the accident had proven fatal. Alkov et al (1985) note that in addition to being unusually successful at coping with risk, pilots often seek risk and in their study report that navy pilots actually seem to enjoy the excitement of landing on an aircraft carrier. Alkov's view

of the aviator confirms that of Ursano (1980) mentioned earlier and views the flier as action-oriented who tends to take decisive action when stressed. Under conditions of excessive stress the tendency for pilots is to "act out" their frustration and aggression directing their anger at others rather than inward; which would result in depressive symptoms. Alkov (1985) obtained information on 737 Navy fliers (381 had been involved in accidents the remaining 356 had not), a 26-item questionnaire was completed by Navy flight surgeons and included questions such as "Does (did) the individual:" "1. Characteristically exhibit poor judgement?" "2. Recently undergo a marital separation?" . . . "26. Take unnecessary risks?" When comparisons were made of the two groups being surveyed it was found that those who were involved in accidents were more likely to be poor leaders, immature, to lack sense of professionalism, and have an inability to correctly assess troublesome situations. Furthermore, it was found that they were more likely to be having financial, interpersonal or alcohol problems. The accidents which resulted were seen as a consequence of "acting out" behavior with emotional problems being the triggering agent. In some aviators there were factors which put them increasingly at risk under conditions of stress (immaturity, inability to assess troublesome situations, and poor sense of their own limitations). These problem in addition to the general coping strategies found among

pilots create special difficulties. When confronted with frustration or stress they tend to direct their frustration and aggression outward while at the same time denying their own feelings. Emotions are seen as weakness; with the result that pilots have few mechanisms for coping with them and thereby increase their emotional load through an inability to reduce emotional problems.

In a study examining the coping strategies of commercial pilots Sloan and Cooper (1986) argued that such a study would have considerable heuristic value for the study of stress in other occupations because (1) pilots are thought to have superior coping strategies, (2) they tend to deny their internal emotional lives. Researchers and practitioners are often confronted in a variety of settings by those who cannot identify the source of their stress nor the mechanism they use to cope with them. The inability to identify stress sources and coping strategies could be the result of lack of insight but it could just as likely be the result of suppression and/or denial of true feelings and responses, and (3) pilots, as mentioned earlier, are self selecting bringing certain attributes to the job with them, and then as a consequence of further training those who do not share those attributes tend to be weeded out. As a consequence of self selection and weeding, pilots tend to be a rather homogeneous group. In their study Sloan and Cooper randomly sampled 1000 British Pilots and received a 52.3% response rate. Based upon

extensive interviews with 54 experienced pilots a list of 33 items describing coping strategies was compiled. Of less importance to the present review were items dealing with job satisfaction and mental health. Four factors describing pilot coping behavior were revealed. Factor 1: "Stability of relationships and home life." This factor sampled items such as "stability of relations with wife," "home life that is smooth and stable," and so on. Factor 2: "Reason and logic." This factor reflected questions such as "unconsciously separate home and work," "deliberately suppressing emotion." Factor 3: "Social support." This factor samples items dealing with statements about talking to understanding friends/colleagues/wife, and finally Factor 4: "Wife's involvement."

With respect to the first factor, items seemed to focus on the general and specific aspects of home life which offer support to pilots, and aspects of home life that offer a "prop" or support for the aviator's career. The factor labelled "reason and logic" examines the extent to which pilots feel they are able to separate their emotional life from their working activities. This is a type of coping response that would follow from the work of Ursano (1980) and is an attempt to ignore or deny emotional problems. The "social support" factor underscores the importance of support groups and a supportive home environment. The source of support which offers the greatest benefit is "friends." It

would appear that it is helpful to gain support through unofficial channels when in emotional difficulty. This avoids the awkwardness of having to admit a problem in an atmosphere where emotional difficulties are seen as weakness. The importance of the wife's role is seen by the emergence of a fourth factor "wife's involvement." Factors 3 and 4 will be further examined in light of other research.

In addition to sources of stress already noted, Johnston (1985) points out that pilots operate in a very constrained environment and that after they have become airborne time and limited control over situations which may arise drastically reduce their options. Furthermore, they operate in an environment where there is considerable supervisory and legal intrusion into their work environment. In addition to these sources of general background stress additional problems, while not great in themselves, have a cumulative effect and can overwhelm pilots. Johnston describes the use of pilot advisory groups (PAGs) in the United Kingdom which have proven successful in assisting aviators deal with personal problems. It is noted that many who have undergone emotional difficulty continue to fly and do not receive proper care. Some feel that by revealing symptoms they may be putting their jobs at risk. In commercial airlines mental disorders are the second most common cause of early career termination. This appears to be the result of

failing to recognize serious symptoms for what they are and initiating proper action; there is also the fear that evidence that a pilot was undergoing therapy may put his pilots license at risk. As mentioned earlier, there is the pilot's attitude toward being self-reliant and not seeking help. Mental toughness is a prized virtue with the result that illness and moral weakness are sometimes confused. The use of PAGs is based on the assumption that peer groups can offer a sympathetic, non-threatening alternative to formal channels of treatment. These PAGs are essentially self-help groups which attempt to keep aviators flying and maintain air safety at the same time. The utility of such programs remains an open question as the contemptuous attitude toward mental health problems appears to be widespread among pilots and it may be difficult to speak freely about personal problems in such an atmosphere. Whatever the problems which may occur in the use of PAGs, Johnston correctly recognizes the problem of getting someone with a pilot's personality characteristics to seek help through official channels.

In considering the effects of emotional problems on pilots it is clear from studies cited that a stable home life is important for the effective functioning of pilots under conditions of job-related stress. Previous studies have clearly shown that job-related stress will summate with stress from other sources, and that if the stress from interpersonal relationships continues it may impair effective performance for pilots facing a crisis while

in the air. Cooper and Sloan (1985) state that domestic stress and other troublesome life events may adversely affect pilot performance and judgement. Given that domestic stress can be of great importance in the performance of aviators, Cooper and Sloan investigated the sources of domestic stress and demographic variables among pilot's wives. In the study reported, 282 wives of civil aviators in the United Kingdom responded. The results indicate that dissatisfaction with personal life was strongly associated with what Cooper and Sloan call "domestic overload." This suggest that pilot's wives feel as if they were the head of a single-parent family, the husband is often away when needed, and then when he returns from a stressful trip the wife is often expected to offer support and encouragement. The life style of a pilot seriously disrupts the social life of the family. At critical times he is not available and this tends to isolate the family in the community. In-depth interviews with wives indicate that they feel socially isolated. In this connection it is interesting to note that wives that work seem to be less susceptible to stress than wives who stay at home. As a general trend it has been noted that wives of professional people who enter the labor market seem to find greater satisfaction with their lives than those who do not. A similar finding with respect to pilot's wives offers support for that view.

It is clear that pilots cope well with stress under most conditions. It is equally clear that those attributes which permit and encourage successful resolution of job-related problems are not ideally suited for dealing with domestic or other interpersonal sources of stress. The inability to cope with emotional problems and the serious consequences that this can have for job performance requires some systematic remediation. The PAG is a start in this direction, but some program which offers non-judgemental support and advice for pilots undergoing some emotional crisis is essential if we are to maximize over-all performance among pilots.

Methodology Issues

In his Critique of Accident Research presented to the New York Academy of Sciences, McFarland (1963) of the Harvard School of Public Health points out that even in the 1960's "a very appreciable volume on research on accidents has been carried out" but that the questions "why have accidents proved so resistant to research" or "why have so few findings of major significance to prevention emerged" have not yet been answered. Taking his discussion as a two way point of departure, the papers discussed will be classified as before or after, so as to gain a perspective on what has been accomplished since his critique was published.

He notes that at the time of his critique the greatest progress in accident prevention had been made in regard to industrial accidents. He notes that industrial accidents have received more attention and that these are probably somewhat more random in nature. The type of accident investigation or research in industry is quite straightforward and uncomplicated. The analysis of the single accident or of recurrent single accidents reveals certain physical factors which can be altered, with the level of causal analysis usually not going beyond the identification of the immediate injury producing factors in the environment. In these situations two working principles of preventive medicine, hold viz..., that measures applied to all individuals at risk without requiring their voluntary cooperation are likely to be more effective, and that effective measures may sometimes be introduced to interrupt a sequence of events prior to complete understanding of the causal chain and the specific details of the etiology.

He notes also that the great bulk of accidents are not very homogeneous in these regards, and that one of the great difficulties in accident research has been to find enough factors common to hazardous situations for specific remediable actions to prevent sizable numbers of accidents.

Maj. Gen. Beall (1972) deals with a precisely defined though dynamic population, viz., that of the Third Army. He was able to

identify "enough personal" factors common to hazardous situations (i.e., the accidents) to recommend specific remediable actions which he hoped would prevent a sizable numbers of accidents."

Beall's study was state-of-the-art from the methodological point of view at the time it was done. He relied heavily on the use of Chi-square tests for fitting distributions attributable to different cause factors. It may well be useful to consider what effect greater computing power may have on the effectiveness of Beall's methods. In particular, with such greater computing power it may be possible to design more complicated and more subtle instruments, which are both better predictors and which lead to less misclassification. The problem of misclassification is always a complicated one, and much just criticism leveled at accident researchers is concerned with the consequences to society and to individuals resulting from misclassification, both from potential accident-makers not so identified, and to safe individuals misclassified. Also, if populations are too well matched, then it becomes impossible to distinguish among individuals via tests or interviews and therefore methods such as those considered in Beall's study, along with other methods will ultimately suffer failure due to homogeneity, with the need present to redirect attention to other factors. It also becomes a question to establish whether particular populations have been, are, or will be subject to conditions leading to this failure.

Methods need to be designed to develop Beall-type programs for several classes of accidents and to check them against the possibility of failure of homogeneity or excessive reduction of efficiency because of this failure.

The study by Peck, McBride and Coppin (1971), based on data originally released as The 1964 California Driver Record Study, Parts 1-9, appeared shortly before Beall's dissertation, but after the McFarland Critique, about the only factor which remains as significantly correlated with accident frequency is the record of previous traffic violations. What we are observing here is a situation where the opposite effect, i.e., the failure due to heterogeneity is beginning to take place. This failure can ultimately lead to the complete absence of discriminating features in that no particular variable or combination of variables can be assigned to a particular class of accidents, thereby reducing analysis to chaos and leading back to the situation where preventive measures can only be based on an "engineering" analysis of particular situations. Attempts to identify a "general" characteristic called accident-proneness in the human population have failed due to this failure of heterogeneity. In the opinion of McFarland (1963) "It is probable that an equal amount of attention to the precursors and the correlates of the accidents these people had would have been more productive of knowledge for prevention", and even so we feel

that either failures of homogeneity or of heterogeneity can well appear to make even that task a very complicated or impossible one. Nevertheless, as illustrated by Beall's (1972) approach, if the right types of groups are matched with the right types of accidents within the right environmental context, much is possible.

In Peck, McBride and Coppin (1971), the following information was presented. An observed multivariate frequency distribution was generated from observed accident data. A test for the stability of reported accidents was performed as well as a test for randomness of accidents and citation frequencies, subjected to assumptions concerning the univariate Poisson distribution as well as those underlying a bivariate correlational study. It was noted that the female accident and citation data provide a better Poisson fit than the distribution for males. In fact, the negative binomial distribution becomes visible as an interesting alternative in this study among others.

The relationship between conviction frequencies and accident frequencies were investigated. Regression analyses for three year accident frequencies with respect to several independent variables was performed. A backward, stepwise approach was performed to derive the final regression equation. Predictors used were: speed, right-of-way, passing, signaling, signs, (small influence), turning, stopping, equipment (larger

influence), turning, stopping, equipment (larger influence). Nonlinearity was also tested for. The multiple prediction linear model finally obtained involved: one count convictions, traffic density, age, two count convictions, license restrictions, marital status. The only factor which remains significantly correlated with accident frequency is the record of previous traffic violations, as noted above.

McFarland's (1963) background in public health makes him extra-sensitive to the benefits of taking an epidemiological point of view. He suggests, we should not compare "accidents" to a "simple" disease such as one caused by a single agent, e.g., smallpox, which has presumably been prevented permanently worldwide, but to much more insidious and complicated families of mutually interdependent diseases and non-wellness conditions which we refer to e.g. as "cancer", or as "cardiovascular illness." Thus, cancer epidemiology is a specialty in its own right within epidemiology. It may be useful to adapt methods from this branch of epidemiology, where the danger of failure of heterogeneity is also quite real.

Contemporary with McFarland's assessment, Froggatt and Smiley (1964), both from the Department of Social and Preventive Medicine, The Queen's University, Belfast published a major paper. Among the 87 references were previous reviews of the literature such as McFarland, Moore and Warren going all the way

back to the early paper by Greenwood and Yule (1920) where an effort was made to come to grips with the concept of accident-proneness on the basis of an analysis of accident frequencies for a group of women workers in the munitions industry. They show that if accident-proneness follows a Pearson type III distribution, then the distribution of the number of accidents would follow a negative binomial distribution. What this group may have in common with Beall's (1972) Third Army is that it is variable enough not to suffer failure of homogeneity, yet not so varied as to suffer from failure of heterogeneity. Thus, whatever successful analysis was accomplished it was ultimately not generalizable to other situations without noticing the operation of the factors which we have identified as particular failures. As a result, the authors conclude that the hypothesis of "individual variation in liability" is more realistic and in better agreement with the data than is the concept of "accident proneness" along with companion hypotheses. The Poisson distribution as the underlying distribution is rejected. The hypothesis of unequal liabilities does support a negative binomial model however.

Whether accident-proneness or insufficient-self-discipline becomes the focus from a methodological point of view we must be careful not to destroy the meaning of any study or potential success of such studies because of improper consideration of the

accompanying models, whether they are identified or not.

Returning to McFarland's (1963) Critique, oversimplification of accident causes is a major failure of accident studies. Later researchers have been much more sensitive to the inevitable consequences of producing expensive and ultimately worthless studies, and it appears that much work is being done to improve methodological perspectives. Boyle (1980) conducted an experiment where he investigated whether or not an industrial sample showed non-random behavior with respect to accident rates. Again, the negative binomial distribution was accepted and the correlation between the first and second halves of the period was $r = .67$. Hauer (1983) developed a methodology for absorbing expert opinion in the construction of estimates of effectiveness. This methodology could be developed into one which could be useful to Army safety research and it is furthermore amenable to software development. The author of this paper is a member of a department of civil engineering and his approach is that of 'quality control,' another methodological tool of great importance in the entire area of prevention and demonstrating that to some extent accident research is ahead of epidemiology in embracing, or being embraced by, a greater variety of disciplines than is usual for purely medical specialties. One place where accident-prevention, based on the proper identification of human factors for human failures must ultimately meet the public health

test of greatest effectiveness, is in the excellence of design which seeks to lower the probability of 'system overload' which is a major reason why many accidents ever take place. Another point of departure for accident researchers is to consider what has been done since McFarland's critique to develop a theoretical framework for accident research in the area of developing conceptual models. If the concept of accident-proneness, which for many years was about the only accepted explanation for the bulk of accidents, has to be replaced by other models, e.g., "individual variation in liability" then this also includes a study of theoretical papers (e.g., Bates, 1955). Along with the above attempts to adapt the entire structure to new circumstances and hypotheses concerning parameters, Bates (1955) was among those in the pre-McFarland period who prescribed certain theoretical distributions under the hypothesis of accident-proneness. In a Polya scheme the identity of individuals with respect to accident-proneness is postulated, with possible contagion effects and experience counted in. The accident rate (non-constant) depends at any time upon previous numbers and experience, in contrast to a no-mixture no-contagion time effect scheme such as the Poisson process. Contagion is taken to be linear in this model. It is proposed that the learning-rate from accidents is a variable which is itself distributed jointly

as to time and person and that replacing constants in an interaction scheme by such a distribution will require considerable effort with much help to be expected from the capabilities of the computers-cum-software available.

Time Interval Between Accidents

The study of time intervals between industrial and other types of accidents has itself a good sized literature, including other examples such as a paper by Maguire, Pearson, and Wynn (1952) on this subject, notes by Mintz (1954), Maritz (1950), and others, all of which could stand reinterpretation along the lines indicated. The Maritz paper is an important paper where he asserts that according to Mintz and Blum (1949) the representability of accident data by a negative binomial distribution is sufficient evidence that accident-proneness is present in the population at risk and that conversely a good Poisson fit should indicate the absence of proneness. Maritz (1950) demonstrates that a good Poisson fit does not exclude proneness and that a good negative binomial fit does not indicate accident proneness. Thus, he allows experimenters to discover the presence of a certain distribution, without being wedded to a particular view because of that discovery. This, in view of the controversies accident researchers must deal with is an important step in the direction of objectivity. Maritz splits a lengthy period into two and he correlates the frequency of accidents per individual for these two periods. Usually proneness is

established from univariate distributions by comparing the variance of accident data with the mean. Maritz considered a bivariate discrete distribution with marginals of Poisson type and with nonzero-correlation. Since the variance exceeds the mean, the sum of these distributions is not Poisson. A Chi-squared test for fit can be used, with Poisson rejected suggesting the choice of negative binomial. It is possible to construct negative binomial distributions in this way with positive as well as zero correlation. In the paper by Maguire, Pearson and Wynn (1952) the possible importance of the word industrial is emphasized. The analysis follows two approaches: (1) consider time intervals between accidents, or (2) consider frequencies of accidents which occurred in successive fixed intervals of time.

The former method is not necessarily discussed because it is superior but because there are advantages due to possible changes as time goes on. The authors talk about mine explosions and discuss the role of the exponential distribution in describing the time between accidents, supposing that the expected number of accidents per unit time remains constant. This may fit for mine explosions and yields the Poisson distribution. The sum distribution for n intervals follows a Pearson type III distribution. Maguire, Pearson, and Wynn (1952) also discuss the testing of equality of mean time between accidents and the mean number of accidents between two non-overlapping intervals. The negative binomial distribution is relevant.

Thus, if $f(t) = Ee^{-Et}$ is the interval between accidents, then $p(r) = e^{-Et} (Et)^r / r!$ becomes Poisson if E is a random variable and $b(E) = C^q / (q-1)! E^{q-1} e^{-ce}$ yields $p(r) = (\quad)^q$, when $t = 1$, the negative binomial distribution. Among recent topics of interest in the methodological literature are discussions and comments on proper measurement of effectiveness (e.g. Hauer, 1983). Another example is Persaud's (1986) who points out that in many cases the observation that the effectiveness of a safety measure is greater at locations which had many accidents than at locations which had few can at least be partially accounted for as an example of regression to the mean. Thus, it is necessary to develop good measures in all situations where determining the effectiveness of increasing safety is important, and where such measures will account for accident effectiveness and designed effectiveness. Among the needs preceding the development of such measures, is an adequate development of semantics to permit useful descriptions of the concepts involved so as to facilitate proper quantification.

Finally, the methodological literature contains a variety of other families of papers. Examples include Williams (1981), where he points out that the basic hypothesis that conflicts (as defined in a variety of publications, e.g., Older and Spicer (1976) are related to accidents has never been proven beyond a reasonable doubt and has in fact become applied as a panacea even

though it may still be an experimental stage. Even if conflict analysis is not as experimental in some areas as others, the typical publication such as LePlat and Rasmussen (1984) still involves those areas where traditionally safety research has best been able to be effective. Even a more recent publication by Rasmussen, Duncan and LePlat (1987) although making great progress toward providing such things as taxonomies of error, the climate of application is still that of industrial processes. Modern industrial processes in their great variability of tasks requiring rapid adaptation and implementation have become more like modern armies in both organization and approach. Beall (1972) is an example of how effective management and systems approaches have percolated through all aspects of Army activity, including safety research and its consequent preventive action component. This is then an example of functional convergence, but as this convergence is by no means complete, care needs to be exercised in not confusing one organism for another nor one set of rules with another, as this could easily lead to garbled information and new points leading to garbled and thus possibly quite harmful conclusions. A relevant example concerns the study of cancer and the difficulties experienced by the most seasoned epidemiologists in avoiding the effects of various contaminations which often introduce unwanted mysteries into situations which were thought to be clear. As far as methodological problems to

be faced by us, most of these other subliterations do not by and large involve either insufficient self discipline in the discussion or recognize it as a factor that is relevant to the topics under investigation. As a consequence they must remain on the periphery of our own domain of investigation. However, it is recognized that being aware of the existence of these papers can be helpful in avoiding errors of duplication or of recognizing irrelevant factors.

It is clear from an inspection and review of the literature that most of the issues discussed here, if addressed at all, have been addressed only very incompletely, with much effort expended on problems which may not at all be typical of Army accident experience.

Motivational Systems and Safety

An examination of the traffic safety area reveals that relatively few studies deal with motivational variables (Wilde & Murdoch, 1982). This neglect appears to be evident in other safety areas. Most of the extant research has focused on individual differences (e.g., age, extroversion), skills, transient states (e.g., stress, fatigue), and ergonomic design of vehicles and work environments.

In the motivational area, Wilde has proposed a theory of risk homeostasis (RHT) (e.g., Wilde, 1982, 1985, 1986). Related theoretical approaches have been labeled risk compensation

(Adams, 1985) or danger compensation (Evans et al., 1982). RHT has its supporters (e.g., Adams) and detractors (Evans, 1985, 1986a, 1986b, McKenna, 1985, Shannon, 1986), and has been hotly debated in the literature. Essentially, the theory proposes that individuals target their own subjective level of risk in a given activity. A second major postulate is that the actual level of risk incurred by the population in that activity is maintained over time by a closed-loop, self-regulating control process. Third, the real level of risk can be reduced by measures that create a stronger desire to perform safely.

Thus Wilde holds that, due to the adjustment of "target" risk, as in driver training, better roads and crash-worthy vehicles will tend to have only temporary effects on the overall safety rate: As Wilde and Murdoch (1982) note, "...there are good reasons for believing that all variables, other than motivational ones, only have a marginal influence upon the causation of accidents."

Whereas RHT has received its share of criticism, it may have some relevance to the problem of inadequate self-discipline. As Army research has shown, human error is involved in approximately 80%-90% of all accidents (Sisk, Throckmorton & Ricketson, 1983; Thomas, M.A., 1982). Furthermore, a major proportion of accidents are due to lack of self discipline. In 1982, for example, 45% of Army aircraft mishaps were due to "...aviators

who knew better but chose to violate regulations, operating procedures or prudent air discipline." (Identifying High-risk, 1985). A case cited in this article is illustrative.

A Huey pilot made an unauthorized low level flight over a bay to show the crew and passengers "some beautiful scenery." The UH-2H struck some wires and crashed, causing major injuries and destroying the aircraft. This 35-year-old pilot had more than 3,000 rotary wing hours and was technically proficient. He also had been previously disciplined for low level flying.

If we analyze cases of this type, it is obvious certain safety measures seem more applicable than others. Flight proficiency did not play a crucial role here (although it may in other types of human error accidents). Helmets and seatbelts no doubt enhanced survivability, but did not prevent the accident-inducing behavior.

Another approach to inadequate self-discipline is to incorporate into the selection of Army personnel factors that would identify these high-risk individuals. Although this approach has been discussed earlier in the present paper, a few comments are in order.

First of all, this selection will not be an easy task. For example, two key demographic variables related to automobile accidents are sex and age. Obviously, the Army cannot stop recruiting young males (although it might be interesting to

analyze Army driving accidents with an age split below and above 20 years old). Secondly, the literature indicates that most other predictors have a low correlation with accidents. Thirdly, the low base rate of accidents will make it very difficult not to predict a large number of "false positives."

This analysis leads us back to Wilde's emphasis on motivation. Although Wilde (and his critics) fail to include the role of individual differences in RHTY, such a role may exist and may be relevant to the high risk population. Wilde and Murdoch (1982) present some prescriptions for accident prevention behavior which seem valuable. They list four different tactics:

1. Decrease the expected benefit of risky behavior.
2. Decrease the expected costs of cautious behavior.
3. Increase the expected benefit of cautious behavior.
4. Increase the expected cost of risky behavior.

These are further broken down into two categories of countermeasure targets:

1. Specific risky or cautious behaviors (like speeding or wearing a seat belt).
2. Outcome variables, i.e., the fact of having an accident or not having an accident. The second category is favored due to the possibility of shifting one risk to another. Examples of tactics and examples of accident countermeasures (that I have adapted to the Army situations) are the following:

Tactic 1: Decrease the expected benefit of risky behavior.

- a. Further change the organizational climate so that "showing off", etc. is not rewarded by peer approval.
- b. Caution commanders not to reward risky actions to achieve other goals, e.g., fast deployment.

Tactic 2: Decrease the expected costs of cautious behavior

- a. Make safety equipment more comfortable to use or wear.

Tactic 3: Increase the expected benefit of cautious behavior.

- a. Introduce or increase administrative incentives for accident-free and violation-free performance.

Tactic 4: Increase the expected cost of risky behavior.

- a. Increase enforcement, tracking, and penalties with respect to unsafe acts.
- b. Use a demerit point-system.
- c. Send warning letters to multiple violators.

It should be noted that certain countermeasures might encompass more than one tactic, e.g., the use of a "feedback package" (to be discussed).

Most current approaches to safety motivation involve some type of punishment, e.g., fines, revocations, court martials, etc.

However, it is evident that these systems are only partially effective. Typically, the punishment is improbable and delayed, whereas the rewards are definite and immediate. For example, speeding rarely results in a crash, or even a ticket, but typically gets you to your destination faster. Unsafe behavior, in addition, is often more comfortable, takes less effort, and increases arousal (or thrills). At times, unsafe behavior is reinforced by social norms, e.g., it is "macho." Also, unsafe behavior may even be induced by a motivation to perform well on a task. For example, a Sergeant commanding a mortar team during a fast fire exercise used two gunners at once. No doubt a fast rate of firing was observed--until a second shell went into the tube on top of the first one.

These types of motivation or incentives for unsafe behavior may be counteracted by the tactics listed above. The following sections of this paper evaluate relevant motivational techniques.

Punitive Approaches

The prevalent approach to safety is punitive in nature, i.e., unsafe behaviors violate laws, regulations, or rules and may result in various aversive outcomes. Though ubiquitous, the usefulness of punitive systems is typically taken for granted. It is certainly reasonable to assume that punishment plays some role as a deterrent. It is also obvious that many individuals engage in unsafe behavior, e.g., traffic violations, despite

possible sanctions. Again, a major problem seems to be that the probability of detection and therefore punishment is typically low. In fact, Ross (1984) has argued that the probability of detection seems to be more important than the severity of punishment. Supportive data were reported by Van Houten and Nau (1983). They found that police handing out warnings to speeding motorists led to larger, more lasting speed reductions than the usual speeding ticket approach. Warnings are less aversive than tickets, but about seven warnings were handed out to each ticket.

This is not to say that severity of punishment has no effect. Drivers who continue to drive with suspended/revoked licenses have improved violation and collision records relative to controls (Hurst, 1980). The increased possible penalties are likely causes for this effect. Another study of interest was that of Barmack and Payne (1961). They reported that Air Force personnel on a Texas air-base were informed that an at-fault accident might result in severe penalties (rank reduction, possible dishonorable discharge, psychiatric referral). After one year the results were compared with prior rates as well as "control" bases. Barmack and Payne concluded that accidents decreased by 50% and injuries by 64%

Point Systems

Demerit point systems are widely used in North America as an aid to driver control. They serve to quantify deviant driving

behavior and to direct governmental action toward persons who accumulate specific point totals. The accumulation of points may serve as a deterrent to deviant driving, in that they signal serious sanctions. In the language of learning theory, points serve as a cue in a passive avoidance paradigm. Thus they should induce people to avoid certain responses, i.e., deviant driving.

Typically, demerit points are non-discretionary. A judge does not control or assign the number of points for a given offense. Rather, the points are administratively assigned upon conviction. Such points then remain on the person's record for a specified time period, e.g. three years.

Although widely used, point systems as a whole have usually not been well researched. However, research has been done on specific attributes of point systems, such as differential weights, publicity, types of warnings, and point reductions and related incentives. This literature will be examined, along with military point systems.

Differential Weights. Point systems assign differential point values depending on the type of violation. For example, a driver convicted of "reckless driving" receives more points than a driver with the less serious offense of "failing to signal". Thus, a driver who accumulates violations with higher point values will more quickly meet a criterion for serious sanctions, e.g. suspension, than a driver who accumulates low-point violations.

One problem of constructing a point system is how to assign differential weights (points) to specific offenses. Obviously, assigned points should correlate with the "seriousness" of the offense. However, the "seriousness" criterion may require better definitions. Murdoch and Wilde (1980) discuss one technique used to address this problem. In a 1970 paper, Brown and Copeman (cited in Murdoch and Wilde, 1980) presented a relevant technique based on a magnitude rating-scale method. This method was used in the development of a questionnaire on which subjects assessed the seriousness of 31 traffic offenses. Also, Brown and Copeman asked these subjects to judge "seriousness" from several standpoints. Four groups of subjects were treated as follows:

1. A "control" group was given no specific instructions concerning the standpoint they should take in rating seriousness.
2. The "personally involved" group was told to rate seriousness as if they were the person most likely to be inconvenienced or injured if the offense was committed by another person.
3. The "personally responsible" group was told to rate seriousness as if they were tempted to commit the offense themselves.
4. The "social consequences" group was told to rate seriousness in relation to the effect they thought the consequences of the offense would have for society in general.

All subjects rated offenses on a ten point scale. A zero on the scale was held to represent "normal driving, unlikely to result in inconvenience or injury." Ten on the scale was held to represent "the most dangerous driving behavior you can imagine, likely to have extremely serious consequences." Some examples of the offenses used in this study include: exceeding displayed speed limit by between 10 and 20 m.p.h.; failing to give right of way to pedestrians at traffic lights; and failing to stop after injury to another road user.

The overall mean rating for seriousness was calculated for each offense and used to rank the 31 offenses. Kendall's Coefficient of Concordance indicated significant agreement among raters.

Murdoch and Wilde (1980) suggest, with good reason, that it is possible to design a finely-graded point system which would reliably match drivers' expectancies of the differentially weighted sanctions. In this way, the point system would reflect a morally acceptable level of punishment for a variety of offenses. For example, a point-system for Army aviation would no doubt be more acceptable if aviators and/or their commanders participated in the differential weighting procedure.

An added consideration in the construction of a point system should be the actual economic and human cost of offenses for society in general (and, in some cases, the offender's

organization). One approach to cost would be to determine which offenses lead to the most costly and most frequent accidents (Campbell, 1958). Given the extensive database of the U.S. Army Safety Center, this would certainly be a possibility.

Based on a 1983 California study, Kadell noted that "...accidents tend to predict accidents while convictions tend to predict convictions." Most point systems use convictions as the only criterion for determining risk and thus points and other sanctions. Kadell recommended that points should be assigned for at-fault accidents. We feel that this is a sound recommendation.

Publicity. One approach used to increase the deterrent effect of point systems is to publicize them. Although the effectiveness of such publicity has not been studied directly, public opinion surveys provide some relevant data. A 1960 study conducted by the Ontario Department of Transport involved giving a questionnaire to 1026 drivers (Murdoch & Wilde, 1980). The results indicated (a) a good knowledge of the system and (b) most of these drivers (86%) thought the point system would improve driver behavior. Although this study shows considerable public support for the point system, it does not indicate how much of a contribution was made by publicity.

Murdoch and Wilde suggest that public awareness of the point system must be maintained and recommend that an informational pamphlet on the system be given with license renewals.

Warnings. In order to increase the deterrent value of points some states issue warning letters or hold hearings at specific point levels. Such warnings provide important feedback, i.e., they inform drivers of their point totals and warn them that additional points will result in license suspension revocation. The efficacy of warning procedures is an important issue: A fair amount of research has been done to determine what is effective.

In New Jersey, Campbell (1958) studied the effectiveness of advisory letters in reducing convictions. A comparison was made between two groups of drivers who had reached eight demerit points but not suspension level (12 points). One group was sent advisory letters while the other group did not receive any signals of departmental action. The warning-letter group showed a 12% conviction rate relative to a 19% rate for the control group. Accident involvement was not investigated, however.

In Oregon, Kaestner, Warmoth and Syring (1967) conducted research on types of warning letters and consequent citations and accidents. In general, warning letters had a beneficial effect: The personalized (personal signature), low-threat letter was most effective. Also, personalized letters seemed especially effective for young drivers. The most extensive research program on warnings was done by the California Department of Motor

Vehicles. In 1967, McBride studied the effects of three different levels of "threat" and "intimacy" (cited in Murdoch & Wilde, 1980). The standard warning letter used in California was rewritten to provide nine letters which differed on the dimensions of threat and intimacy across three different intensities--high, medium and low. Ratings by 106 negligent operators indicated the letters differed as intended. Threat level was manipulated by the number of words and sentences containing threat stimuli. Intimacy level was varied through the use of personal pronouns in references to the subject and the department, and in the type of format.

McBride and Peck (1970) then assessed the effects of these types of warning letters on accident rates and traffic violations. A sample of 18,000 drivers, with a point count of 3 to 4 points within the twelve months prior to the warning letter, were assigned at random in a factorial design.

The results showed that subjects receiving the low-threat letters had significantly fewer accidents than those receiving the high-threat letters. The intimacy dimension had no significant effects. Also, analyses on violations in the seven months subsequent to treatment showed no significant interaction effects.

A later California study found no differences in accidents or violations between a warning letter group and a no-letter control

group (Marsh, 1971). However, Marsh's negative results could have been due to (a) a limited metropolitan sample and (b) a high-threat letter. More recent research supports this possibility.

In 1976, Brown, Marchi, and Sandreno reported a 10.7 percent reduction in point count for California drivers receiving warning letters, as well as a consistently small but significant reduction in accidents. Brown et al. also provided evidence of the cost-effectiveness of warning letters.

As of 1985, California modified its evaluation system for negligent-operators (Neg-Ops). Three evaluation reports provide further information on the effectiveness of warnings. Since the most recent report is the most extensive, it will be reviewed herein.

According to Marsh (1987), the California Neg-Op program provides four levels of treatment. They are:

1. Warning letter (W/L)
2. Notice of intent to suspend (N/I) -- a more severe warning letter
3. Probation hearing (P/H)
4. Probation violation sanctions (P/V)--suspensions and revocations.

Typically, the legal definition of Neg-Op is four points in one year, six points in two years, or eight points in three

years. The W/L (level) sent when a driver received two points in one year: the N/I (level 2) is sent when the accumulated points are one point below the definition of Neg-Op. If the driver accumulates enough points to be classified as a Neg-Op, the level 3 P/H intervention is imposed. The P/H almost always resulted in probation rather than suspension. At level 4 P/V a license suspension is generally imposed.

Marsh (1987) reports research in which the Neg-Op treatment (levels 1, 2, and 3) group is compared to an untreated control group over 18 months. Assignment to groups was essentially random. Survival rates for accidents and traffic citations served as the primary dependent variables.

The results indicated a small and non-significant reduction for both W/L and N/I at six months. However, combining both results led to statistical significance for the combined treatments. Marsh notes that even a small effect may be very cost effective, given the low unit cost of letters, the cost of accidents, and the large number of drivers.

The level 3--P/H treatment led to a significant, strong, and consistent reduction in accidents and convictions over at least 19 months. However, after about six months a portion of this effect may be due to level 4 P/V treatments.

The effects of the Neg-Op program on citations were: W/L (-.56%), N/I (-8.0%) and P/H (-15.3%). All these results were highly significant. Furthermore, they were similar to results of

the earlier Neg-Op studies (Marsh, 1986; Marsh & Kadell, 1985), except that W/L was less effective than in earlier years.

Marsh (1987) concluded that during fiscal 1986/87 the Neg-Op program prevented an estimated 2,172 accidents, 31,330 citations, 2,172 accidents, and 17 fatalities. Further, the program is estimated to be cost effective, as it cost \$889 per accident prevented, far below the National Safety Council's estimated cost of \$1,600 for a property damage accident alone.

In Israel, Ben-David, Lewin, and Halvia (1972) sent warning letters to drivers who had been observed committing violations at intersections. Observation was maintained for up to 6 months after communications. Their results indicated the following:

1. One or two advisory letters sent targeting a specific observed violation reduced the relative percentage of such violations 20-50%.
2. There was no effect of three levels of threat intensity.
3. Improvement generalized from the specific intersection mentioned in the letter to similar nearby intersections.
4. Improvement lasted past 3 months, but began to decline after 6 months.
5. Control groups showed no comparable improvement.

Ben-David et al. hypothesized that they are dealing with

"pre-attentive" mechanisms: The letters call the drivers' attention to their behavior. However, it may be that the letters serve another function--they signify that someone is observing their traffic violations (besides the police). The observation technique, while interesting, does not seem feasible to use on any major scale.

A related approach, however, entails an automated observation procedure in vehicles which are owned by an organization. For example, tachograph recorders have been used for years in the trucking industry to monitor such variables as speed and idling time. Safe driving behavior and fewer trucking accidents have been attributed to the use of tachographs (e.g., Lee & Smallwood, 1979). However, no controlled studies have been performed.

Police departments using tachographs have also reported anecdotal evidence of accident reduction. (e.g., Wynn, 1973). Furthermore, Larson, Schnelle, Krichner, Carr, Domash and Risley (1980) systematically investigated the use of the tachograph on police driving safety through a multiple baseline design. Tachograph units were installed in 224 vehicles of a metropolitan police department (Nashville). Three sections of the department received the "Feedback" treatment at different time intervals and baseline length. Supervisory personnel monitored (a) use of emergency lights (b) high rates of speed and (c) non-movement over 30 minutes.

Two treatments given to the "Traffic Section" after tachograph installation (no feedback and feedback from sergeants) had little or no effect. Larson et al. then introduced a "Feedback plus inspections" condition. Here tachograph records went directly to the Inspections Section of the department -- a unit responsible for compliance with rules, regulations and policies. When necessary, they requested explanations from the officer and his or her sergeant and also administered disciplinary actions.

The Feedback/inspections treatment led to virtual elimination of personal injury accidents and at-fault accidents were substantially reduced. The data also indicated that the tachograph program was cost effective. Initial officer discontent appeared to dissipate with time. Larson et al. attribute these results primarily to feedback. However, the increased accountability and threat of disciplinary action appear to play a role in this outcome.

The use of automated recorders on vehicles, combined with feedback, warnings, and point systems, might be applicable to Army safety. For example, the new flight data recorder for helicopters could provide information on unsafe flight practices, leading to warning letters, points, and/or hearings for pilots. Also, if a pilot accumulated a certain point level, the recorder data might be sampled more extensively -- thus focusing on pilots showing a tendency toward inadequate self discipline.

In summary, the literature indicates that various types of warnings increase the effect of point systems on reducing traffic violations and accidents. However, the efficacy of warnings depends on other variables. Such variables include:

1. Warning letter content/style:
 - a. Low-threat letters are more effective than high-threat letters.
 - b. Personalized letters may be more effective than non-personalized letters.
2. Warning letters are more cost-effective than several other techniques, e.g., Group Educational Hearings.
3. California's probation-hearing treatment had a major impact on violations and accidents (note that this program also contains the effects of two warning letters).
4. A second warning letter may add to the effect of the first letter.
5. Observations of violations communicated in warning letters appear to lead to sharp reductions in specific violations. Although this technique is hardly feasible for civilian drivers, an automated approach seems feasible in an organization through the use of tachographs or flight recorders.

Point-reduction incentives. In 1978, Marsh studied various

alternative Neg-Op programs as an alternative to the Group Educational Program (GEM) used in California at that time. Only one program promised to be superior to the GEM--the Home Instruction/Point Incentive (HI/PRI) program. This approach involved mailing drivers a booklet and self-test to complete. If they returned the work within 2 weeks and maintained a clean driving record for 6 months, a violation point was removed from their record. Certain inconsistencies in the results, however, led Marsh to recommend further study of the HI/PRI program before implementation.

Kadell (1984) evaluated HI/PRI in comparison with GEM, SEM (Speed Education Meeting) and an untreated control group ($N = 4,900/\text{group}$). All subjects were Neg-Ops. Four modifications were made in the HI/PRI technique: (a) although the point count was reduced by one point, the violation remained on the record; however the violation was masked from printouts sent to non-governmental requestors, (b) drivers were not notified if they qualified for the masking, (c) homework was accepted if received in 5 weeks and (d) the tone of the notice was "milder."

Kadell also used drivers who exceeded the 55 m.p.h speed limit twice or more in one year but were not in the Neg-Op program. They were assigned randomly to a control group or a "speed HI/PRI" group ($N = 12,000/\text{group}$). The latter group was given a handbook focused on advantages of the 55 mph speed limit as well as information on masking a point.

Kadell (1984) found that the HI/PRI led to the lowest accident rate and significantly and substantially (12%) fewer accidents than the control group. However, the mean HI/PRI accident rate was not significantly different from the pooled GEM and SEM mean. The HI/PRI (as well as GEM and SEM) also reduced convictions relative to the control groups.

Since the HI/PRI had a far lower cost than the other techniques, Kadell concluded that this program should be extended and tested further as one component of the about-to-be instituted "NOTS" system.

Incentives within point systems. Several large-scale field experiments involving the use of rewards or positive reinforcement for "good" (accident-free and violation-free) driving have been reported in the literature. In California, Kuan, Miller and Peck (1969) tested the effect of waiving the written test and/or receiving a congratulatory letter following 3 years of good driving. The primary result was that the congratulatory letter led to more accidents relative to a control group.

In a similar vein, Harrington and Ratz (1978) added an educational self-test to the waiver reward procedure, using one-accident/conviction drivers as well as 3-year good drivers and

controls. No significant differences in accident rates were found between the control and treatment groups. A similar study done in North Carolina (Waller, Hall, & Padgett (1977) also found that test waivers as an incentive had essentially no effect on subsequent driving records of "good" or "bad" drivers.

Research by Harano and Hubert (1974) may elucidate these unexpected results. They found that rewards (letter, key chain, promise of license extension) for "good" drivers led to an increase in accident rates.

A key factor in this study, as well as earlier studies cited, seems to be that these rewards were unexpected, i.e., they appeared "out of the blue," so to speak. In Harano and Hubert's second study, the contingency between behavior and incentive was made explicit: Drivers ("bad") were told that they would receive a free 1-year extension of their license if they had a clean record during the forthcoming year. This treatment led to accident rate reductions, especially in drivers whose licenses were up for renewal one year later. With longer renewal dates, the rate reductions were not as pronounced.

The complexity of the above findings indicates that the design of the reward/incentive programs must be carefully considered. In these traffic safety studies, there appear to be at least two key limitations: (a) the incentives seem to be weak, e.g., test waivers and (b) the definition of a "good" driver. Due to the low rate of accidents and the weak detection of violations some "good drivers" are, in reality, "bad but lucky" drivers.

Finally, it should be noted that, when Ontario drivers were asked to rate 40 accident countermeasures, incentives and rewards were among the most favored (Wilde et al., 1975).

Military point systems. Most research cited so far was conducted on civilian traffic safety -- one should be aware of this fact when generalizing to military contexts. However, point systems are not limited to civilian traffic-safety behavior. French Army Aviation has a mixed-consequence point system (A. Boyd, personal communication, February 12, 1988). In this system, all offense categories become a permanent part of his record.

Negative points are given for a variety of violations, e.g., incorrect radio phraseology, lack of control, and "risking the safety of a flight placed under his charge" (see Table 1). Personnel who observe such violations are required to report them in detail. In this system, the number and type of points acquired have important effects. If an aviator accumulates 50 negative points in one year, he automatically appears before a flight review board.

Table 1

French Army Aviation Point System

<u>"Shortcoming Professional Errors"</u>	<u>Sanction</u>
1. Serious error or repeated lacking of professional partial attitude.	Total or withdrawal, temporary or final, of flight status
	<u>Negative Points</u>
2. Erroneous appreciation of a flight situation	40
3. Underestimation of the flight difficulty/emergency	30
4. Unjustified persistence in continuing a flight action	30
5. Acting hastily when not justified by the circumstances	30
6. Erroneous evaluation of the authorized limits of a flight action	20
7. Slowness in recognizing fault or error in other personnel	20
8. Failure to make a decision	40
9. Delay in making a decision	30
10. Insufficient attendance to duties (dereliction)	40
11. Failure to react to a situation	30
12. Delay in reacting to a situation	20
13. Reacting in an insufficient manner (to a flight situation)	10

14. Neglect	25
15. Poorly performed inspection	20
16. Clumsiness	20
17. Unrequired flight maneuvers	15
18. Erroneous judgment in transferring controls	20
19. Erroneous execution of procedures	15
20. Incorrect phraseology used in radio transmissions or through telephone patched transmissions	10
21. Using equipment for other than their intended use	30
22. Wrongful appropriation (use) of equipment	20
23. Lack of control by a PIC, air mission commander, dispatcher or air traffic controller, risking the safety of a flight placed under his charge	40
24. Lack of control by a PIC, air mission commander, dispatcher or air traffic controller, over the actions of personnel placed under his charge	30

Positive points are earned primarily by completing blocks of flight hours without accidents or negative incidents, i.e., negative points in one year disallow earning any positive points for that same year. The board action is very serious and the same person is unlikely to appear more than once. The total record (positive and negative points) is considered by the board. The board may release an aviator or civil authorities for prosecution if warranted. Furthermore, the point system plays a role in the awarding of Aeronautical Medal, a highly sought-after and respected award. The assessment of any negative points makes it virtually impossible to be eligible for this award, as it is extremely exclusive.

The French point system has been in effect since prior to 1969 and has been considerably modified through the years. Although no formal evaluation of this system has been reported, it seems worthy of further investigation.

A combination of the above-mentioned point systems could be devised for Army personnel. This approach would standardize penalties for safety violations and accidents due to inadequate self-discipline, as well as track them. It would also provide positive incentives for improvements in safety-related behavior.

Although West German Army Aviation does not use a point system, they have a mechanism for tracking unsafe flight

actions. Minor violations are dealt with at the company level and may involve reprimands, fines, and/or flight duty restrictions (H. Schwarzmans, personal communication, June, 1988). As severity of the violation increases, higher levels of command are involved and more serious sanctions may be applied. Violations are tracked, i.e., minor violations stay on the aviator's record for 3 years and major violations for 5 years.

Summary: Point Systems Research

1. Construction of point systems involve differential weights for specific offenses. Weighting should be done considering the potential or actual human and economic cost of the offense and its rated seriousness by participants in the system.
2. Point systems should be well publicized and awareness of system details maintained.
3. Warning letters and hearings are important in enhancing the deterrent effect of point systems.
4. Warning letters are more effective if they are (a) low-threat (b) personalized and (c) are followed up by second warning letters and then a hearing.
5. Warning letters tend to be more cost effective than several other techniques; however, probation hearings had the most powerful impact on violations and accidents.
6. Point reduction incentive programs, e.g., California's HI/PRI program are effective in reducing convictions and accidents.

7. Research findings on the use of "administrative" incentives such as waivers, license extensions, etc. for accident/violation free driving are mixed. When such incentives were effective, the contingency was specified in advance.
8. The use of automated flight data recorders or tachographs could be integrated into a point system.
9. A military point system is used by French Army Aviation for tracking and discipline. Specific negative points are assigned for a number of safety violations. Positive points for safe flying are also given.

Non-punitive Motivational Systems in Organizations

The studies reviewed in this section address the motivational safety issue through a variety of techniques--tangible and social rewards, feedback, competition, and goal setting. They primarily involve positive incentives, although feedback can be considered a mixed-consequence system.

Some large industrial concerns have turned to safety programs involving monetary rewards and lotteries. Examples of incentives include safety-contingent bonuses, merit raises, (as one factor), silver belt buckles, awards, prizes from gift catalogs, ceremonies, raffles, "safety bingo", silver dollars and various combinations of the above. (Cohen et al., 1979;

Crapnell, 1981; Czernek & Clack, 1973; Lancianese, 1981; Palisano, 1981). Such incentives are usually given after short time periods, e.g., twice a year (usually between one month and one year). Often the value of prizes increases as employees continue to be accident free. Incentives have been based on individual performance, group performance, or both. So far, the only undesirable side effect of incentive systems seems to be a possible underreporting of minor accidents.

Although the evaluation of these programs is often unsystematic, many major companies, e.g., Kraft, Olin, and Kerr-McGee, have established them. The lowest cost benefit reported is twice the cost of the incentive program. Generally, these companies have reported considerable reductions in the injury rate after the introduction of incentives. Although these results are impressive, the research designs, if any, used by these companies are weak, and incentives may be mixed in with other ongoing safety programs.

More systematic research comes from the area organizational behavior management or "OB mod" (see O'Hara, Johnson, & Beehr, 1985) and other empirical approaches. Since randomized group designs are often impossible to apply in field settings, these researchers use quasi-experimental and small-N designs.

The following review deals with the systematic evaluation of a number of safety interventions including feedback, social and

tangible reinforcers, competition, and goal setting -- often in combination. Also, an important facet of such studies is the criterion -- this factor will be examined first.

Criteria. Three general types of criteria are used to evaluate results of interventions: safe/unsafe behaviors, hazards, and outcome measures, e.g., injuries.

Some investigators have targeted one safe behavior, e.g., wearing seat belts or ear plugs. While one behavior is relatively simple to record, this approach requires observers. Also, the target behavior should be of major importance and substantially related to injuries and accidents.

A related approach is to identify a number of important safe (or unsafe) behaviors and to use these combined behaviors as the criterion. For example, Komaki has used a "package" of safe behaviors as an effective criterion measure of safe practices (e.g., Komaki, Barwick, & Scott, 1978; Komaki, Collins, & Penn, 1982). By pinpointing desired behaviors, one can have a more sensitive measure of the safety level of the workers, and also clarify and reinforce specific behavior patterns. Although this is a sensitive measure counting the number of safe behaviors is often very time consuming and usually requires observers who must observe the workers in an obtrusive manner.

Another approach is the identification of hazards in the workplace that could lead to accidents, e.g., unsafe chemical

storage. This approach has been used by Sulzer-Azaroff in several studies (e.g., Sulzer-Azaroff and de Santamaria, 1980). The focus of this criterion is not safe or unsafe behaviors, but the products of unsafe practices. This approach is useful for smaller industries, is feasible in terms of cost and time needed, and is unobtrusive. However, it appears limited to certain settings in which "hazards" are more likely.

The third, and most important category, of criteria is some type of "outcome" criterion, e.g., accidents and/or injuries. Modifying a specific behavior is worthless (for safety) if it does not decrease accidents or injuries in some fashion. However, due to the relative rarity of accidents, outcome variables are not always sensitive enough for evaluation. However, with large organizations, large databases, risky jobs, or long time frames, outcome variables can and should be employed. These data are usually already available to the organizations, do not require behavioral observation on the job, and provide an objective basis for intervention treatments, e.g., graphic feedback. It should be noted that if one uses an outcome variable as a criterion, an assumption is made that the worker knows safe practices. Otherwise, training should be part of the treatment package.

Examples of researchers using outcome criteria are Haynes et.al. (1982), Larson et.al. (1980), and Karen and Koppelman (1986).

Safe/unsafe behaviors. A number of researchers have targeted one specific behavior. Wearing seat belts was increased by incentives (Geller, Davis, & Spicer, 1983). Geller et al. used incentive flyers that informed employees that they could win free dinners for using seat belts when driving in or out of an engine bearing plant. This program showed more success with salaried than with hourly employees. Similar results have been reported by a number of researchers (Ellman & Killebrew, 1978; Geller, Paterson, & Tabott, 1982; Geller, 1983; Sisk & Ricketson, 1985; Rudd & Geller, 1985; Weinstein, Grubb, & Vautier, 1986).

The use of earplugs by factory workers was targeted by Zohar and his associates in three research studies. Zohar, Cohen, and Azar (1980) conducted a study in a noisy metal fabrication plant in which the workers were using their ear protectors only 30 percent to 50 percent of the time. A multiple time-series design was used. Audiometric testing was given to individual workers before and after their work shift in the experimental group. The control group received a lecture only. The results of the tests were provided as feedback to each individual and posted for the entire group. Because earplug use was indicated on the audiometric feedback chart, workers could look at the reduction in hearing loss of those who did not wear earplugs as compared to those who did wear earplugs. Earplug use in the experimental

group increased from a range of 30 to 50 percent at baseline to 85 to 90 percent during and following the intervention period. An interesting finding was that after the feedback was terminated, earplug use never decreased. Instead, use gradually increased, peaking at a five-month follow-up period at 90 percent. The information that the feedback provided (temporary hearing loss without earplug use) was meaningful to the workers and reinforced earplug use, as did the lower noise level during work. Despite high turnover, earplug use held at about 90 percent, as all new workers "modeled" the earplug-using behavior of the experienced worker.

Two related studies (Zohar, 1980, Zohar & Fussfeld, 1981) involved weavers as subjects and token economies as interventions. Tokens were contingent on earplug use and had a small monetary worth. Earplug use quickly went to 90 percent and remained there even after tokens were discontinued. Again, all new workers wore earplugs. Zohar attributes these results to: (a) the earplugs are self-reinforcing (after adaptation) and (b) a new "safety climate" has been established.

Other researchers have focused on a number of safe behaviors associated with a specific job. Komaki, Barwick, and Scott (1978) applied a behavior analysis approach to a food manufacturing plant. Safety practices were identified, observed, and rewarded (intermittent praise), departmental goals were set,

and graphic feedback provided. Komaki et al. combined a reversal with a multiple baseline design to provide convincing data showing increases in safe behaviors. An "outcome" criterion was also considered -- injury rates. Long term effects in terms of injury rate reductions were also impressive.

Komaki, Heinzman, and Lawson (1980) performed a component analysis to determine if training alone could improve safe behaviors in vehicle maintenance units, therefore making feedback unnecessary. This study found that training helped, but was not optimally effective until feedback was provided to the employees. Komaki et al. concluded that training alone was not sufficient to improve and maintain safety performance and that more importance should be placed on the consequences of desired behaviors. This study was systematically replicated keeping supervisory involvement constant (Komaki, Collins, & Penn, 1982), and similar results were obtained.

A similar approach was used in a farm machinery plant by Reber and Wallin (1984). They developed a check list of 37 safety items. Using a four-phase multiple baseline design, Reber and Wallin (1984) performed a component analysis of training, goal setting, and feedback. The major finding was that feedback appeared to be a beneficial condition for the achievement of maximum performance when specific and difficult but attainable goals were set. Although performance did improve after training and after was set, in general, "90% safe" goal was not achieved until feedback was provided.

Hazards. Focusing on specific safe practices requires the use of observers, which may be costly or impractical. Another approach is to focus on the products of unsafe practices, e.g., physical safety hazards such as blocked stairways. Sulzer-Azaroff (1978) used this approach successfully in a study of feedback to reduce hazards in materials research laboratories. Her results were systematically replicated in a small industrial plant (Sulzer-Azaroff & de Santamaria, 1980). In the latter study, a "feedback package" system presented supervisors with data, information on safety, and congratulations on good performance. A multiple baseline design showed that hazard frequencies dropped by 60%.

Two studies have combined safe behavior with "hazards" at the targets of the intervention. Fellner and Sulzer-Azaroff (1984) examined the effects of feedback in divisions of a paper mill. Data were collected on 25 practices and seven conditions. Posting feedback on safe and unsafe conditions made conditions and practices safer. Also, the number of injuries was reduced by half. In a study by Rhoton (1980), coal miners were given praise, graphic feedback and verbal feedback relative to safety practices and mine conditions. Ventilation violations dropped from 2.6/mo. to 0. Two problems with this study involve (a) no reversal and (b) reliability of MSHA inspections.

Outcome criteria. Another approach to motivating safe behaviors is to target an "outcome" criterion--accident and/or injury reduction--for intervention. Haynes, Pine, and Fitch (1982) combined a randomized two-group design with a within-group reversal design in a study of city bus drivers. An intervention package of team feedback charts, team competition, and low cost incentives was used. Accidents decreased 25% for experimental drivers relative to control drivers and the data revealed a 4.6:1 cost benefit ratio. Drivers reported that they took fewer chances when driving.

Another study using outcome feedback was done by Karan and Kopelman (1986). They gave group and individual feedback in the form of posted signs. These signs indicated the number of accidents in the year to date and during the same period last year, the number of days since the last shift accident, and the shift's relative accident standing. An overall net improvement among the different shifts was 22.3% for truck accidents and 15% for industrial accidents.

In terms of cost effectiveness, these results are impressive. Whereas the cost of the feedback program was \$500, the savings to the company in terms of accident reduction, lost time from work, medical expenses, etc. was \$28,129.

Summary: Non-punitive Motivational Systems in Organizations

1. Many industrial companies are using incentives in safety programs. Although positive results are often reported, the evaluation techniques are usually weak.
2. Systematic evaluations have identified several strategies that are effective under certain conditions. they include:
 - a. Social reinforcement
 - b. Tangible reinforcement
 - c. Competition
 - d. Goal setting
 - e. Feedback
3. These techniques have been applied across a variety of settings. However, the small number of research studies leaves many questions still to be answered.
4. Graphic feedback seems to be a very cost-effective technique, especially combined with an outcome criterion.

Organizational Safety Climate

Organizational climate is defined as a summary of perceptions which organization members share about their work environments. These perceptions serve as a frame of reference for guiding adaptive (and sometimes maladaptive) task behaviors.

Schneider (1975) has proposed that specific climate measures be used in an area of research. In the safety area, Zohar (1980) has developed and validated an organizational climate scale.

Also, reviews of the literature (Zohar, 1980; Cohen, 1977) defined six key organization characteristics which differentiate high versus low accident-rate companies. These were as follows (for successful companies):

1. A strong management commitment to safety, e.g., safety officers had a higher status in low-accident companies.
2. Strong emphasis on safety training.
3. Open communication links and frequent contacts between workers and management, e.g., frequent safety inspections.
4. General environmental control and good housekeeping.
5. A stable workforce with less turnover and older workers (this may reflect good personnel practices).
6. Distinctive ways of promoting safety, e.g., counseling recognition, etc.

Whereas these characteristics were derived from civilian industrial organizations, a study of Army aviation units reveal some definite commonalities (Lindsey, Ricketson, Reeder, & Smith, 1983). Three battalion/squadron-sized units with good safety records were surveyed onsite. The USASC report shows very similar organizational characteristics (with the possible exception of No. 5) to those derived from civilian data.

It is felt than an organizaitonal safety climate scale would be valuable to measure climate across Army units. Zohar (1980) showed that safety climate, as measured by his scale, correlated

with safety inspections done in industrial companies. Whereas Zohar's scale is oriented toward civilian industry, a similar type scale, i.e., an "Army Safety Climate Scale" might be valuable.

Summary: Organizational Safety Climate

1. The organizational safety climate is an important concept and is measurable.
2. Research on the organization safety climate shows that important characteristics are common to civilian and military organizations.
3. Further research seems warranted as to the "Army Safety Climate."

Appendix B

**Legal Opinions concerning the use of
recruitment file indicators and
motivational systems to reduce accidents**

LEGAL IMPLICATIONS OF COLLECTION AND USE OF RECRUITING INDICATORS

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INTRODUCTION

The authors were retained to explore the legal implications of executing the proposals developed in the study report. As will be seen, we conclude that there should be no substantial legal roadblocks to this process based upon the facts presented to us.

Our primary concerns from a legal perspective are similar to the concerns expressed to us by the psychologists developing the instruments to be used:

1. Are the traits (factors) to be utilized, in fact, valid predictors of the specific future behavior that is of concern? Some of the studies relied upon to select traits at this point are of dubious application to the task at hand even if the studies were professionally conducted. Moreover, many of the traits listed separately may, in fact, be measuring the same underlying trait. False positives and false negatives are important to psychologists. The law generally bans "arbitrary" or "irrational" distinctions between citizens who are otherwise equal.

Also, certain kinds of discrimination are banned outright by our constitutions and laws. E.g., discrimination based upon race, sex, religion, or national origin. Some of the traits selected at this point may result in a disparate impact on some of these classes of people. Put another way, some of the traits may, in fact, measure race, etc., rather than anything else. To

the extent there is any such disparate impact, the traits should not be used or the reliability of the trait to measure the relevant future behavior must be very high.

Since the producers of the study report recognize the importance of validation of the suggested traits before any indicators are selected for use, we have assumed that these primary concerns will be met.

TASK II: IDENTIFICATION OF INDICATORS FOR RECRUITING

An element of Task II is to determine the potential legal implications of the collection of indicators for personnel recruiting. Based on our review of the study report, if such data collection is handled sensitively, the legal implications should be insubstantial. This memorandum surveys those implications identified by us and the reasons for our conclusion.¹

The collection of data leading to the identification of recruitment indicators would give rise to legal questions along the following lines:

1. Would the collection involve an invasion of privacy against the personnel involved or would it be otherwise objectionable?

The law is very clear that the armed services have extremely broad, judicially-unreviewable discretion in the composition, training and control of a military force. Gilligan v. Morgan, 413 U.S. 1, 10 (1973). Assuming that the validation studies proposed on pages 157-158 of the report are successfully completed, the "traits" ultimately utilized should be proven to bear a reasonable relationship to military service and safety. If so, there would be

¹This memorandum clearly may not be exhaustive of all legal implications that could be hypothesized.

no basis for finding any of them an undue invasion of privacy under the circumstances.

That said, a measure of sensitivity must be employed when further articulating or implementing the use of these factors. In particular, although Title VII of the Civil Rights Act does not apply to uniformed personnel, the objective of equal opportunity is an established part of military personnel administration, and in a proper case minority personnel can gain access to the federal courts and the military record correction process on claims of racial discrimination. Chappell v. Wallace, 462 U.S. 296 (1983); 10 U.S.C. § 1552 (1982 & Supp IV 1986).

Thus, factors described as "demographic" must be examined with care and sensitivity to ensure that they do not serve as an inadvertent means of fostering or cloaking subtle racial discrimination. Any recruitment factor identified in the study process should certainly be color-blind. Thus, further studies should determine whether the use of any such factors results in a disparate impact on minorities. The Army is committed to this both in principle and practice, so there is no novelty in this proposition and no occasion to fashion a new basic personnel policy in the context of the safety study. Similarly, while not binding in the military personnel context, attention could properly be given to the Equal Employment Opportunity Commission's 1978 Uniform Guidelines on Employee Selection Procedures, 29 C.F.R. Part 1607 (1988), as a basic source against which to judge the method and outcome of the development of recruiting indicators.

Any factors that might be perceived as encouraging or perpetuating stereotypical views of gender-based differences would also have to be guarded against, again as a matter of policy as much as of law. The Department of Defense's commitment to equal opportunity for women, subject to narrow

combat limitations prescribed by Congress, is well-known and deeply held. For example, the Department has a Defense Advisory Committee on Women in the Service ("DACOWITS") which has been very active in ensuring equal opportunity for women in all branches. Designation of gender as a key safety index for recruitment would be highly questionable even if it enjoyed a firm empirical basis; it would be subject to hostile scrutiny and rejection on grounds of basic Departmental policy.

A different approach must be taken with regard to the demographic factor of age. The services have age limits for recruitment and reenlistment. These serve the public interest to the extent that physical agility and condition may be demonstrated to be "bona fide occupational qualifications" for soldiering. Because the civil rights laws do not apply to the uniformed services, e.g., Gonzalez v. Department of the Army, 718 F.2d 926 (9th Cir. 1983); Cobb v. U.S. Merchant Marine Academy, 592 F.Supp. 640 (E.D.N.Y. 1984), and age in this context is not a protected status under the equal protection dimension of Fifth Amendment due process, there need be no fear that the rational use of age as a demographic discriminator would expose the program to legal attack.

A complicating factor in the use of age as a discriminator is its possible role in reenlistment decision making. The study reviewers may wish to consider whether the same screening criteria are properly applied to successive reenlistments as to initial entrance on active duty. To the extent that middle level or senior personnel are more likely to be involved with the operation and maintenance of aircraft and other sensitive, sophisticated, expensive and hazardous equipment, it could be argued that the need for screening criteria is greater at the reenlistment stage than at initial enlistment. Hence, attention may have to be given to the identification of

personnel screening factors that may vary depending on the nature of the enlistment decision.

There remains the policy question as to whether--legal constraints aside--recruitment issues related to age should be resolved on the basis of mere presumptions about the interaction between age and the practical consequences of the aging process, or whether a more finely-tuned approach that looks past chronological age to the aging process is in order.

A few of the other candidate recruitment factors listed on pages 156-157 also merit brief comment. Care should be exercised to ensure that some of the broader factors do not mask impermissible areas of governmental inquiry or impermissible substantive criteria.

In particular, categories such as "social/intellectual/achievement" or "life events/peers/work history" are extremely broad, and could sweep along inquiries that infringe on constitutional rights such as the First Amendment rights of free speech and association. Inquiries into whether a recruit had lived with a person of the opposite sex to whom he or she was not married could raise a substantial federal question without necessarily advancing the safety purposes of the inquiry. Similarly, inquiries directed at a recruit's views on social or political issues or which could be viewed as subjecting the recruit to guilt by association based on his or her friendships or affiliations with organizations (other than those dedicated to the violent overthrow of the government) would be impermissible. It is assumed, of course, that use of a "peers" category of recruit screening would not envision a guilty-by-association process. If this is not the case, substantial First Amendment and arbitrariness questions would be presented.

If "life events" were construed broadly enough to cover such matters as childbearing, birth control, single-parenthood and the like, questions of

personal freedom and privacy would be implicated. Hence, these broad categories should be refined and narrowed so that they do not become vehicles for the importation of unconstitutional or simply excessive probing into matters society deems none of the government's business. The Army already has policies with regard to recruitment and retention of single parents, and the study therefore requires that no new legal ground be broken on that score.

Questions about criminal and arrest records have, of course, long been part of the military recruiting process. As a result, the category of "criminal offenses" should engender no special legal concerns as a recruitment criterion provided administrators responsible for the program recognize the possibility of juvenile adjudications that may not constitute criminal convictions properly so-called, and of convictions that have been expunged by court action. The report employs the term "criminal offenses" rather than "convictions". It is assumed that any recruitment-stage questioning would focus on convictions rendered by a court, rather than offenses, since otherwise a Fifth Amendment problem of self-incrimination could arise where a recruit was asked about offenses for which he or she had not been prosecuted.

It should be stressed that the danger of judicial disapproval of recruitment file factors on grounds other than constitutional ones is extremely slight due to the overwhelming deference the courts give to military personnel decision making. Mere arbitrariness is, to be sure, offensive and the service should certainly avoid it whether or not there is a viable threat of judicial intervention. The constitutional side is more troublesome as the factors grow more remote from those commonly understood to bear on safety and begin to

encroach on areas of individual autonomy that are typically thought to be insulated from government probing.

2. Would the results of the research effort be exempt from disclosure under the Privacy Act, 5 U.S.C. § 552a (1982), the Freedom of Information Act, 5 U.S.C. § 552 (1982 & Supp. IV 1986), or in discovery in civil litigation? These are related questions, but the answers are not identical.

Under the Privacy Act, the individual with respect to whom a record has been kept is entitled to obtain a copy and have it corrected, or append his own views if he feels it is factually wrong. This applies, however, only to records found in a "system of records." 5 U.S.C. § 552a(5) (1982). Thus, the Privacy Act's application would be a function of whether the resulting records were designated in the Department's listing of "systems" of records. The possibility that an individual might employ the Privacy Act to attack the identification of recruitment factors is extremely remote; it is more likely that individuals whose personnel status is affected by the actual application of the identified factors would invoke the protections of this statute.

The Freedom of Information Act is available to anyone, whether or not they are personally affected by the governmental activity or record in question. The FOIA has a number of exemptions from mandatory release of documents, including one for interagency and intraagency memoranda "which would not be available to a party other than an agency in litigation with the agency," and another for personnel and medical files "the disclosure of which would constitute a clearly unwarranted invasion of personal privacy." 5 U.S.C. § 552(b) (1982). The inter/intraagency memoranda exemption would probably not support complete withholding of the study. Another exemption

applies to "internal personnel rules and practices," but here again it is doubtful that it would authorize withholding of the entire study.

As for individuals' records, even if it were possible to identify individuals from the data or study report, FOIA permits withholding only after a determination that release would constitute a clearly unwarranted invasion of personal privacy. At least some of the data to be employed in identifying and validating the indicators would qualify for withholding from public disclosure under the personnel and medical records exemption.

Finally, if there were to be civil litigation over the study or if an effort were made in accident litigation to call the study into question, it is almost certain that an opposing party would seek to obtain the study in discovery (i.e., by request for production of documents under the Federal Rules of Civil Procedure). In such litigation, the Justice Department would almost certainly move to dismiss or for summary judgment before any discovery had occurred, and as a result, the case would probably be disposed of prior to having to confront the releaseability of the study and underlying data. If no such motion were made, or if it were denied or held in abeyance pending the outcome of discovery, the Government would probably resist disclosure by means of a motion for a protective order.

Conversely, in accident litigation the Government might--if it failed to obtain a summary judgment or dismissal prior to discovery--actually disclose the study voluntarily as part of its own presentation as to the care it exercised in personnel recruitment and retention.

On the other hand, to be safe, any further studies to be done should be designed to the extent possible so that names (or other identifiers) of participants are not maintained and, therefore, will simply be unavailable to be discovered.

3. What if the Task II effort should lead to a mistaken identification of recruitment indicators: Potential Government liability may be analyzed under these subheadings: (a) liability to whom, (b) problems of causation, and (c) problems of negligence.

Potential claimants for the mistaken identification of recruitment indicators fall into two categories: disappointed recruits and persons injured in accidents. Disappointed recruits (i.e., those barred from the service on the basis of the indicators) would have no claim for money damages since in general there is no right to be a soldier. Only if a constitutional violation were made out might there be a so-called Bivens cause of action under the Fifth Amendment's due process clause. Bivens v. Six Unknown Federal Narcotics Agents, 403 U.S. 388 (1971). It is even more questionable that a disappointed recruit would be able to obtain nonmonetary relief such as an injunction, since the courts are especially loath to tell the services who they must accept. Again, to the extent further studies validate the factors and traits used as being rationally related to the recruitment process and that the use of those factors do not have a disparate impact on constitutionally protected classes of citizens, then no due process or equal protection action seems viable in any event.

The other category of litigants who might challenge the recruitment indicators are those persons injured in casualties. These may include service personnel, dependents, civilian employees and third parties. Congress has woven a complex web of remedies for these interests. Active duty personnel are effectively precluded from suing under the Federal Tort Claims Act under the doctrine of Feres v. United States, 340 U.S. 135 (1950). Dependents and civilians may file FTCA claims and pursue them in court if they do not receive satisfaction administratively. Certain claims, such as those occurring

overseas, are covered by other legislation, such as the Military Claims Act, which provides only an administrative remedy, not a right of action in the courts.

At common law, the sovereign was immune from suit. Congress waived sovereign immunity in part under the FTCA and related legislation. To be actionable under the FTCA, the Government's conduct must be negligent under the law of the state in which the negligence occurred; under the Military Claims Act (applicable outside the United States), the negligence is determined by the general rules of the common law. In either case, there must be causation between the negligence and the injury sustained by the plaintiff(s).

Negligent hiring is an increasingly accepted tort in American law. Most, if not all, American jurisdictions recognize the principle that due care must be employed in hiring personnel, and to that extent the principle of the FTCA would be met if it could be shown both that the indicators were negligently chosen or negligently administered and that the negligence caused the accident or injury. For an illustrative decision, see Bennett v. United States, 803 F.2d 1502 (9th Cir. 1986), where the Court of Appeals permitted an FTCA claim to proceed based on a theory of negligent hiring of a school teacher.

In a more recent decision, however, the Supreme Court, in a case involving an assault by a drunken off-duty serviceman, expressly declined to decide "whether negligent hiring, negligent supervision, or negligent training may ever provide the basis for liability under the FTCA for a foreseeable assault and battery by a Government employee." Sheridan v. United States, 108 S.Ct. 2449, 2456 n. 8 (1988). It has also not reached the question of negligent hiring or supervision as a basis for FTCA liability for negligence.

Even if the FTCA were to encompass such a cause of action, however, the statute expressly excludes conduct that is discretionary. 28 U.S.C. § 2680(a) (Supp. IV 1986). Much judicial ink has been spilled on this subject, but the cases seem to indicate that the discretionary function exception will be applied, at most, only to decision making at the policy level, rather than at the operational level.

For example, in Bryson v. United States, 463 F.Supp. 908 (E.D.Pa. 1978), an FTCA claim was asserted where one soldier was killed by another whom he was trying to help remove from a barracks men's room. The deceased soldier's administratrix argued that the other soldier was enlisted under negligently-developed special enlistment standards. The District Court held, however, that the FTCA did not permit such a claim of generic or policy negligence. It did allow a negligence claim based on the specific decisions to admit the soldier or remove him from the men's room. Similarly, in Smith v. United States, 330 F.Supp. 867 (E.D.Mich. 1971), the court held that the discretionary functions exception barred an FTCA suit over personal injuries sustained allegedly as a result of the use of untrained and improperly guided or supervised troops of a federalized National Guard.

In United States v. Shearer, 105 S.Ct. 3039, 3043 (1985), the Supreme Court rejected a claim for wrongful death of a serviceman based on a theory that the killer's military superiors negligently failed to exert sufficient control over him and carelessly failed to remove him from active duty. The Court reasoned that such a suit "calls into question basic choices about the discipline, supervision, and control of a serviceman." Id. at 3043 & n.4.

In Shirey v. United States, 582 F.Supp. 1251 (D.S.C. 1984), the court rejected an FTCA claim based in part on a theory that the Postal Service was negligent in gathering and evaluating data on the safety of a

particular type of jeep, invoking the discretionary function exception. In Berkovitz v. United States, 108 S.Ct. 1954 (1988), the Supreme Court held that the discretionary function exception did not bar suit against the United States when the National Institutes of Health approved a polio vaccine without the required safety data; the Court, however, also held that an action would not lie with respect to policy decisions as to how to regulate release of the vaccine, since formulation of that policy would have entailed a discretionary function.

Negligent selection of a contractor to perform work for a Government agency has been recognized in FTCA litigation, e.g., Melton v. United States, 488 F.Supp. 1066 (D.D.C. 1908), but the contest was selection of a contractor to rehabilitate a historic site--a far cry from the kinds of military personnel decision making as to which the courts have adopted a rigorously hands-off policy. Of course, it could be argued that airlines hire and train pilots and ground crews much like the Armed Forces, and presumably they would be held liable in a negligence case if their hiring, screening or training were shown to have been negligent. While this analogy cannot be dismissed, the cases teach that military activities of the Government stand on a unique footing because of the lack of judicial expertise in running armies and navies, and the constitutional commitment of responsibility for such matters to the Congress and the President in his capacity as Commander in Chief. If, as the Supreme Court held in Boyle v. United Technologies Corp., 108 S.Ct. 2510, 2517 (1988), "the selection of the appropriate design for military equipment to be used by our Armed Forces is assuredly a discretionary function within the meaning of" the FTCA, one would certainly think the recruitment of military personnel and measures to foster their self-discipline would equally fall outside the FTCA's limited waiver of sovereign immunity.

Finally, even if all of the obstacles noted above were overcome, a claimant would still have to show that his injuries were proximately caused by the Government's negligence. Thus, it would be of no moment to show that the recruitment indicators were carelessly developed or administered if one could not trace the injuries back to that lack of care. Thus, if mechanical or design problems were to blame, it would make no difference that the indicators were inappropriate or unfounded.

TASK IV: USE OF INDICATORS FOR IN-SERVICE PERSONNEL

The first part of this paper identifies some of the salient features of the legal landscape surrounding the collection of recruiting indicators. A separate issue presented by the Statement of Work involves Task IV, and has to do with the use to be made of such indicators for the purpose of motivating personnel with inadequate self-discipline to increase their self-discipline. In our opinion, there is no need to "reinvent the wheel" in this connection since the Army (and the other Armed Services) already has in place a highly sophisticated framework for personnel decision making and the reconciliation of the competing demands of institutional needs and individual rights.

The key legal concerns about administration of a program of incentives and disincentives along the lines proposed are easily stated. Are the groundrules and sanctions clear? Due process requires fair notice prior to the imposition of sanctions. E.g., United States v. Johanns, 20 M.J. 155 (C.M.A.), cert. denied, 474 U.S. 850; United States v. Tolkach, 14 M.J. 239 (C.M.A. 1982). Are the procedures geared to render decisions that are fair and impartial? If official action is taken in the absence of substantial

evidence or under circumstances that are arbitrary, capricious or an abuse of discretion, it may be set aside either by higher levels within the service or by the courts. See, Chappell v. Wallace, supra; Administrative Procedure Act, 5 U.S.C. § 706 (1982).

This is not to say that summary action cannot be taken in an emergency to avert a safety problem, nor do soldiers have due process rights to the perpetuation of every aspect of their military service. But if a procedure has been put in place to guide the exercise of command discretion as to either rewards or sanctions, that procedure must be followed without favoritism. Like cases must be decided in like fashion. Any directives prepared as a result of the study should be framed with these needs in mind.

The range of official actions that may be taken in the light of evidence of unsafe activities is considerable, and the study gives no reason to believe that any new mechanism that may be introduced as a result of the identification and use of recruiting indicators would in principle be subject to invalidation.

Thus, a point system for aviators (as for motor vehicle operators) would be lawful in principle, but would have to be applied in accordance with the groundrules that have been laid down for it. Because of the broad discretion of command and the strong interest in achieving safety in military aviation and other fields of military activity, a point system might survive attack even if it were applied retroactively to events occurring before institution of the system. However, any retroactive effect would be a source of controversy, and might strip the effort of legitimacy in the eyes of the affected personnel. Accordingly, it is not recommended.

At one extreme, the Army is subject to the Uniform Code of Military Justice, which penalizes misconduct such as fraudulent enlistment (Art.

83(1)), dereliction of duty (Art. 92(3)), failure to obey orders (Art. 92), false official statements (Art. 107), negligent loss, damage or destruction of military property of the United States (Art. 108(3)), hazarding a vessel (Art. 110), drunken or reckless driving (Art. 111), being drunk on duty (Art. 112), drug abuse (Art. 112a), and conduct that is unbecoming an officer (Art. 133) or to the prejudice of good order and discipline (Art. 134). Such offenses are punishable either by court-martial or, if sufficiently minor, by nonjudicial punishment (Art. 15). The point system would presumably be promulgated by general order which would have the force of law.

The judicial and nonjudicial machinery is highly developed and competent to deal with offenses under the punitive articles of the UCMJ. Appellate review is available, with varying levels of formality, for courts-martial and nonjudicial punishment.

The services also have at their disposal a broad range of other means by which to ensure safety and safety-consciousness in their personnel. For example, additional training may be ordered in the discretion of a commander. Where authorized by regulation, special privileges such as flight orders may be suspended or revoked, with concomitant reduction of special pay, if the individual is not competent to fly. In a proper case, many commands have deemed it best to transfer personnel to another unit where particular problems may not manifest themselves. If not used for punitive purposes, there is no objection to transfers and no reason to believe any court in the land would interfere. Driving privileges may also be suspended or revoked for cause in the discretion of the command. Given the range of options long available to military personnel management, we know of no impediment to the use of point systems as proposed.

For personnel whose conduct falls sufficiently far below the expected norm, there are procedures for the administrative separation of enlisted personnel and for the removal of officers by boards of inquiry. Such procedures are carefully regulated by existing directives and include multiple levels of review.

Personnel who wish to dispute non-court-martial personnel actions taken against them may apply to have their records corrected under 10 U.S.C. § 1552 (1982 & Supp. IV 1986), which broadly authorizes the Secretary, acting through a board of civilians, to correct any error or injustice in military records. See generally 32 C.F.R. § 581.3 (1987). Many officers, for example, seek relief from OERs under this authority. If discharged, military personnel may also seek review of the level of discharge from the Discharge Review Board. 32 C.F.R. § 581.2 (1987).

Decisions of these bodies are subject to review in the federal courts and, in some instances, in the United States Claims Court if the individual has lost money to which he would otherwise have been entitled. The extent to which the courts will adjudicate the loss of minor privileges with no dollar consequences is not clear at this time, and there is a split of authority for the proposition that a reviewing court can look behind a pay decision to address the underlying validity of a personnel action such as dismissal from flight training. Compare Voge v. United States, 11 Cl.Ct. 510 (1987), vacated in part & aff'd in part, 844 F.2d 776 (Fed. Cir.), cert. denied, No. 88-81 (U.S. 1988), with Henderson v. United States, 175 Cl.Ct. 690, 701 (1966), cert. denied, 386 U.S. 1016 (1967). The power of the correction board to address such matters seems free of doubt, although the board is likely to give substantial deference to the judgments of commanders and various service tribunals such as flight boards.

This summary does not address the administrative remedies available to civilian personnel who might also, in time, be affected by incentive and disincentive programs along the lines proposed in the study. Such personnel are subject to the basically different employment regime erected by the Civil Service Reform Act of 1978 and the Federal Personnel Manual. While relations with civilian employees are necessarily affected by institutional considerations not found in the military superior-subordinate framework, the civilian framework is equally complex and is believed to include sufficient flexibility so that the same broad purposes of increasing safety can be achieved.

CONCLUSION

The authors find no legal obstacles to: (1) the cautious and prudent collection of relevant data; (2) the application of validated traits which do not cause a disparate impact on constitutionally protected classes of recruits; or, (3) use of point systems for motivation of personnel as outlined.

Appendix C

**The use of differential weighting systems
for scoring recruitment file factors**

Scoring of Recruitment File Factors:

The Differential Weighting System

The scoring procedure will subject responses to the individual items to item analysis against the accident related criterion (ISD Accident Group versus the No-accident Group). Those responses which are found to discriminate significantly in terms of the criterion are then used in a special scoring key. Individual items are given differential weights to the extent to which they contribute to the prediction of the criterion.

There are several related methods used to weight items. Typically, they are based on the magnitude and direction of the difference in percentages of the two criterion groups. For example, a study of real estate salespersons used as a criterion the attainment of real estate licenses. One application blank item (residence) was scored in the following fashion:

Table 1: Weight-assignment example

<u>License?</u>				
<u>DO YOU</u>	<u>YES</u>	<u>NO</u>	<u>DIFFERENCE</u>	<u>WEIGHT</u>
Own your own home?	81%	60%	21%	5
Rent your home?	5%	5%	0%	0
Rent an apartment?	9%	25%	-16%	-4
Live with a relative	<u>5%</u>	<u>10%</u>	-5%	-1
	100%	100%		

A person's total score is based on the sum of the weights of the response to the various items. Such scores would then be used to predict membership in a criterion group. Cross validation in an additional group would be warranted, as some personal-data items may be related to a criterion simply by choice (and thus will not be differentially discriminating in terms of the criterion).

Appendix D

Detailed Summaries of Key Research Studies

DETAILED SUMMARIES OF KEY RESEARCH

STUDIES

General Methodological Studies

Montag & Comrey 1987

The Montag & Comrey (1987) research relates a modification of Rotter's Internality-Externality (I-E) Locus of Control Scale to driving behavior. The modified I-E scale was administered to 200 individuals who had been involved in a fatal driving accident, and 200 control subjects drawn at random from the driving population.

The study makes the case that those who show an internal locus of control (see events as being under their control) tend to be more cautious in their driving behavior. This, and other literature, suggests that internals are more attentive and adept at avoiding unnecessary risk, and are generally highly motivated to perform well in a variety of settings. In the context of the present study, the findings reported here have considerable face validity, as they fit nicely with what would be predicted from the general I-E literature.

Another feature of this research is the development of an I-E scale specifically for use with drivers. The more general Locus of Control Scale has sometimes not been effective in specific situations with the result that more specific scales have evolved to meet the needs of those working in circumscribed areas. This I-E scale for driving reports Driving Internality to be negatively correlated with fatal accidents and Driving

Externality to be positively correlated with fatal accidents. A problem remains is that those involved in fatal accidents may wish to attribute accidents to chance factors. The authors present some data that this is not the case; more research is currently being conducted on this question.

Shannon 1986

This paper approaches accident data from an epidemiological perspective. The focus of the paper is to explore the plausibility of Risk Homeostasis Theory (RHT) (which states that conventional, non-motivational safety measures will fail to reduce the accident per unity time of exposure) from a methodological perspective. RHT postulates that in risky situations individuals will adjust to their level of acceptable risk. This is seen as a closed-loop process where acceptable risk operates as the reference variable; the number of deaths due to road accidents is a direct function of how much time is spent on the road multiplied by the acceptable amount of risk individuals are willing to assume.

A number of difficulties with RHT have surfaced, and while the discussion of RHT is itself interesting, the more general methodological issues dealing with accident reporting and data analysis deserve special attention. Some possible alternate explanations of RHT based upon methodological issues are considered.

1. The change in accident rate over time suggests that the level of acceptable risk must have changed over time.

Conceptually this is difficult to accept, as homeostasis is defined by its property of resistance to change and of returning to some set-point.

2. It is also possible that individuals may be aware of total accidents rather than accident rates. This would suggest that with population increases there would be the perception of more accidents even though the actual rate may be decreasing. If the level of acceptable risk is based upon the perception of accident frequency a number of variables will influence that perception, including vividness and frequency of reports in the media. This would suggest short-term fluctuations, whereas in the data base being considered, fluctuations were gradual and over a 35-year period.

3. The quality and consistency of data have a bearing on the rates. At one time a driving fatality was recorded if the death was within 60 days of the accident, now a fatality is recorded only if the death is within 30 days of the accident. During the period of the study there have been changes in the way in which driving distances were estimated. There have also been notable improvements in emergency medical care for road accident victims. While these factors clearly have an effect on accident rate data they do not appear to provide an explanation for the decrease in

accidents. The changes noted appear at some particular point in time, whereas the decrease in accidents has been a continuous process.

4. A number of covariants may have also changed. The sex, age, and experience of drivers may have changed; with increased affluence, faster and more powerful automobiles may be purchased and driven in different parts of the country. The construction of freeways which separates motor traffic from pedestrians and cyclists may decrease accidents through good engineering, but may increase accidents because of increased usage and greater speeds. It is clear that only a very sophisticated analysis can deal with these issues.

5. The distribution of deaths for different classes of road use has changed (pedestrian, cyclist, motorist, etc.). This probably represents changing preferences for modes of travel. The pattern of change in fatalities for each mode of travel does not mirror the change in usage for each mode.

6. Finally, there have been a number of safety measures implemented over the period of this study; some of these have been of a non-motivational nature and some are difficult to classify one way or another. As these various measures have been introduced continuously over time it is the opinion of Shannon (1986) that they are responsible for the gradual and continuous decrease in accidents.

McKenna 1983

The McKenna (1983) paper examines the concept of accident proneness and attempts to explain why the history of this concept has been so controversial. If accidents were a random occurrence then they would be described by a Poisson distribution; if, on the other hand, there was a differential probability of certain individuals having an accident then a negative binomial distribution may be expected. Given that the negative binomial has historically given the better fit, it follows that the concept of accident proneness should be accepted. There are several difficulties in accepting the accident proneness concept on these grounds. In interpreting the negative binomial as evidence for accident proneness, it is necessary to control for such factors as differential occupational risk and biases in accident reporting across jobs. Even when these factors are adequately controlled, there is no reason for assuming that when a Poisson distribution is not found that the cause is some unknown personal variable. It is just as reasonable to assume that the cause is some unknown non-personal variable. In addition, some critics have pointed out that the negative binomial can be derived from assumptions that do not include differential initial liability to accident involvement. It has been shown that the negative binomial can be derived from assumptions of equal initial accident liability if the occurrence of an accident alters the probability of further accidents.

It has been stated in the literature that a few people are responsible for many accidents (e.g., 4% responsible for 36% of accidents). This claim has been refuted often, and the finding explained based purely on the laws of probability. There is considerable confusion as to whether accident proneness is a unitary concept or a mixture of various psychological factors. Furthermore, there is a lack of consensus as to whether it is a general characteristic which will generalize across different environments; there are some who subscribe to the concept of accident proneness while rejecting the generality notion. An additional, but related concept, is to regard accident proneness as an innate and unmodifiable characteristic. Those viewed in the above manner, are seen as carrying their accident proneness "hung like an albatross around each person's neck" (McKenna, 1983, p. 66).

It is clear that there is no universal concept or standard definition of accident proneness. What appears promising in clarifying the concept is the use of certain concrete operations which can be conceptually linked to a reasonable definition of accident proneness. It has been shown that locus of control, field dependence, ability to switch attention, and life events scores can be linked to a concept of accident proneness and that these measures show the possibility of improving our understanding of the psychological processes underlying human performance errors.

Klein 1976

Klein (1976) in his paper dealing with social aspects of exposure to highway crashes, notes that with an increase in funding from governmental and private agencies that many sophisticated researchers have become market driven and have moved into the area of accident research. The problem, he observes, is that these investigators come from rather narrow disciplines and then apply their technology to an aspect of accident research that is amenable to that technology. The domain of investigation becomes restricted to the area where the researcher's technology and accident problems overlap. The social perspective is to view a highway accident and its resulting trauma as a public-health problem involving a variety of interactions among psychological, sociological, cultural, legal, political, educational, and other factors.

One by-product of this narrow view is unquestioned support of the status quo in accident research. This in turn results in a great deal of research being directed at attempts to modify driver behavior, and very little effort being directed at the driver's environment. Evidence is accumulating to demonstrate that programs directed at one aspect of driver behavior are seldom effective. There is little in the way of program evaluation, or cost-benefit analyses, and in cases where this is adequately performed the results have not been encouraging.

Klein contends that the driver and his environment are too narrowly defined. For example, research on passive restraint in motor vehicles has been superior in quality and overwhelmingly superior in quantity to research directed at public resistance to the use of these same passive restraints. Many programs of research and public action are directed at the average driver. It would be of greater value to identify those who are at greatest risk and then direct research and intervention programs at them so that limited resources can provide the most advantageous cost-benefit ratios.

It is suggested that investigators have noted the association between a number of variables and accidents. In this context it is not suggested that any of these variables be used to screen the accident prone, but rather to better understand the characteristics of those who are likely to be involved in accidents. This is based on the belief that automobile accidents are not isolated behaviors but rather one index of general tendencies "you drive as you live" (Klein, 1983, p. 216).

In order for the social perspectives approach to work, Klein feels investigators must get beyond their own technical specialties, show trust in the efforts of others from different disciplines, and adopt accident research as their primary affiliation. In many cases researchers see accident research as a source of data to investigate a problem outside the area of

accident research. Until investigators see themselves primarily as accident researchers and are able to educate the research establishment to the potential contributions that the social perspective can make we will have a fragmentary approach to the problem of human error.

Summaries of References - Tasks 2 and 3

Beall, J. A. Jr. (1972).

A study of fatal and disabling private motor vehicle accidents in the Third U.S. Army included a review of the literature, an analysis of prominent characteristics of third army accidents, an identification of the personal characteristics of a sample of the accident-involved drivers, and a comparison of the accident-involved and a group of accident-free drivers on those personal characteristics.

The literature review indicated that prior criminal offenses, previous traffic violations, driver age, and drug and alcohol abuse were related to the accident involvement of drivers in general. Among the personal characteristics of accident-involved army drivers were years of military service, military rank, record of previous traffic violations, record of non-traffic disciplinary offenses, and several aptitude subscale scores. The analysis of the matched groups of accident-involved and accident-free army drivers indicated that those same three personal characteristics significantly discriminated between the two groups of drivers.

Beshai, N. (1984).

Data were analyzed on accidents and on drivers convicted of alcohol-related traffic offenses (ARTCs) during a 4-year period in Los Angeles County and California. The indications were that, although ARTCs and accidents decreased across time, recidivism was higher for ARTCs than for accident involvement.

Clayton, A. (1985).

Participants at the symposium agreed without exception that young people are involved in more accidents and are overrepresented in fatal accidents. Among the factors identified in various studies, age, inexperience and gender were found to be significantly related to accidents. Also, the number of miles driven was useful in the prediction of accident rate.

Ferguson, J. C., McNally, M. S., & Booth, R. F. (1983).

In a study concerning the high accident rates for initial enlistees in the Navy, hospital admissions and deaths due to accidents were analyzed for a group of such personnel during the first four years of enlistment. Personal characteristics such as age, education level, and mental ability at time of enlistment were also analyzed. It was found that, when considered alone, each of the personal characteristics was significantly correlated with accidents; however, when considered simultaneously, education level was the only characteristic which related significantly to accidents.

Finn, P., & Bragg, B. W. (1986).

This study attempted to use misperception of risk to account for the overrepresentation of young people in traffic accidents. A group of young male drivers and a group of older male drivers estimated the risk of accident involvement using several methods: A questionnaire about accident involvement, ratings of riskiness of photographs depicting driving situations, and ratings of riskiness of videotapes of driving situations. The results indicated that young people tend to misperceive the riskiness of driving situations, a failure which may contribute to their over-involvement in traffic accidents.

Hansen, C. P. (1988).

As part of a study validating two personality scales as predictors of industrial accident risk, a review of the literature relating accidents and personality characteristics was conducted. The review revealed a consistent relationship between accidents, both industrial and traffic, and maladaptive behaviors as manifested in delinquency, criminal acts, marital and/or familial problems, and problem drinking, among others.

Harano, R. M. (1975).

A group of repeat traffic violators in California was evaluated to determine whether subsequent driving record could be predicted psychometrically after a group intervention aimed at driver improvement. The results indicated that driving record

and criminal record were the best predictors of future driving record. Age was also a factor associated with collisions.

Jonah, B. A. (1986).

A review of research concerning the risk of involvement of young people in traffic accidents supported the contention that young drivers are at a greater risk of accident involvement than are older drivers due to their tendency to take risks while driving. Epidemiological data lent support to the hypothesis that young drivers are overrepresented in traffic accidents. Data from self-reports and observations of driving behavior supported the hypothesis that it is their propensity for taking risks when driving which is a primary contributor to the greater accident involvement of young people.

Kadell, D. J., & Peck, R. C. (1984).

California has established a reexamination program (REX) for those drivers who accumulate two major traffic violations within three years. A comparison of 6,000 reexamined drivers with 6,000 controls revealed that the REX information improved the prediction of future alcohol-related traffic violations over driving-record information alone.

Koz, J. P. (1984).

As part of a dissertation analyzing accident proneness in fighter pilots, an extensive review of factors related to accident proneness was conducted. Among the variables indicated

by previous research to be related to accidents and accident risk were socioeconomic status, previous accident history, aviation aptitude scores, vocational interest test scores, and type of parenting.

Majors, J. S. (1984).

As part of a study of the relationship between human factors and aircraft accidents and near accidents, 34 U.S. Air Force C-5 pilots were surveyed regarding possible human factors problem areas which could affect the flight experience. Among the areas noted were cognitive skills and information processing, fatigue, problems with attention, changes in moods and/or emotions, career and promotion difficulties, and life events and/or changes. It was also found that 17.6% of the pilots reported a history of significant behavioral, cognitive, emotional, and/or interpersonal problems or changes.

McGuire, F. L. (1976).

Personality factors which have been found to be associated with traffic accidents were delineated. The accident driver has been described as tending to possess a more disturbed life history including such experiences as an unhappy childhood, delinquency, family disruptions, and an uneven work record. Age of the driver has also been found to be related to accident occurrence.

McKenna, F. P. (1983).

The concept of accident proneness was analyzed and factors relating to individuals who are repeatedly involved in accidents were delineated. A review of accident literature indicated, among other things, that people who have more accidents at home tend to have more accidents at work.

Peck, R. C. (1985).

The symposium participants examined data on young California drivers involved in traffic accidents and convicted of traffic violations. The analyses revealed that although young drivers are overrepresented in traffic accidents in comparison to older drivers, the factors which correlate with accident involvement and risk are similar for all age groups. It was found that the best predictor of accident risk was the number of 1-point traffic convictions.

Pestonjee, C. M., Singh, A. P., & Singh, U. B. (1980).

A brief review of accident literature was conducted as part of a study of personality factors associated with traffic accidents. Previous research indicated that driver age, driving experience, marital status, and previous traffic conviction records were consistent predictors of accident involvement. A study comparing 20 accident-involved drivers with 20 accident-free drivers revealed a number of personality factors which differentiated between the two groups of drivers.

Plant, M. A., Peck, D. F., & Stuart, R. (1984).

A questionnaire concerning alcohol and drug use and the occurrence of alcohol-related consequences (ARCs) was administered to 484 males and 552 females aged 14-15 years. Approximately 20% of the males and 13% of the females reported at least one significant ARC. Effective predictors of ARCs for both sexes were found to be factors associated with leisure activities and bar frequenting. In addition, drug use was positively correlated with accidents in general and with ARCs. For males, drug use was a significant predictor of ARCs whereas deriving pleasure from drinking was predictive of ARCs for females.

Risser, R. (1985).

In this study of the relationship between traffic conflict (TC) situations and accidents and the role of driver behavior in increasing accident risk, 201 drivers were observed in a standardized driving test. Subsequently, 196 of these drivers were interviewed about their driving experience and their record for the previous five years. It was found that TCs and accidents were positively correlated and that there was a positive correlation between driving errors and accident records and TCs.

Sanders, E. P. (1964).

The frequency of accidents was evaluated for 597 hospital employees representing 46 jobs grouped into 6 job levels. It was found that there were more accidents for lower level jobs than

for higher level ones; however, there were no significant differences in the frequency of accidents within a given job level.

Sipes, W. E. (1986).

In this dissertation, the psychological profile was studied as a means of identifying human factors which contribute to aircraft accidents. The literature review revealed that accident repeaters tend to experience problems with interpersonal relations, erratic work histories, and difficulty with authority figures.

Voicu, C., & Nereuta, A. (1985).

The relationship between aptitudes and efficient work functioning for equipment operators whose tasks involve accident risk was evaluated using a battery of assessment instruments. Based on a sample of 35 operators it was found that factors such as intelligence (e.g., use of abstract ideas, reasoning), memory for numbers, attention flexibility, and speed of visual information acquisition, among others, were significantly related to efficiency of functioning.

Wilde, G. J. S. (1976).

The social interactive aspect of driving behavior was discussed, and a brief review of pertinent literature was conducted. It was found that level of education and the amount of beating and/or bossing around by parents were related to driver aggression.

Williams, C. L., Henderson, A. S., & Mills, J. M. (1974). A brief review of the literature on factors related to traffic accidents revealed that four variables are associated with the occurrence of traffic accidents: (1) youth of the driver; (2) the driver's attitude concerning risk and danger; (3) a pattern of maladaptive and strong emotions; and (4) the social irresponsibility of the driver. A study comparing 100 serious-offense drivers with 99 matched controls using a battery of assessment instruments indicated that socioeconomic status, occupation, and type of driver training were significant discriminators for the two groups.

Motivation and Intervention Studies

Larson et al., 1980

The Larson et al. research is important for several reasons:

1. The subjects were members of a paramilitary organization, i.e., police officers.
2. The targeted behavior is on-duty driving. Given the social structure of most police departments, driving violations by police are rarely reported or recorded, unless they result in an accident. As in certain military settings, the evaluation of police driving is complicated by the remoteness and isolation of the job activity. In addition, the results of both safe and unsafe behavior are inconsistent and rare e.g., safety awards, accidents, or reprimands.

3. Due to high exposure and emergency/pursuit driving, police have a high accident rate.

4. The Larson et al. study is methodologically sound.

These investigators studied the use of the tachograph--a clock-driven recording device which provides a permanent record of vehicle functions. Tachograph units were installed in 224 vehicles of a metropolitan police department (Nashville). Three sections of the department received the "Feedback" treatment at different time intervals and baseline length in a multiple baseline design. Supervisory personnel monitored (a) use of emergency lights (b) high rates of speed and (c) non-movement over 30 minutes.

Two treatments given to the "Traffic Section" after tachograph installation (no feedback and feedback from sergeants) as well as the installation itself had little or no effect. Larson et al. then introduced a "Feedback plus inspections" condition. Here tachograph records went directly to the Inspections Section of the department -- a unit responsible for compliance with rules, regulations and policies. When necessary, they requested explanations from the officer and his or her sergeant and also administered disciplinary actions.

In the traffic section, the Feedback/inspection treatment led to the virtual elimination of personal injury accidents and at-fault accidents were substantially reduced. The remaining two

sections were given just the Feedback/inspections treatment condition after a baseline (no tachograph) condition with similar results. The rate of officer related accidents during baseline was 1.47 per 100,000 miles, but showed a marked drop to .85 during the intervention. The data also revealed that the tachograph/feedback program was cost effective.

At the onset of the program, officers reacted negatively to the tachograph, which they termed the "iron sergeant". By the end of the data collection, however, tachograph use was accepted as routine.

Larson et al. attribute their results primarily to feedback. However, increased accountability and disciplinary actions obviously play a major role in this outcome. It should be noted that accident rate reduction only occurred when the Inspections Section monitored the procedures. Reliance on field sergeants alone to provide feedback was not effective. It may be that the sergeants' close working relationships with their subordinates undermines the effectiveness of the feedback procedures, at least without a strong "back-up" by higher authority. This factor should be considered in any military application of the tachograph/feedback technique.

The use of automated recorders on vehicles, combined with feedback, warnings, and point systems, might be applicable to Army safety. For example, the new flight data recorder for

helicopters could provide information on unsafe flight practices, leading to feedback, warning letters, points, and/or hearings for pilots. Also, if a pilot accumulated a certain point level, the recorder data might be sampled more extensively -- thus focusing on pilots showing a tendency toward inadequate self discipline.

Haynes, Pine and Fitch (1982)

This study is selected for analysis due to the following reasons:

1. It is a good example of the organizational behavior modification approach.
2. It uses relatively low-cost techniques that are applicable to military organizations.
3. It focuses on outcome variables, i.e., accident rates, severity and cost.

Haynes et al. studied the effectiveness of an intervention package (feedback, competition, and incentives) in reducing accidents of mass transit operators. The setting was a regional transport authority in a large midwestern city. Despite prior interventions, e.g., a disciplinary code, safety awards, this authority continued to have the high accident rate common to city buses.

The experimental design consisted of two facets (a) bus drivers were randomly assigned to a control group (N = 325) or an experimental group (N = 100). The experimental treatment was also evaluated through a within-group reversal design.

For the experimental group, four operators were selected as team captains and four supervisory personnel as team sponsors. Twenty-four team members were then randomly assigned to each of the four teams.

Accidents were defined as any contact between the bus and a vehicle or fixed object, regardless of fault or extent of damage and/or when a passenger reported on the operator observed injury. A number of built-in reliability checks were used to enhance the reliability of accident reporting.

Prior to the intervention, baseline accident data was collected for 15 months. The intervention strategy was then administered to the experimental group for 18 weeks. It consisted of three components. Haynes et al. (1980, p. 411) describe them as follows:

Performance Feedback. Performance feedback charts were posted in the operators' lunchroom and updated on a daily basis. Each team's chart consisted of the name of each member on the vertical axis and the date for each day of the program across the horizontal axis. Green dots were placed next to the operator's name under the corresponding date for each accident-free day; a red dot when the operator was involved in an accident.

Team Competition. Accidents were assigned points based on their classification. Avoidable vehicle accidents were

assigned 3 points, passenger accidents 2 points, and unavoidable accidents 1 point. Accident classification was made by management personnel who were not aware of the names of operators who participated in the program.

Teams competed for the lowest number of total accident points per 2-week period. Each member of the winning team(s) received his/her choice from a menu of available incentives. All teams started over again with 0 points at the beginning of the next 2-week period. (Competition, a common strategy for behavior change, moves the focus of reinforcement contingencies from the individual to the group.)

Incentives. The incentives that were available to each member of the winning team averaged \$5 in value and ranged from cash to free gasoline to free monthly passes on the bus system. Team captains and sponsors, along with incentive group operators, were encouraged to suggest desirable incentives. A double bonus was added for teams that were involved in no accidents for the entire 2-week period. In addition to the monetary incentives, each of the winning team captains was personally congratulated by the director of operations, and the team sponsors the general manager of the transit authority. When meetings were impossible to schedule because of time conflicts, personal letters were sent to the winning captains and sponsors.

Following the intervention, the incentive program ended and the feedback charts were removed. Data were collected for an additional 18 weeks (Baseline I).

No differences were found for accident rates during the two baseline phases, as expected. However, during the last 10 weeks of the intervention, the experimental group showed a statistically significant 35% lower accident rate than the control group. Also, accident costs differed substantially during the intervention phase (experimental = \$35; control = \$116) and to a lesser extent in Baseline II (experimental = \$28; control = \$76).

Another interesting effect was seen during the intervention phase. Experimental group drivers were involved in 39.7% fewer "avoidable" accidents and 23.7% fewer "unavoidable" accidents. It appears that even certain of those accidents classified as "unavoidable" may be affected.

Furthermore, the benefit-cost, ratio appears quite favorable, being approximately 4.6:1. and at least 3:1.

Interviews with experimental-group drivers revealed that they tried to minimize the risks they took. Thus, it appears that the intervention motivate drivers to reduce high-risk behaviors.

Given these results and considering relative simplicity and how cost of the intervention, the procedures used by Haynes et al. are worthy of consideration.

Zohar, 1980

Zohar's research on safety climate is selected for several reasons:

1. It delineates theoretical and applied implications of the organizational safety climate.
2. Zohar's data helps define the organizational safety climate.
3. The study is a good illustration of a useful methodology to construct and validate a scale of this type. Zohar defines organizational climate as a summary of perceptions which organization members share about their work environments. These perceptions serve as a frame of reference for guiding adaptive (and sometimes maladaptive) task behaviors.

Schneider (1975) has proposed that specific climate measures be used in an area of research. In the safety area, Zohar (1980) has developed and validated an organizational climate scale. Also, reviews of the literature (Zohar, 1980; Cohen, 1977) defined six key organization characteristics which differentiate high versus low accident-rate companies. These were as follows (for successful companies):

1. A strong management commitment to safety, e.g., safety officers had a higher status in low-accident companies.
2. Strong emphasis on safety training.

3. Open communication links and frequent contacts between workers and management, e.g., frequent safety inspections.
4. General environmental control and good housekeeping.
5. A stable workforce with less turnover and older workers (this may reflect good personnel practices).
6. distinctive ways of promoting safety, e.g., counseling, recognition, etc.

Based on reviewed literature, Zohar decided that the safety climate questionnaire would contain the following dimensions:

1. perceived management attitudes toward safety
2. perceived effects of safe conduct on promotion
3. perceived effects of safe conduct on social status
4. perceived organizational status of safety officer
5. perceived risk level at work place
6. perceived effectiveness of enforcement versus guidance in promoting safety
7. perceived importance and effectiveness of safety training

Scale construction involved using seven Likert-type items for each of the seven dimensions. The scale was then administered to 120 factory workers. Factor analysis revealed eight factors, including the original seven factors. The final safety climate scale contained five items per factor.

In order to validate the scale, Zohar administered it to twenty factories in Israel. Five factories each were randomly

chosen from the four areas of: metal fabrication, food processing, chemicals, and the textile industry. The average safety climate score varied significantly across factories. In general, chemical plants had the highest scores, whereas food processing plants have the lowest scores--a finding which seems to reflect the high risks involved in chemical production.

Safety inspectors also ranked the factories within each area as to safety practices. Correlation coefficients (Rho) between climate scores and inspectors safety rankings were .90 (metal), .80 (chemical) and .50 (food). Given the small Ns, these coefficients should be interpreted with caution.

Zohar's research points the way for a similar approach to assessing military safety climate. Initial factors and items could be selected on the basis of the research of Zohar (1980) and Lindsey et al. (1983). A sample of 200-300 Army personnel from several units would be given the Army Safety Climate Scale (ASCS). The data then would be factor-analyzed and the final scale constructed.

A validation study would entail administering the scale to samples of personnel from a number of Army Units (e.g., 30), then correlating ASCS scores with objective measures of safety, e.g., accident rates, from the USASC database. Care should be taken to match of weight accident data for different types of units, exposure rates, and other key variables. Another possibility

would be to run correlations only across units in the same category--e.g., ASCS scores correlated with accident rates in 15 transportation companies.

References

- Adams, J.G.V. (1985). Smeed's law, seat belts, and the emperor's new clothes. In L. Evans & R. C. Schwing (Eds.), Human Behavior and Traffic Safety (pp. 193-257). New York: Plenum.
- Aitken, R. C. B. (1969). Prevalence of worry in normal aircrew. British Journal of Psychology, 42, 283-286.
- Alkov, R. A., Gaynor, J. A., & Borowsky, M. S. (1985). Pilot error as a symptom of inadequate stress coping. Aviation, Space, and Environmental Medicine, 56, 244-247.
- Asher, W., & Dodson, B. (1971). Automobile accidents in the year following high school: The predictive value of 377 unobtrusive variables. Behavioral Research in Highway Safety, 2, 107-124.
- Barmack, J. E., & Payne, P. E. (1961). The Lackland accident countermeasure experiment. Highway research Board Proceedings, 40, 513-522.
- Bates, G. E. (1955). Joint distributions of time intervals for the occurrence of successive accidents in a generalized poly scheme. Annals of Mathematical Statistics, 26, 705-720.
- Beall, J. A., Jr. (1972). A strategy for the reduction of private motor vehicle accidents in a military unit. Headquarters Third U. S. Army, Fort McPherson, Georgia.

- Beall, J.A. & Blumenfeld, W.S. Development of a psychometric procedure to forecast private motor vehicle accidents within a military sample. Reprinted from the Proceedings, 80th Annual Convention, APA, 1972.
- Ben-David, G. Lewin, I. and Halvia, Y. (1972). The influence of personal communication on the driving behavior of private motorists in Israel. Accident Analysis and Prevention, 4, 269-301.
- Benner, Jr., L. (1978). Generating hypotheses to explain accidents and other rare events. Journal of Safety Research, 10, 2-4.
- Beshai, N. (1984). Trends in problem driving behavior in Los Angeles county and California. Abstracts & Reviews in Alcohol and Driving, 5, 20-27.
- Borowsky, M.S. (1981). Dual accident pilots in Naval aircraft. Aviation, Space, and Environmental Medicine, May, 310-311.
- Boyle, A. J. (1980). 'Found experiments' in accident research: Report of a study of accident rates and implications for future research. Journal of Occupational Psychology, 53, 53-64.
- Bramwell, S. T., Masuda, M., Wagner, N. N., & Holmes, T. H. (1975). Psychosocial factors in athletic injuries: Development and application of the social and athletic readjustment rating scale. Journal of Human Stress, 1(2), 6-20.

- Brown, R. L. (1983). Multidimensional graphic techniques for exploratory analysis of archival accident data. Accidental Analysis & Prevention, 15, 299-307.
- Brown, I. D. (1986). Prospects for improving road safety. Ergonomics, 29, 1495-1505.
- Brown, I.D., & Copemena, A.K. (1973, October 8-12). Drivers' attitudes to the seriousness of road traffic offenses considered in relation to design of sanctions. Paper presented at the First International Conference on Driver Behaviour, Zurich, Switzerland.
- Brown, E., Marchi E., & Sandreno, A. (1976). Post licensing control reporting and evaluation system. (Summary Report). Sacramento, CA: California Department of Motor Vehicles.
- Burke, C.J. (1951) A Chi-Square test for "proneess" in accident data. Psychological Bulletin, 48, 496-504.
- Campbell, B.J. (1958). Driver improvement-the point system. (Tech. Report). Chapel Hill, NC: University of North Carolina, Institute of Government.
- Clark, A.W. & Prolisko, A. (1979). Social-role correlates of driving accidents. Human Factors, 21, 655-659.
- Clayton, A.B. (1972). An accident-based analysis of road-user errors. Journal of Safety Research, 4, 69-74.

- Clayton, A. (1985). Youth and traffic safety. International symposium: Alcohol, drugs, and driving. Alcohol, Drugs & Driving - Abstracts & Reviews, 1, 107-110.
- Cobb, P.W. (1940) The Limit of Usefullness of Accident Rate as a measure of accident proneness. Journal of Applied Psychology, 24, 154-159.
- Cohen, A. (1977). Factors in successful occupational safety programs. Journal of Safety Research, 9, 168-178.
- Cohen, A., Smith, M. J., & Anger, K. W. (1979). Self-protection measures against workplace hazards. Journal of Safety Research, 11, 121-131.
- Cooper, C. L., & Sloan, S. J. (1985). Occupational and psychosocial stress among commercial aviation pilots. Journal of Occupational Medicine, 27, 570-576.
- Crapnell, S. G. (1981). For prize-winning programs, try awards and incentives. Occupational Hazards, 44, 35-40.
- Czerneck, A., & Clack, G. (1973). Incentives for safety: How prizes for avoiding accidents foster safety awareness. Job Safety and Health, 1, 7-11.
- Dalton, K. (1960). Menstruation and accidents. British Medical Journal, 2, 1425-1426.
- DeBobes, L. (1986). The work environment: The psychological factors in accident prevention. Personnel Journal, 34-38.

- Denney, T. J. (1985). Pilot error in aircraft mishaps. (Tech. Note 85-1). Ft. Rucker, AL: U.S. Army Safety Center.
- Department of the Navy, Naval Safety Center (1983). A report on the High-Risk Aviator Study. Norfolk, VA: Author.
- Do defensive driving courses make better drivers? (1984). Journal of American Insurance, 60(3), 25-27.
- Elman, D. & Killebrew, T.J. (1978). Incentives and seatbelts: changing a risstant behavior through extrinsic motivation. Journal of Applied Social Psychology, 8, 77-83.
- Evans, L. & Wasielewski, P. (1982). Do accident-involved drivers exhibit riskier everyday driving behavior? Accident Analysis and Prevention, 14, 57-64.
- Evans, L. (1985). Human behavior feedback and traffic safety. Human Factors, 27, 555-576.
- Evans, L. (1986). Comments on Wilde's notes on "risk homeostasis theory and traffic accident data." Risk Analysis, 6, 103-107.
- Evans, L. (1986). Risk homeostasis theory and traffic accident data. Risk Analysis, 6, 81-94.
- Evans, L., Wasielewski, P., & Von Buseck, C. R. (1982). Compulsory seat belt usage and driver risk-taking behavior. Human Factors, 24, 41-48.
- Fellner, D. J., & Sulzer-Azaroff, B. (1984). Increasing industrial safety practices and conditions through posted feedback. Journal of Safety Research, 15, 7-21.

- Ferguson, J.C., McNally, M.S. & Booth, R.F. (1983). Individual characteristics as predictors of accidental injuries in naval personnel (Report No., 83-10). San Diego: Naval Health Research Center.
- Ferguson, J.C., McNally, M.S., & Booth, R.F. (1984). Individual characteristics as predictors of accidental injuries in naval personnel. Accident Analysis and Prevention, 16, 55-62.
- Ferreira, Jr., J. (1970) Accidents and the accident repeater. Driver Behavior and Accident Involvement, Oct., 58-99.
- Finding the accident prone. (1984). Aviation Safety, April, 8-9.
- Finn, P., & Bragg, B.W. (1986). Perception of the risk of an accident by young and older drivers. Special issue: Youth and traffic accident risk. Accident analysis & Prevention, 18, 289-298.
- Froggatt, P., & Smiley, J. A. (1964). The concept of accident proneness: A review. British Journal of Industrial Medicine, 21, 1-12.
- Fuller, R. (1984). A conceptualization of driving behavior as threat avoidance. Ergonomics, 27, 1139-1155.
- Garretson, M. & Peck, R.C. (1982). Factors associated with fatal accident involvement among California drivers. Journal of Safety Research, 13, 141-156.

- Gebers, M. A., & Peck, R. C. (1987). Basic California traffic conviction and accident record facts. (Report No. CAL-DMV-RSS-114). Sacramento, CA: Department of Motor Vehicles.
- Geller, E. S. (1983). Industry-based incentives for promoting seat-belt use: Differential impact on white collar versus blue collar employees. Journal of Organizational Behavior Management, 5(1), 17-29.
- Geller, E. S., Davis, L., & Spicer, K. (1983). Industry-based incentives for promoting seat belt use: Differential impact on white-collar versus blue-collar employees. Journal of Organizational Behavior Management, 5(1), 17-29.
- Geller, E. S., Paterson, L., & Talbott, E. (1982). A behavioral analysis incentive prompts for motivating seat belt use. Journal of Applied Behavior Analysis, 15, 403-415.
- Green, R. G. (1985). Stress and accidents. Aviation, Space and Environmental Medicine, 56, 638-641.
- Greenshield, B. D. & Plott, F. N. (1967). Development of a method of predicting high-violation drivers. Journal of Applied Psychology, 51, 205-210.
- Greenwood, M. (1950). Accident Proneness. Biometrika, 37, 24-29.
- Greenwood, M., & Woods, H. M. (1919). The incidence of industrial accidents upon individuals with specific reference to multiple accidents. Industrial Fatigue Research Board Report, 4, London: HSMO.

- Greenwood, M., & Yule, G. U. (1920). An inquiry into the nature of frequency distributions representative of multiple happenings with particular reference to the occurrence of multiple attacks of disease or of repeated accidents. Journal of the Royal Statistical Society, 83, 255-279.
- Haight, F. A. (1986). Risk, especially risk of traffic accident. Accident Analysis & Prevention, 18, 359-366.
- Hakkinen, S. (1958). Traffic accidents and driver characteristics. A statistical and psychological study. (No. 13). Helsinki: Findland Institute of Technology Scientific Researches.
- Hansen, C.P. (1988). Development and validation of two industrial alccident liability measures. Unpublished manuscript.
- Harano, R.M. (1975). The psychometric prediction of negligent driver recidivism. Journal of Safety Research, 7(4), 170-179.
- Harano, R., & Hubert, D. E. (1974). An evaluation of California's good driver' incentive program. (Report No. 6) Sacramento, CA: Department of Motor Vehicle.
- Harano, R.M., Peck, R.C., & McBride, R.S. (1975). The prediction of accident liability through biographical data and psychometric tests. Journal of Safety Research, 7, 16-52.
- Harrington, D.M., and Ratz, M. (1978). The effectiveness of an at-home driver's licensing test. (Tech, Rep. 60). California: California Department of Motor Vehicles.

- Harris, F.J. (1950). Can personality tests identify accident-prone employees? Personnel Psychology, 3, 455-459.
- Hauer, E. (1983). An application of the likelihood/Bayes approach to the estimation of safety counter-measure effectiveness. Accidental Analysis & Prevention, 15, 287-298.
- Hauer, E. (1986). On the estimation of the expected number of accidents. Accident Analysis & Prevention, 18, 1-12.
- Haynes, R. S., Pine, S. I., & Fitch, G. (1982). Reducing accident rates with organizational behavior modification. Academy of Management Journal, 25, 407-416.
- Helander, C. J. (1983). Intervention strategies for accident-involved drivers: An experimental evaluation of current California policy and alternatives. (CAL-DMV-RSS-83-85). Sacramento, CA: Department of Motor Vehicles.
- Horn, D. (1947). A study of pilots with repeated aircraft accidents. Aviation Medicine, Oct., 440-449.
- Hudgens, G. A., & Fatkin, L. T. (1984). Risk-taking performance of military personnel: Sex differences and practice effects. (in DTIC Tech. Report). Aberdeen, Maryland: US Army Human Engineering Laboratory.
- Hurst, P. M. (1980). Can anyone reward safe driving? Accident Analysis and Prevention, 12, 217-220.
- Identifying high-risk aviator behavior (1985, April). United States Army Aviation Digest, 31, pp. 16-19.

- Incentive plans spur safe work habits (1987, April). The Wall Street Journal, p. 1.
- Johnston, N. (1985). Occupational stress and the professional pilot: The role of the pilot advisory group (PAG). Aviation, Space, and Environmental Medicine, 56, 633-637.
- Jonah, B.A. (1986). Accident risk and risk-taking behavior among young drivers. Accident Analysis & Prevention, 18, 255-271.
- Kadell, D. J. (1984). The traffic safety impact of driver improvement counter measures targeting 55-MPH speed limit compliance. (CAL-DMV-RSS-84-91.) Sacramento: Department of Motor Vehicles.
- Kadell, D.J., & Peck, R.C. (1984). An evaluation of the alcohol reexamination program for drivers with two major traffic offenses. Abstracts & Reviews in Alcohol & Driving, 5, 3-12.
- Kaestner, N., Warmoth, E.J., and Syring, E.M. (1967). Oregon study of advisory letters: the effectiveness of warning letters on driver improvement. Traffic Safety Research Review, 11, 67-72.
- Kahneman, D., Ben-Ishai, R., & Lotan, M. (1973). Relation of a test of attention to road accidents. Journal of Applied Psychology, 58, 113-115.
- Kalez, M. M., & Hovde, R. C. (1945). Pilots with repeated "pilot-inaptitude" accidents. The Journal of Aviation Medicine, 16, 370-375.

- Kalez, M.M., & Hovde, R.C. (1946). Fatal aviation accidents. Journal of Aviation Medicine, 17, 234-243, 264.
- Karan, B. S., & Kopelman, R. E. (1986). Effects of objective feedback on vehicular and industrial accidents: A field experiment using outcome feedback. Journal of Organizational Behavior Management, 8, 45-56.
- Kaz, J.P. (1984). An analysis of accident proneness in the fighter pilot. Unpublished doctoral dissertation, The American University, Washington, D.C.
- Khalil, T. M., & Kurucz, C. N. (1977). The influence of "biorhythm" on accident performance and performance. Ergonomics, 20, 389-398.
- Klein, D. (1976). Social aspects of exposure to highway crash. Human Factor, 18, 211-220.
- Komaki, J., Barwick, K. D., & Scott, L. R. (1978). A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. Journal of Applied Psychology, 63, 434-445.
- Komaki, J., Collins, R. L., & Penn, P. (1982). The role of performance antecedents and consequences in work motivation. Journal of Applied Psychology, 67, 334-340.
- Komaki, J., Heinzmann, A.T., & Lawson, L. (1980). Effect of training and feedback: Component analysis of a behavioral safety program. Journal of applied psychology, 65, 261-270.

- Krajick, K. (1986). Do seat belts kill? Psychology Today, May, 10-11.
- Kruglanski, A. W. (1986). Freeze-think and the Challenger. Psychology Today, 48-49.
- Kuan, J., Miller, M.F., and Peck, R. (1969). An evaluation of the renewal test waiver program for good and average drivers. (Tech, Report). Sacramento, CA: Department of Motor Vehicles.
- Lancianese, F. W. (1981). Small plant's safety success formula. Occupational Hazards, 43, 45-48.
- Larson, L.D., Schnelle, J.F., Kirchner, R., Carr, A.F., Domash, M., & Risley, T.R. (1980). Reduction of police vehicle accidents through mechanically aided supervision. Journal of Applied Behavior Analysis, 13, 571-581.
- Lategola, M. T., Fiorica, V., Booze, C. F., & Folk, E. D. (1970). Comparison of status variables among accident and non-accident airmen from the active airman population. (AM no. 70-18A). Oklahoma City, OK: Office of Aviation Medicine.
- Lave, L. B. (1987). Injury as externality: An economic perspective of trauma. Accident Analysis and Prevention, 19, 29-37.
- Lee, P., & Smallwood, R. (1979). The tachograph: Still out in the cold? Management Accounting, 57, 16-17.

- Leplat, J., & Rasmussen, J. (1984). Analysis of human errors in industrial incidents and accidents for improvement of work safety. Accidents Analysis & Prevention, 16, 77-88.
- Levine, J. B., Lee, J. O., Ryman, D. H., & Rahe, R. H. (1976). Attitudes and accidents aboard an aircraft carrier. Aviation, Space, and Environmental Medicine, Jan., 82-85.
- Lindsey, G. D., Ricketson, D. S., Reeder, M. J., & Smith, C. (1983). Lessons learned from FY 82 U.S. Army aviation mishaps. (Tech. Rep. 83-7). Fort Rucker, AL: U.S. Army Safety Center.
- Liskey, N. E. (1972). Accidents--rhythmic threat to females. Accident Analysis and Prevention, 4, 1-11.
- Loo, R. (1978). Individual Differences and the perception of traffic signs. Human Factors, 20(1), 65-74.
- Majors, J. S. (1984). Human factors survey: C-5 pilots. USAF School of Aerospace Medicine Technical Report (Report No. TR 84-26).
- Maguire, B. A., Pearson, E. S., & Wynn, A. H. A. (1952). The time intervals between industrial accidents. Biometrika, 39, 168-180.
- Maritz, J. S. (1950). On the validity of inferences drawn from the fitting of Poisson and Negative binomial Distributions to observed accident data. Psychological Bulletin, 47, 434-443.

- Marsh, W. C. (1971). Modifying negligent driving behavior: Evaluaiton of selected driver improvement techniques. (Report No. 36). Sacramento, CA: Department of Motor Vehicles.
- Marsh, W. C. (1978). Educational approaches to driver improvement. (Tech. Report 66). Sacrament, CA: Department of Motor Vehicles.
- Marsh, W. C. (1986). Negligent-operator treatment evaluation system: Program effectiveness report #2. (Report No. 110). Sacramento, CA: Department of Motor Vehicles.
- Marsh, W. C. (1987). Negligent-operator treatment evaluation system: Program effectiveness report #3. (CAL-DMV-RSS-887-115). Sacramento, CA: Department of Motor Vehicles.
- Marsh, W. C., & Kadell, D. J. (1985). Negligent-operator treatment evaluation system: Program effectiveness report #1. (Report No. 102). Sacramento: Californai Department of Motor Vehicles.
- Martoccia, C. T., & Nelson, W. H. (April 24, 1956). Instructor prediction of student aircraft accidents in naval air flight training: A Negative Finding. Special Report No. 56-11.
- McBride, R. S., & Peck, R. C. (1970). Modifying negligent driving behavior through warning letters. Accident Analysis and PRevention, 2, 147-174.
- McConnell, E. J., & Hagen, R. E. (1980). Design and evaluation of a crash prediction strategy. CAL-DMV-RSS-8076. Sacramento: Department of Motor Vehicles.

- McFarland, R. A. (1963). A critique of accident research.
Annals of the New York Academy of Sciences, 107, 686-695.
- McGuire, F. L. (1976). Personality factors in highway accidents.
Human Factors, 18, 433-442.
- McKenna, F. P. (1982). The human factor in driving accidents:
An overview of approaches and problems. Ergonomics, 25, 867-877.
- McKenna, F. P. (1983). Accident proneness: A conceptual
analysis. Accident Analysis and Prevention, 15, 65-71.
- McKenna, F. (1985). Do safety measures really work? Ergonomics,
28, 489-498.
- Michiels, W., & Schneider, P. A. (1984). Traffic offenses:
Another approach to description and prediction. Accident
Analysis and Prevention, 16, 223-238.
- Mihal, W. L., & Barnett, G. V. (1976). Individual differences in
perceptual information processing and their relation to
automobile accident involvement. Journal of Applied
Psychology, 61, 229-233.
- Miller, T. M., & Schuster, D. H. (1983). Long-term
predictability of driver behavior. Accident Analysis and
Prevention, 15, 11-22.
- Milosevic, S. & Vucinic, S. (1975). Statistical study of tram
driver accidents. Accident Analysis and Prevention, 1, 1-7.
- Mintz, A. (1954). Time intervals between accidents. Journal of
Applied Psychology, 38, 401-406.

- Mintz, A. (1956). A methodological note on time intervals between consecutive accidents. The Journal of Applied Psychology, 40(3), 189-191.
- Mintz, A., & Blum, M. L. (1949). A re-examination of the accident-proneness concept. Journal of Applied Psychology, 33, 195-211.
- Montag, I. & Comrey, A.L. (1987). Internality and externality as correlates of involvement in fatal driving accidents. Journal of Applied Psychology, 72, 339-343.
- Murdoch, P.A. & Wilde, G.J.S. (1980). Reward and punishment in driver control. (Tech. Rep.). Toronto, Canada: Ministry of Transportation and Communication.
- Naatanen, R., & Summala, H. (1974). A model for the role of motivational factors in drivers' decision-making. Accident Analysis and Prevention, 6, 243-261.
- Nataanen, R., & Summala, H. (1976). Road user behavior and traffic accidents. New York: Elsevier.
- National Transportation Safety Board (1967). Pilot age groups by airmen certificates and number of accidents (NTSB Report No. 67-20). Washington DC: Department of Transportation.
- Nimick, B., Cooper, C. L., & Sloan, S. J. (1984). Emotional Stress and Pilots: A review. International Journal of Aviation Safety, 1, 493-498.

- O'Hara, K., Johnson, M. C., & Beehr, T. (1985). Organizational behavior management in the private sector: A review of empirical research and recommendations for further investigation. Academy of Management Review, 10, 848-864.
- Older, S. J., & Spicer, B. R. (1976). Traffic conflicts - a development in accident research. Human Factors, 18, 335-350.
- Palisano, P. (1981). Awards and incentives heighten workers' safety awareness. Occupational Hazards, 43, 35-40.
- Pastonjee, D.M. Singh, A.P. & Singh, U.B. (1980). Personality factors in road accidents. The Japanese Journal of Experimental Social Psychology, 20, 69-73.
- Peck, R. C. (1976). Toward a dynamic system of driver improvement programs. Human Factors, 18, 493-506.
- Peck, R.C. (1985). The role of youth in traffic accidents: A review of past and current California data. International symposium: Alcohol, drugs, and driving. Alcohol, Drugs & Driving - Abstracts & Reviews, 1, 45-68.
- Peck, R. C., & Kadell, D. (1983). California's post-licensing control reporting and evaluation system--A summary of the first three years of results. Traffic Safety Evaluation Research Review, 2(2), 7-21.
- Peck, R. C., McBride, R. S., & Coppin, R. S. (1971). The distribution and prediction of driver accident frequencies. Accident Analysis and Prevention, 2, 243-299.

- Persaud, B. (1986). Relating the effect of safety measures to expected number of accidents. Accident Analysis and Prevention, 18, 63-70.
- Persinger, M. A., Cooke, W. J., & Janes, J. T. (1978). No evidence for relationship between biorhythms and industrial accidents. Perceptual and Motor Skills, 46, 423-426.
- Plant, M.A., Peck, D.F., & Stuart, R. (1984). The correlates of serious alcohol - related consequences and illicit drug use amongst a cohort of Scottish teenagers. British Journal of Addiction, 79, 197-200.
- Prophet, W. W. (1969). Prediction of aviator performance. (Professional Paper 5-69). Alexandria, VA: The George Washington University, Human Resources Research Office.
- Rasmussen, T., Duncan, K., & LePlat, T. (1987). New technology and human error. New York: Wiley.
- Reber, R.A., & Wallin, J. A. (1984). The effects of goal setting, training, and knowledge of results on safe behavior: A component analysis. Academy of Management Journal, 27, 544-560.
- Restak, R. (1986). How klutzes are killing us--and themselves--with clumsiness. (Research Notes). Sacramento, CA: Department of Motor Vehicles.
- Rhoton, W. W. (1980). A procedure to improve compliance with coal mine safety regulations. Journal of Organizational Behavior Management, 2, 243-249.

- Risser, R. (1985). Behavior in traffic conflict situations. Accident Analysis & Prevention, 17, 179-197.
- Ross, H. L. (1984). Social control through deterrence: Drinking and driving laws. Annual Review of Sociology, 10, p. 21-35.
- Rudd, J. R., & Geller, E. S. (1985). A university-based incentive program to increase safety belt use: Toward cost-effective institutionalization. Journal of Applied Behavior Analysis, 18, 215-226.
- Runnion, A., Watson, J. O., & McWhorter, J. (1978). Energy savings in interstate transportation through feedback and reinforcement. Journal of Organizational Behavior Management, 1, 180-191.
- Sanders, E.P. (1964). Relation between accident incidence and type and level of job. Psychological Reports, 14, 670.
- Sanders, M. G., Hofmann, M. A., Hunt, P. D., & Snow, Jr, A. C. (1974). Personality aspects of pilot-error accident involvement. (US AARL Report No. 75-1). Ft. Rucker, AL: U. S. Army Aeromedical Research Laboratory.
- Schneider, B. (1975). Organizational climate: Individual preferences and organizational realities revisited. Journal of Applied Psychology, 60, 459-465.
- Schuster, D. H. (1968). Prediction of follow-up driving accidents and violations. Traffic Safety Research Review, 12(1), 17-21.
- Selye, H. (1956). The Stress of Life. New York: McGraw-Hill.

- Selzer, M. L. & Vinokur, A. (1974). Life events, subjective stress, and traffic accidents. American Journal of Psychiatry 131, 903-906.
- Shannon, H.S. (1986). Road-accident data: Interpreting the British experience with particular reference to the risk homoeostasis theory. Ergonomics, 29, 1005-1015.
- Shinar, D., & McKnight, A. J. (1985). The effects of enforcement and public information on compliance. In L. Evans & R. C. Schwing (Eds.), Human behavior and traffic safety (pp. 385-419). New York: Plenum.
- Sipes, W.E. (1986). The psychological profile in aircraft accident investigations. Unpublished manuscript.
- Sisk, F., & Ricketson, D. S. (1985). Seatbelt usage in U.S. Army vehicle accidents. (Tech. Rep. 85-2). Fort Rucker, AL: U.S. Army Safety Center.
- Sisk, F. G., Throckmorton, W., & Ricketson, D. S. (1983). Analysis of FY 82 M113 APC and M60 tank accidents. (Report No. 84-1). Fort Rucker, AL: U.S. Army Safety Center.
- Sloan, S. J., & Cooper, C. L. (1986). Stress coping strategies in commercial airline pilots. Journal of Occupational Medicine, 28(1), 49-52.
- Stuart, J. C., & Brown, B. M. (1981). The relationship of stress and coping ability to incidence of diseases and accidents. Journal of Psychosomatic Research, 25, 255-260.

- Sulzer-Azaroff, B. (1978). Behavioral ecology and accident prevention. Journal of Organizational Behavior Management, 2, 11-44.
- Sulzer-Azaroff, B. (1980). Industrial safety hazard reduction through performance feedback. Journal of Applied Behavioral Analysis, 13, 287-295.
- Sulzer-Azaroff, B. (1982). Behavioral approaches to occupational health and safety. In L. W. Frederiksen (Ed.), Handbook of organizational behavior management (pp. 505-538). New York: Wiley.
- Szasz, A. (1984). Accident proneness: the career of an ideological concept. Psychology & Social Theory, 4, 25-35.
- Thissen, D., & Wainer, D. (1983). Toward the measurement and prediction of victim proneness. Journal of Research in Crime and Delinquency, 243-261.
- Thomas, M. A. (1982). Analysis of CY 81 Army ground accidents: Volume I (Report No. 83-2). Fort Rucker, AL: U.S. Army Safety Center.
- Ursano, R. J. (1980). Stress and adaption: The interaction of the pilot personality and disease. Aviation, Space, and Environmental Medicine, 51, 1245-1249.
- Van Houten, R., & Nau, P. A. (1983). Feedback intervention: A parametric and comparative analysis. Journal of Applied Behavior Analysis, 56, 253-281.

- Van Zelst, R. H. (1954). The effect of age and experience upon accident rate. The Journal of Applied Psychology, 38(5), p. 313-317.
- Voicu, C., & Nereuta, A. (1980). Relation between aptitude level and professional efficiency with operators who control complex supervising and command equipment involving failure and accident producing risks. Review Room. Sci. Sociales--De Psychologie, 29, 131-137.
- Voicu, C., & Nereuta, A. (1985). Relation between aptitude level and professional efficiency with operators who control complex supervising and command equipment involving failure and accident producing risks. Romanian Review of the Social Sciences: Series in Psychology, 29, 131-137.
- Waller, J. A. (1987). Injury as disease. Accident Analysis and Prevention 19, 13-20.
- Waller, P.F., Hall, R.G., and Padgett, S.S. (1977). The North Carolina test waiver law: an evaluation of its impact. (Tech. Report). North Carolina: Highway Safety Research Center.
- Ware, Jr., C. T. (1964). Individual and situational variables affecting human performance. Human Factors, 6, 673-674.
- Warren, R. A. (1982). Rewards for unsafe driving? A rejoinder to P. M. Hurst. Accident Analysis & Prevention, 14, 169-172.

- Webb, W. B. (1956). The prediction of aircraft accidents from pilot-centered measures. Aviation Medicine, 27, 141-147.
- Weinstein, N. D., Grubb, P. D., & Vautier, J. S. (1986). Increasing automobile seat belt use: An intervention emphasizing risk susceptibility. Journal of Applied Psychology, 71, 285-290.
- Whitehead, R. E. (1934). Journal of Aviation Medicine 5:47.
- Wilde, G.J.S. (1976). Social interaction patterns in driver behavior: An introductory review. Human Factors, 18, 477-492.
- Wilde, G. J. S. (1982). The theory of risk homeostasis: Implication for safety and health. Risk Analysis, 2, 209-225.
- Wilde, G. J. S. (1985). The use of incentives for accident-free driving. Quarterly Journal of Alcohol Studies, (Supp. 10), 161-167.
- Wilde, G. J. S. (1986). Beyond the concept of risk homeostasis suggestions for research and application toward the prevention of accidents and lifestyle-related disease. Accident Analysis and Prevention, 18, 377-401.
- Wilde, G. J. S., & Murdoch, P. (1982). Incentive systems for accident-free and violation-free driving in the general population. Ergonomics, 25, 879-890.

- Wilde, G.J.S., O'Neil, B., & Cannon, D. (1975). A psychometric investigation of drivers' concern for road safety and their opinions of various measures for accident prevention. (Tech. Report). Kingston, Ontario: Dept. of Psychology, Queen's University.
- Williams, C. L., Henderson, A. S., & Mills, J. M. (1974). An epidemiological study of serious traffic offenders. Social Psychiatry, 9, 99-109.
- Williams, M. J. (1981). Validity of the traffic conflicts technique.. Accident Analysis & Prevention, 13, 133-145.
- Wolcott, J. H., & McMeekin, R. R. (1977). Correlation of general aviation accidents with the biorhythm theory. Human Factors, 19, 283-293.
- Wynn, E.R. (1973). The "third-rider" in Greensboro patrol cars. Law and order, August, 92-93.
- Zeller, A. F. (1961, April). Current flying and accident potential. Paper presented at the Aerospace Medical Association Annual Convention, Chicago, IL.
- Zeller; A. F., & Weil, N. (1969, April). Relation of kind of background flying tactical pilots' accident potential. Paper presented at the Aerospace Medical Association Convention, San Francisco, CA.
- Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. Journal of Applied Psychology, 65, 96-102.

Zohar, D., Cohen, A., & Azar, N. (1980). Promoting increased use of ear protectors in noise through information feedback.

Human Factors, 22, 69-78.

Zohar, D., & Fussfield, N. (1981). Modifying earplug wearing behavior by behavior modification techniques: An empirical evaluation. Journal of Organizational Behavior Management, 3, 41-52.

Zylman, R. (1975). DWI enforcement programs: Why are they not more effective. Accident Analysis and Prevention, 7, 179-190.

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