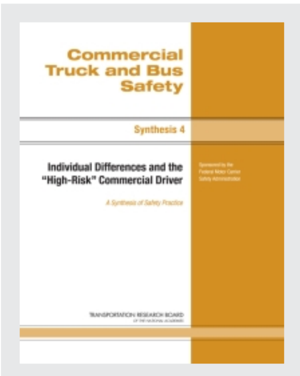

Individual Differences and the "High-Risk" Commercial Driver

DETAILS

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Transportation Research Board

COMMERCIAL TRUCK AND BUS SAFETY SYNTHESIS PROGRAM

Synthesis 4

Individual Differences and the "High-Risk" Commercial Driver

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COMMERCIAL TRUCK AND BUS SAFETY SYNTHESIS PROGRAM

Safety is a principal focus of government agencies and private-sector organizations concerned with transportation. The Federal Motor Carrier Safety Administration (FMCSA) was established within the Department of Transportation on January 1, 2000, pursuant to the Motor Carrier Safety Improvement Act of 1999. Formerly a part of the Federal Highway Administration, the FMCSA's primary mission is to prevent commercial motor vehicle-related fatalities and injuries. Administration activities contribute to ensuring safety in motor carrier operations through strong enforcement of safety regulations, targeting high-risk carriers and commercial motor vehicle drivers; improving safety information systems and commercial motor vehicle technologies; strengthening commercial motor vehicle equipment and operating standards; and increasing safety awareness. To accomplish these activities, the Administration works with federal, state, and local enforcement agencies, the motor carrier industry, labor, safety interest groups, and others. In addition to safety, security-related issues are also receiving significant attention in light of the terrorist events of September 11, 2001.

Administrators, commercial truck and bus carriers, government regulators, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and underevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information available on nearly every subject of concern to commercial truck and bus safety. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the commercial truck and bus industry, the Commercial Truck and Bus Safety Synthesis Program (CTBSSP) was established by the FMCSA to undertake a series of studies to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern. Reports from this endeavor constitute the CTBSSP Synthesis series, which collects and assembles the various forms of information into single concise documents pertaining to specific commercial truck and bus safety problems or sets of closely related problems

The CTBSSP, administered by the Transportation Research Board, began in early 2002 in support of the FMCSA's safety research programs. The program initiates three to four synthesis studies annually that address concerns in the area of commercial truck and bus safety. A synthesis report is a document that summarizes existing practice in a specific technical area based typically on a literature search and a survey of relevant organizations (e.g., state DOTs, enforcement agencies, commercial truck and bus companies, or other organizations appropriate for the specific topic). The primary users of the syntheses are practitioners who work on issues or problems using diverse approaches in their individual settings. The program is modeled after the successful synthesis programs currently operated as part of the National Cooperative Highway Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP).

This synthesis series reports on various practices, making recommendations where appropriate. Each document is a compendium of the best knowledge available on measures found to be successful in resolving specific problems. To develop these syntheses in a comprehensive manner and to ensure inclusion of significant knowledge, available information assembled from numerous sources, including a large number of relevant organizations, is analyzed.

For each topic, the project objectives are (1) to locate and assemble documented information (2) to learn what practice has been used for solving or alleviating problems; (3) to identify all ongoing research; (4) to learn what problems remain largely unsolved; and (5) to organize, evaluate, and document the useful information that is acquired. Each synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation.

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FOREWORD

By Christopher W. Jenks
CTBSSP Manager
Transportation Research Board

This synthesis will be of use to state agencies, commercial truck and bus carriers, and others interested in improving commercial vehicle safety. It explores individual differences among commercial drivers, particularly as these differences relate to the "high-risk" commercial driver. The synthesis identifies factors relating to commercial vehicle crash risk and assesses ways that the high-risk driver can be targeted by various safety programs and practices, at both fleet- and industry-wide levels. It summarizes available information on individual differences in commercial driver safety performance and alertness, examines various metrics and tests that might be used to hire safer drivers and avoid hiring high-risk drivers, and identifies safety management techniques that are currently used by commercial vehicle carriers to target problem drivers and their specific risky behaviors. Information for this synthesis was obtained through surveys of current commercial motor vehicle safety managers and other experts in commercial motor vehicle safety; a focus group conducted with staff members of the U.S. DOT Federal Motor Carrier Safety Administration (FMCSA); and a review of relevant literature.

Administrators, commercial truck and bus carriers, government regulators, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and underevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

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CONTENTS

INDIVIDUAL DIFFERENCES AND THE "HIGH-RISK" COMMERCIAL DRIVER

SUMMARY

This synthesis focuses on the "high-risk" commercial driver. Most truck and bus drivers are both conscientious and safe, but the findings of this research project support the notion, and widespread industry belief, that a relatively small percentage of commercial drivers are associated with a significant and inordinate percentage of the overall motor carrier crash risk.

This research project has attempted to document this phenomenon, explore related factors, and identify ways that the high-risk driver can be targeted by various safety management practices and other safety interventions. Expert industry opinion has been accessed through survey questionnaires on the topic. The research literature on the topic has been reviewed, with emphasis on the personal factors associated with risk and carrier management approaches to reducing the problem. This synthesis focuses on commercial (i.e., large truck and bus) drivers, but also presents the results from a literature review on transportation operators in other modes such as air, rail, and maritime.

Commercial motor vehicle (CMV) fleet safety managers are the principal audience for this synthesis, although this synthesis is a presentation of findings, not a "how to" guide to practice. In addition, the synthesis should be useful to government, industry, and academic personnel involved in formulating and conducting studies to gain knowledge (i.e., research) and to create tools (development) relating to this safety topic.

As noted, one basis for the research project was survey data collected from fleet safety managers and "other experts" in motor carrier safety. Safety manager surveys were distributed primarily through a random sample mailing to carriers listed in the American Trucking Associations fleet directory. In addition, survey forms were sent to people who responded to a *CTBSSP Synthesis 1* survey (also on carrier safety management), and, in order to obtain motor coach segment respondents, some survey forms were distributed to members of the American Bus Association Safety Council. The safety manager survey return rate was about 15%, so the sample cannot be described as representing the CMV industry in general. Instead, it represents 178 interested managers from a variety of CMV operations.

A second survey sample consisted of 67 other experts. These are individuals professionally involved in CMV safety who are not fleet safety managers. This group

includes former drivers and fleet managers, government regulatory and enforcement personnel, industry trade association representatives, and researchers. Of course, these are overlapping categories, and most other experts indicated several different motor carrier safety-related professional experience areas.

The safety manager and other expert survey forms were parallel in their questions and content, but there was one key difference. Regarding management practices, safety managers were asked if they currently used the method and then, if "yes," they were asked to rate its effectiveness. This yielded data on the percentage of carriers actually using various methods and opinions of effectiveness of respondents actually using the methods. For the other experts, parallel items only elicited evaluation ratings because there were no questions regarding use.

Perhaps the most fundamental question about high-risk commercial drivers is whether the problem is genuine and significant or the result of chance or other factors uncontrollable by commercial drivers and their fleets. Survey findings strongly support the notion that the problem is real and significant and that individual differences in safety among drivers are enduring. Empirical data cited from a number of studies corroborate this view, but do not sufficiently describe or explain the problem. In one cited study, for example, large individual differences were seen in the rate of driver involvement in traffic "near-miss" incidents, and 12% of the drivers in the study were associated with 38% of the incidents. However, the study did not track drivers for a long period of time to determine the degree of consistency of differential risk or the personal traits that could produce enduring individual differences in risk.

Many factors affect commercial driver crash involvement. The focus of this synthesis is on enduring personal risk factors. Nevertheless, at any given time, commercial driver crash risk is affected by personal risk factors (e.g., hours of sleep the previous night), vehicle risk factors (e.g., brake adjustment), environmental factors (e.g., weather and roadway features), and, perhaps most important, risks created by other drivers and traffic. "Accident proneness" was originally conceptualized nearly 100 years ago. Early concepts of it considered it an innate, unitary trait, a view that is no longer widely held. However, it certainly appears that individual differences in personality and performance predispose some people to increased crash risk. Driver errors can be violations of rules, mistakes of judgment, inattention errors, or inexperience errors. Common driver errors resulting in crashes include recognition errors (failure to perceive a crash threat) and decision errors (risky driving behavior such as tailgating), or poor decision-making in dynamic traffic situations (such as trying to cross a stream of traffic).

There are many personal dimensions that may be correlated with individual crash risk. In the research project survey, respondents were asked to rate the strength of association of 16 such factors with crash risk. Personality traits such as aggressiveness, impulsivity, and inattentiveness were rated by both respondent groups as having the highest associations with risk.

This synthesis reviews literature relating to the following factors related to commercial driver risk. A number of factors potentially correlate with risk and may be the basis for safety interventions to reduce risk. Factors discussed include the following:

- Driver age and gender
- Driving history
  - Commercial driving experience
  - Longevity with company
  - Crashes, violations, and incidents
  - Defensive driving

- Non-driving criminal history
- Medical conditions and health
  - Sleep apnea
  - Narcolepsy
  - Diabetes
  - Other medical conditions
- Alcohol and drug abuse
- Driver fatigue
- Personality
  - Impulsivity and risk-taking
  - Social maladjustment and aggressive/angry personalities
  - Introversion-extroversion
  - Locus of control
  - Extreme (“dichotomous”) thinking
- Sensory-motor performance
- Other risk factors
  - Stress
  - Recent involvement in other crashes
  - Safety belt use
- Risks identified in other transportation modes
  - Maritime operations
  - Rail
  - Aviation

Fleet safety management approaches to preventing high-risk-driver–related crashes revolve around the basic management functions of selection and hiring, performance evaluation, and driver safety management practices. The clearest advice to safety managers is, “Don’t hire a problem.” Methods for improving driver selection and job aids for safety managers are provided in Appendix F.

Once drivers are hired, there are various ways to monitor their driving behaviors and modify their behavior in ways that reduce risk. Performance evaluation and feedback (perhaps enhanced by on-board safety monitoring of driver behavior), training and counseling, performance incentives, behavior-based safety, and driver self-management are among the methods described. Of course, termination may be the ultimate solution when drivers are unmanageable from the safety perspective.

Recommended research and development (R&D) to address the problem of high-risk drivers includes the following:

- Verification of the reliability of research findings indicating differential driver risk.
- Determination of how enduring these differences are across time. To the extent that they are enduring, they constitute personal traits. To the extent that they change, they likely reflect short-term personal conditions (states) or purely situational factors.
- The conducting of case control or other driver studies that profile individual driver differences within a group of drivers and relate these differences to safety outcomes (e.g., crashes).
- Creation and field testing of various types of driver selection instruments.
- Investigation of individual fatigue susceptibility. Research should verify that differences in fatigue susceptibility are long-term personal traits and identify ways to assess the level of fatigue susceptibility. Highly susceptible individuals should not

be hired as commercial drivers or should receive special attention, including medical screening for sleep disorders and counseling about sleep hygiene habits.
- Documentation of the best driver management practices for use by carrier safety managers and dissemination of this information throughout the industry.
- Industry pilot testing of behavioral safety management techniques, perhaps enhanced by the use of on-board safety monitoring of driver safety performance and behaviors. This should include determination of the effectiveness of various management interventions including both positive rewards and negative discipline (punishment).

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND: ILLUSTRATIVE EXAMPLE

In an instrumented vehicle study of local/short-haul (LSH) truck driving sponsored by the Federal Motor Carrier Safety Administration (FMCSA), Hanowski et al. (2000) observed 42 truck drivers driving a total of 28,000 vehicle miles. The study identified 249 critical incidents (CIs), which were defined as significant unsafe driver actions or "near-crashes." Of these 249 CIs, 77 were related primarily to the actions and errors of truck drivers. Common critical incidents included running late yellow or red lights and crossing traffic with insufficient gaps (i.e., approaching vehicles too close for safe crossing). The 42 truck drivers initiated 77 CIs in 1,376 hours of driving, yielding an average rate of 0.06 truck driver–initiated CIs per hour. Figure 1 shows the frequency distribution of CI/hour rates among the 42 drivers.

Of the 42 truck drivers, 6 drivers had CI/hour rates greater than 0.15. These 6 drivers drove 12% of the total driving hours of the study but were responsible for 38% of all the truck driver–initiated CIs (29 of 77). In contrast, the 25 "best" of the 42 drivers (the first two bars in Figure 1) drove 63% of the driving hours but were responsible for 16% of the CIs. Figure 2 illustrates these exposure-risk relationships for the "worst" and "best" LSH drivers in terms of CI initiation.

The study also assessed driver alertness level, using a 5-point Observer Rating of Drowsiness (ORD) scale, which had previously been validated against physiological alertness measures. Levels 4 and 5 corresponded to "very" and "extremely" drowsy. The equipment malfunctioned for one driver, so there were 41 drivers in this sample. The 41 drivers had a total of 285 time episodes of Level 4 or 5 on the ORD scale over 1,348 hours of driving, for an average rate of 0.21 high-drowsiness episodes per hour. Figure 3 shows the frequency distribution of high-drowsiness episodes for the 41 drivers.

Four drivers had rates of more than 0.75 high-drowsiness episodes per hour. These four drivers drove 7% of the total driving hours but were responsible for 39% of all observed high-drowsiness episodes (112 of 285). There was also a moderate-risk group (10 drivers) who had 29% of the exposure and 47% of the drowsy episodes. In contrast, the 27 most alert drivers (the first two bars in Figure 3) drove 64% of the driving hours but were responsible for only 14% of high-drowsiness episodes. Figure 4 illustrates the exposure-risk relationships for the high-, moderate-, and low-risk subgroups of LSH drivers.

The risk-exposure odds ratios between the worst and best groups of drivers identified here were 12.5 for CIs and 25.5 for high-drowsiness episodes. In other words, on average, each high-risk driver in Figure 2 was 12.5 times more likely to be involved in CIs than the low-risk drivers. In Figure 4, the high-risk drivers were 25.5 times more likely to have drowsy episodes than were the low-risk drivers.

There was only a small positive relationship between the rate of CIs and the rate of drowsiness among the 41 drivers for which both types of data were available. This suggests that drowsiness was a factor in CI involvement, but it was not a predominant factor. Only one of the six high-CI drivers was among the four high-drowsiness drivers.

1.2 SCOPE

These LSH study statistics were presented to introduce and demonstrate the phenomenon of high-risk commercial drivers. Although commercial drivers generally drive responsibly and exhibit lower rates of most types of incident and crash involvement than drivers in general (FMCSA 2003, Craft 2004, Wang, Knipling, and Blincoe, 1999), it appears that there are significant safety-related individual differences among groups of drivers, and that a few commercial drivers have significantly elevated risk compared with their peers.

This synthesis will explore individual differences among commercial drivers in general and high-risk commercial drivers in particular. It will identify dimensions and factors relating to differences in commercial driver crash risk and assess ways that the high-risk driver can be targeted by various safety programs and practices, at both fleet- and industry-wide levels. Specifically, the synthesis will

- Summarize available information on individual differences in commercial driver safety performance and alertness.
- Examine various metrics and tests that might be used to hire better drivers and avoid hiring high-risk drivers.
- Identify safety management techniques that are currently used by commercial vehicle carriers to target problem drivers and their specific risky behaviors.

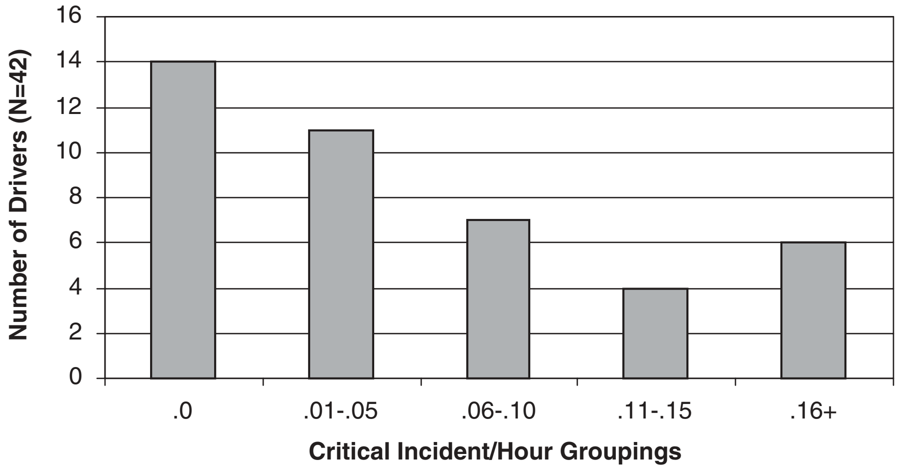


Figure 1. *Frequency distribution of LSH truck driver critical incident rate.*

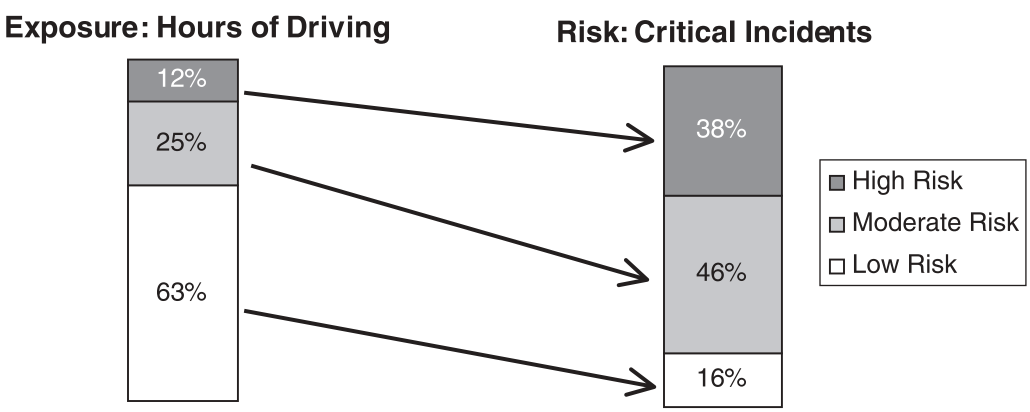


Figure 2. *Relationship between exposure and CI risk for high-risk, moderate-risk, and low-risk groups of drivers in the Hanowski et al. (2000) LSH truck driver study.*

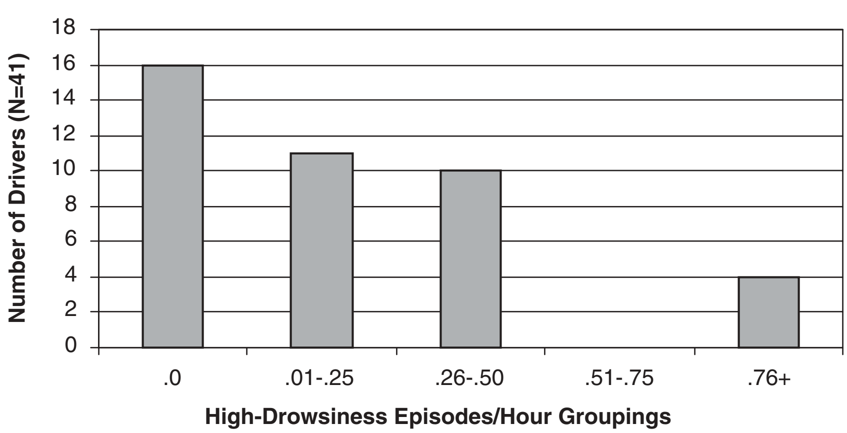


Figure 3. *Frequency distribution of LSH truck driver high-drowsiness episodes.*

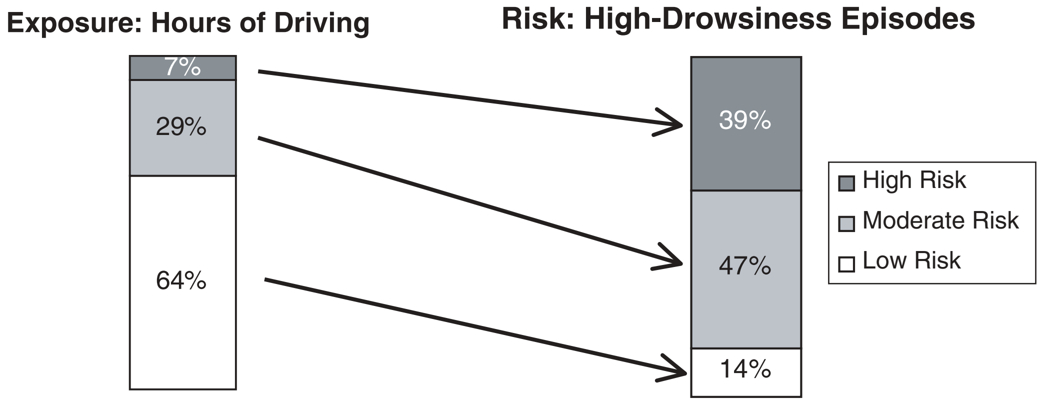


Figure 4. Relationship between exposure and drowsiness risk for high-risk, moderate-risk, and low-risk groups of drivers in the Hanowski et al. (2000) LSH truck driver study.

Although the synthesis focuses primarily on heavy truck drivers, it will also address long-haul motor coach drivers and, to a limited extent, the phenomenon of high-risk transportation operators in general. Most safety interventions described in the synthesis are carrier management related, and carrier safety managers are the major information source and intended audience for the synthesis. However, a few of the safety approaches discussed are related to national regulatory and enforcement issues. Appendix B reproduces the research project's Statement of Work.

The reasons and causes behind differential driver risk will be explored in this synthesis. In the LSH study, for example, each driver was observed for only 1 week. It is possible that the differences observed were related to long-term constitutional factors (e.g., enduring individual differences in aggression, risk-taking, health), short-term personal factors (e.g., temporary illness, lack of sleep due to a new baby at home), or situational factors (e.g., weather, traffic variations, new delivery routes). The study collected no longitudinal data on drivers, and few truck safety studies seem to have done so.

1.3 APPROACH

Information on high-risk commercial drivers and potential management solutions was obtained through several major approaches. The primary vehicle for obtaining information was surveys. Two parallel survey forms were employed: one for current CMV fleet safety managers and one for other experts in motor carrier safety. The safety manager and other expert survey forms were parallel in their questions and content, but there was a key difference in the way the management effectiveness-related questions were asked. Safety managers were asked if they currently used the method and then, if "yes," were asked to rate its effectiveness. Thus, these questions yield data on the prevalence of industry use of the methods as well as subjective evaluations of them. The other expert survey provided data only on expert opinion because the questions regarding use of the methods were not applicable. Findings from these surveys will be the centerpiece of this synthesis, although the authors concede that opinion surveys are not a substitute for empirical data.

To supplement the expert survey, a focus group was conducted with staff members of the FMCSA, the major federal agency overseeing truck and bus safety. Supporting the survey and focus group findings is information obtained from literature reviews relating to the various personal correlates of driver risk and to safety management methods. The literature reviews employed Transportation Research Information System (TRIS) and other reference systems to identify relevant publications in the transportation literature. Also reviewed were FMCSA research publications and research journals on traffic safety, psychometrics, and industrial safety management.

The remainder of this synthesis will present the survey methodology and results, define and characterize the basic phenomenon of high-risk commercial drivers, explore factors related to driver risk, and discuss operational safety management methods for addressing the problem. The synthesis concludes with recommendations for R&D that might be performed to address the many unanswered questions relating to this issue, deepen current knowledge, and create tools that industry can apply to ameliorate the problem. R&D is conceived broadly and may include many different types of initiatives undertaken by various parties and stakeholders involved in motor carrier safety. If it is true that approximately 10% of commercial drivers are associated with one-third or more of safety risk caused by commercial drivers, there is clearly an opportunity to significantly reduce crash loss through focused efforts on these drivers.

CHAPTER 2

SURVEY METHOD AND RESULTS

2.1 METHOD

A primary vehicle for obtaining information in this research project was surveys. Two parallel survey forms were employed: (a) one for current CMV fleet safety managers and (b) one for other experts in motor carrier safety. These are provided in Appendices C and D, respectively. This section describes the survey methodology in more detail, and Section 2.2 provides principal results.

A general concern regarding most of the survey responses is that they represent subjective responses to subjective questions. A few questions were objective (e.g., questions asking safety managers whether or not they use a particular safety management practice), but most called for subjective judgments by respondents. Both groups were highly qualified to render such judgments, however, so the surveys are considered to capture expert opinion.

2.1.1 Survey Design and Content

The safety manager and other expert survey forms contained 48 and 50 questions, respectively. These were divided into seven parts:

- Part 1: How Important Is the Problem? This short section included both fill-in and multiple choice questions on the basic phenomena of individual differences in driver safety.
- Part 2: Driver Factors Associated with Risk. Questions on both forms listed personal driver traits and, using a 5-point scale (0–4), asked respondents to rate the association (correlation) of the factor with driver risk.
- Part 3: Driver Hiring Practices and Tools. For the other experts, this section listed eight hiring practices and asked respondents to rate the effectiveness of each using the same 5-point scale. For the safety managers, the section was titled, "Which Driver Hiring Practices and Tools Do You Regularly Use?" and included two parts for each question. First, the respondent circled "yes" or "no." Then, the instructions stated, "If 'Yes,' please rate effectiveness." Consistent with these instructions, safety manager data for the 5-point scale were entered only if respondents circled "yes" to the first part of each question. On one question ("Selection Tests"), safety managers responding "yes" were also asked to write in the selection test(s) they use.
- Part 4: Driver Evaluation. This section consisted of four questions and had the same instructions as Part 3. For safety managers, it was titled, "How Do You Evaluate Drivers in Your Fleet?"
- Part 5: Driver Management. This section contained 12 questions and had the same instructions as Parts 3 and 4. Even though the individual questions were parallel between the two respondent groups for Parts 3, 4, and 5, the instructions for answering most of the questions were different. Other experts were answering for commercial fleets and drivers in general, whereas safety managers were answering for their own practices (yes or no) and then rating effectiveness for their own fleets.

  Part 5 also contained three-choice questions relating to positive, reward-based safety management practices versus "disciplinary" approaches. These questions were identical on the two forms.
- Part 6: Comments. Three lines of blank space were provided on each form. Respondents were asked to comment on high-risk drivers and list any questions they had about the survey. This information on the completed forms was reviewed separately and reported selectively in this synthesis.
- Part 7: Respondent Information. For other experts, the last section contained two questions relating to years of experience and types of positions held. For safety managers, the section contained questions on their personal years of experience and the size and operation type of their fleet.

2.1.2 Survey Distribution and Analysis

The two forms of the survey were distributed primarily by U.S. mail. Potential carrier safety manager respondents were identified primarily from the North American Truck Fleet Directory published by Transport Topics Press in conjunction with the American Trucking Associations, Inc. A nationwide random sample of approximately 700 carriers was selected from the database accompanying the directory. In addition, 100% samples were selected from the directory for the geographic areas around Blacksburg, Virginia (location of Virginia Tech and VTTI), Northern Virginia (location of the VTTI principal investigator), and Iowa City, Iowa (location of the University of Iowa). Letters to the large national sample and these geographic samples were addressed to "Fleet Safety Director" at the selected carriers. Other survey recipients were respondents from *CTBSSP Synthesis 1* for whom contact information was available. Most of these individuals were active in industry trade association safety councils. Finally, to ensure an adequate subsample of motor coach fleet safety managers, survey forms were distributed directly to attendees at a Safety Counsel meeting of the American Bus Association. All survey forms were accompanied by a cover letter and a stamped envelope addressed to research project personnel at VTTI in Northern Virginia (primarily), VTTI in Blacksburg, or the University of Iowa. Altogether, approximately 1,000 safety manager survey forms were distributed. Respondents in the three geographic areas were also invited to a research project briefing, held at each location after the study's completion.

Even though most of the carrier safety manager survey distribution sample was randomly generated from a national directory, the safety manager respondent sample is perhaps considered as a convenience sample. Research project resources did not permit the design of a systematic subject sampling and survey distribution process or the tracking of survey return rates for various respondent groups. Moreover, those who complete and return a survey of this nature are likely to be those most interested in the topic and committed to supporting efforts relating to it. Also, because there was a special effort to obtain passenger carrier fleet respondents, their percentages in the respondent sample (13% long haul/motor coach; 4% local/transit) were high compared with the overall commercial motor transport industry.

The other expert survey form was distributed primarily to professional associates of the principal investigator. Many had been respondents to *CTBSSP Synthesis 1*. Many were individuals active in TRB truck and bus safety activities, in particular the Committee on Truck and Bus Safety Research (ANB70). In addition to the mail distribution of approximately 125 surveys, about 30 were distributed directly during the 2004 TRB Annual Meeting, and a few were completed by FMCSA employees during a research project focus group held on the topic. Obviously, this group is highly involved in motor carrier safety and has extensive knowledge and experience relating to the topic, although most did not and had not worked for a motor carrier. More information on their backgrounds is provided in Section 2.2.7.

All survey responses were confidential and there is no attribution of responses by individual, company name, or other organizational affiliation in this synthesis. Statistics are cited in the synthesis for the two major respondent groups: fleet safety managers and other experts.

2.2 PRINCIPAL SURVEY RESULTS

2.2.1 Part 1: How Important Is the Problem?

The first few questions of the survey were intended to assess respondents' views on the importance of the high-risk driver phenomenon. These were the most conceptual survey questions. Respondents were asked to attribute percentages of crash risk to "behavior/skill" and to "uncontrollable factors (i.e., luck)." Implicit in this question is the idea that the concept of high-risk drivers assumes that there are significant behavior/skill differences among drivers. Both respondent groups averaged around 70% (69% for safety managers and 72% for other experts) in their attribution of crash risk to behavior/skill, although the safety manager attribution was more variable.

Respondents were asked a hypothetical question designed to elicit an assessment of the degree to which high-risk drivers are a problem for fleets (see Table 1). The majority of both respondent groups believed that the worst 10% of drivers were associated with 50% or more of fleet crash risk.

Respondents were also asked to assess how consistent and enduring individual differences in crash risk are (see Table 2). About two-thirds of both respondent groups believed that there is a "strong tendency" for individual differences in crash risk to be consistent and enduring year-to-year.

2.2.2 Part 2: Driver Factors Associated with Risk

Respondents were asked to rate 16 personal factors with regard to their strength of association with crash risk. The 5-point scale went from "0" (no association) to "4" (strong

TABLE 1 Disproportion of risk

RESPONSE CHOICE	SAFETY MANAGERS	OTHER EXPERTS
Worst 10% → 10% of problems	6%	0%
Worst 10% → 20% of problems	6%	6%
Worst 10% → 30% of problems	14%	19%
Worst 10% → 40% of problems	15%	21%
Worst 10% → 50+% of problems	59%	54%

TABLE 2 Consistency of individual differences

RESPONSE CHOICE	SAFETY MANAGERS	OTHER EXPERTS
Risk can change dramatically	10%	0%
Moderate consistency	25%	35%
Risk stays about the same	65%	65%

association). Respondents in both groups rated personality traits such as aggressiveness, impulsivity, and inattentiveness as having the highest associations with risk. The lowest rated associations were for "did not attend formal truck driving school," introversion, and obesity. The factors, mean ratings (to the nearest tenth), and rankings are presented in order of safety manager ranking in Table 3. When there were ties in the mean ratings, rankings were determined by looking at additional decimal places. However, for simplicity, these decimal places are not shown in the tables. Across the 16 items, there was strong agreement between the safety managers and the other experts in their mean ratings.

2.2.3 Part 3: Driver Hiring Practices and Tools

Part 3 presented eight hiring practices and tools and asked safety managers to first indicate whether they used the practice, and then, if "yes," to rate its effectiveness (again using a 5-point scale). For other experts, there was no "yes-no" question regarding use; instead, they just rated the effectiveness of the practice. Thus, the safety manager ratings here are based on actual use of the practice/tool, whereas the other expert ratings were not. Among the most frequently used and highest rated practices were checking the applicant motor vehicle record (MVR), contacting past employers, testing for alcohol and drugs (required by federal regulation for interstate carriers), and on-road driving tests. Table 4 lists the practices in the order safety managers ranked them.

2.2.4 Part 4: Driver Evaluation

Part 4 presented four driver evaluation practices. The instructions were the same as in Part 3 for the two respondent groups. "Continuous tracking of driver crashes, incidents, and violations" was almost universally used by safety manager respondents and had the highest-rated effective-

TABLE 3 Driver factors associated with risk

DRIVER RISK FACTOR	SAFETY MANAGERS		OTHER EXPERTS	
	Mean	Rank (of 16)	Mean	Rank (of 16)
Aggressive/angry	3.4	1	3.4	3
Impatient/impulsive	3.4	2	3.5	1
Inattentive	3.4	3	3.4	2
Inexperienced (new CMV driver)	3.2	4	3.2	4
Unhappy w/ job/company	2.6	5	2.4	7
Young Driver (e.g., less than 25)	2.5	6	3.1	5
Sleep apnea/other sleep disorder	2.4	7	2.9	6
Unhappy marriage/family prob.	2.2	8	2.2	8
Debt or other financial problems	2.0	9	2.1	9
Heart or other medical condition	1.9	10	2.1	10
Dishonest	1.8	11	1.8	14
Older driver (e.g., 60 or older)	1.7	12	1.9	12
New to company	1.6	13	2.0	11
Obese/overweight	1.4	14	1.7	15
Introverted/unsociable	1.3	15	1.1	16
Did not attend truck driving school	1.2	16	1.8	13

TABLE 4 Driver hiring practices and tools

HIRING PRACTICE/TOOL	SAFETY MANAGERS			OTHER EXPERTS	
	% Who Use	Mean	Rank (of 8)	Mean	Rank (of 8)
Check MVR	100%	3.4	1	3.2	1
On-road driving test	88%	3.3	2	3.1	2
Test for alcohol/drugs	99%	3.3	3	2.8	4
Use third-party service	46%	3.1	4	2.3	8
Contact past employers	99%	3.0	5	3.0	3
Check criminal record	61%	3.0	6	2.7	5
Selection tests	26%	2.9	7	2.4	6
Check credit history & rating	21%	2.4	8	2.3	7

ness for both respondent groups. Other factors were also ranked in the same order by safety managers and other experts (see Table 5).

2.2.5 Part 5: Driver Management

Part 5 presented 12 driver management practices. The instructions were the same as in Part 3 for the two respondent groups. Among safety managers, reprimands (verbal and written) and manager counseling were among the most-used methods. Among the safety managers who used the methods, "monetary penalties," "suspension from service," and "monetary rewards" received the highest effectiveness ratings. There was little variation in the mean ratings given to the 12 safety management methods by safety manager users of these methods.

The other expert respondents rated the effectiveness of the 12 methods somewhat differently from the safety managers. Monetary rewards were rated highest in effectiveness among the 12 methods, which was consistent with the safety manager relative ratings. Ratings of other methods tended to differ more between the two groups, however. Among the other experts there was also relatively little variation in effectiveness rating across the 12 methods (see Table 6).

Respondents were asked to weigh the relative effectiveness of rewards and "discipline" for drivers in general and for problem drivers (see Table 7). Both groups tended to favor rewards for drivers in general but "discipline" for problem drivers. Among both respondent groups, there were fairly large percentages that chose "equal impact."

2.2.6 Part 6: Comments

A space was provided for written comments. About one-half of the safety managers and other experts made such comments. The comments focused on a variety of issues and expressed many different views. A number are cited in various sections of this synthesis.

2.2.7 Part 7: Respondent Information

Respondents were also asked to provide some general demographic information about themselves and, for safety

TABLE 5 Driver evaluation practices

EVALUATION PRACTICE	SAFETY MANAGERS			OTHER EXPERTS	
	% Who Use	Mean	Rank (of 4)	Mean	Rank (of 4)
Continuous tracking: crashes, etc.	99%	3.3	1	3.6	1
On-board electronic monitoring	31%	3.0	2	3.2	2
Periodic observations of driving	82%	3.0	3	3.0	3
"How's My Driving" placards	24%	2.7	4	1.9	4

TABLE 6 Driver management practices

MANAGEMENT PRACTICE	SAFETY MANAGERS			OTHER EXPERTS	
	% Who Use	Mean	Rank (of 12)	Mean	Rank (of 12)
Monetary penalties	48%	3.1	1	2.6	8
Suspension from service	84%	3.0	2	2.7	7
Monetary rewards	38%	3.0	3	2.9	1
Written reprimand	94%	2.8	4	2.4	10
Counseling by manager	87%	2.8	5	2.5	9
Teach drivers to self-manage	31%	2.8	6	2.3	11
Remedial training	69%	2.7	7	2.8	2
Non-monetary rewards	60%	2.7	8	2.8	4
Senior driver ride-alongs	28%	2.7	9	2.8	3
Manager ride-alongs	45%	2.7	10	2.8	6
Verbal reprimand	97%	2.7	11	2.0	12
Counseling by senior driver	19%	2.6	12	2.8	4

TABLE 7 Which has stronger influence: rewards or discipline?

RESPONSE CHOICE	SAFETY MANAGERS		OTHER EXPERTS	
	Drivers in General	Problem Drivers	Drivers in General	Problem Drivers
Rewards	28%	12%	52%	12%
Discipline	17%	52%	9%	46%
Equal Impact	55%	36%	39%	42%

TABLE 8 Safety managers' fleet operation types

OPERATION TYPE	% SAFETY MANAGERS
For hire: long haul/truckload	39%
For hire: long haul/less-than-truckload (LTL)	7%
For hire: local/short haul (most trips < 100 miles)	12%
Private industry: long haul	9%
Private industry: local/short haul (< 100 miles)	19%
Passenger carrier: long haul/motor coach	13%
Passenger carrier: local/transit	4%
"Other" (mostly variations of above types)	10%

Note: Totals more than 100% because some fleets had more than one operation type.

managers, their fleets. Key points are summarized in the following two subsections.

Safety Managers

The 178 safety manager respondents had been safety managers for an average of 12.8 years (range: 1 to 43) and had an average of 22.1 total years of experience in CMV operations (range: 1 to 50). Fleet size varied widely, ranging from 3 to 4,500 power units. The median fleet size was 50.

Respondents were asked to characterize their fleet's primary operation by selecting one of seven major truck and bus operation types or writing in an alternative. Results are shown in Table 8. The percentages total more than

100% because some respondents cited two or more operation types.

Other Experts

The years of motor carrier safety experience of the 67 other expert respondents ranged widely from 3 years to 43 years. The mean was 17.7 years. These respondents were also asked to indicate their professional experience areas relating to motor carrier safety. The breakdown is shown in Table 9. The percentages shown total more than 100% because most respondents gave multiple responses. The results show that the experience base of the other experts was both extensive and varied, with heavy representation of individuals with backgrounds in government, accident investigation/data analysis, motor carrier safety research, and industry trade associations.

TABLE 9 Other expert experience areas

EXPERIENCE AREAS	% OTHER EXPERTS
Government enforcement	27%
Other government (e.g., rulemaking)	49%
Industry trade association	30%
CMV driver	12%
Carrier safety manager	12%
Other carrier management position	9%
Safety consultant or vendor to fleets	22%
Accident investigation/data analysis	39%
Motor carrier safety research	63%
Journalist	3%
Driver trainer	10%
Insurance for motor carriers	9%
Other (e.g., training developer, manufacturer)	7%

Note: Totals more than 100% because many respondents had multiple experience areas.

CHAPTER **3**

CONCEPTS OF CRASH RISK

Many interacting factors affect commercial driver crash involvement. Figure 5 is a conceptualization of some major interacting factors. The focus of this synthesis is on personal "constitutional" risk factors, that is, relatively enduring characteristics such as health, physical skills, and some personality traits. At any given moment, however, a number of other factors and influences are operative. Drivers are influenced by fatigue-related situational factors such as amount of prior sleep, time-of-day, and hours driving (time on task), but also by non-fatigue situational stressors such as pressure to deliver on time or recent events causing anger or anxiety (e.g., argument with boss or spouse). The driver may also be operating a vehicle on a roadway in bad weather. Each of these can become major crash factors, although crash investigations have not found vehicle, roadway, or environmental factors to be frequent principal causes of crashes for either large trucks or other vehicles (Craft et al. 2004, Treat et al. 1979). Other drivers and traffic are significant sources of large truck crash involvement. Indeed, it appears that the majority of large truck crashes and fatal crashes are precipitated by the actions and errors of other involved motorists (Craft et al. 2004, FMCSA 2003, Blower 1998). Commercial driver behavior and responses may be considered a product of all these interacting factors. The principal interest here is personal "constitutional" risk factors.

The remainder of this chapter reviews the original concept of accident proneness and describes several models or concepts of crash risk and the driver errors associated with them.

3.1 THE CONCEPT OF ACCIDENT PRONENESS

Accident proneness as an industrial safety human factors concept was first proposed by Greenwood and Woods (1919). The idea spawned much research, and many studies have been conducted on the subject since Greenwood and Woods's study. Greenwood and Woods analyzed the accident records of similarly exposed and experienced munitions workers in Britain and found that a small percentage of the workers accounted for the majority of accidents. Accident proneness was conceived as a unitary, innate trait that resulted in stable differential risk across time; in other words, the same workers would continue over time to have the greatest risk (Hansen 1988).

While early studies found support for the accident proneness concept, more recent studies on the topic have not supported the view that it is a unitary personality trait (Hansen 1988). Studies have found a number of different personal traits that correlate with crash and other accident risk (reviewed in Chapter 4), but many of these traits may be largely independent of each other. Moreover, there is an appreciation of the fact that chance (i.e., factors outside the control of drivers) plays a significant role in crash involvement and that variations in crash involvement within groups of drivers are partly the result of chance (Dewer and Olson 2002).

While the concept of accident proneness as a unitary trait has been discredited, researchers have discovered that certain personal traits are related to the occurrence of a vehicle crash. Rather than using the discredited term "accident proneness," a more appropriate term that reflects the empirical evidence may be "differential crash risk." To the extent that this differential risk is enduring, it probably reflects constitutional or other long-term personal traits. To the extent that it varies across time, it may reflect chance variation or changeable traits such as age, maturation, or learning by experience. Chapter 4 of this synthesis presents numerous examples of personal traits that correlate with crash involvement. Most of these studies were conducted over a short time period, so the question of whether or not they document enduring influences on crash risk is unanswered.

3.2 MODELS OF DRIVER ERROR AND RISK

Various models or concepts of driver errors and crash involvement have been developed (Dewer and Olson 2002, Rimmo 2002). The Indiana Tri-Level Study (Treat et al. 1979, Treat 1980) posited three major causal categories and classified 420 in-depth light vehicle crash investigation cases accordingly: human (93%), environmental (34%), and vehicular (13%). Of course, more than one category can be operative in a crash, and so these percentages total more than 100%. Within the human category, four subcategories included recognition errors (56% of in-depth cases), decision errors (52%), performance errors (11%), and "critical non-performance" (e.g., blackout, dozing; 2%). Again, these categories are not mutually exclusive and thus total more than 93%. Recognition errors include distraction (which may be from inside or outside the vehicle), general inattention (e.g., daydreaming), and "improper lookout" (looked but did not see). Recognition

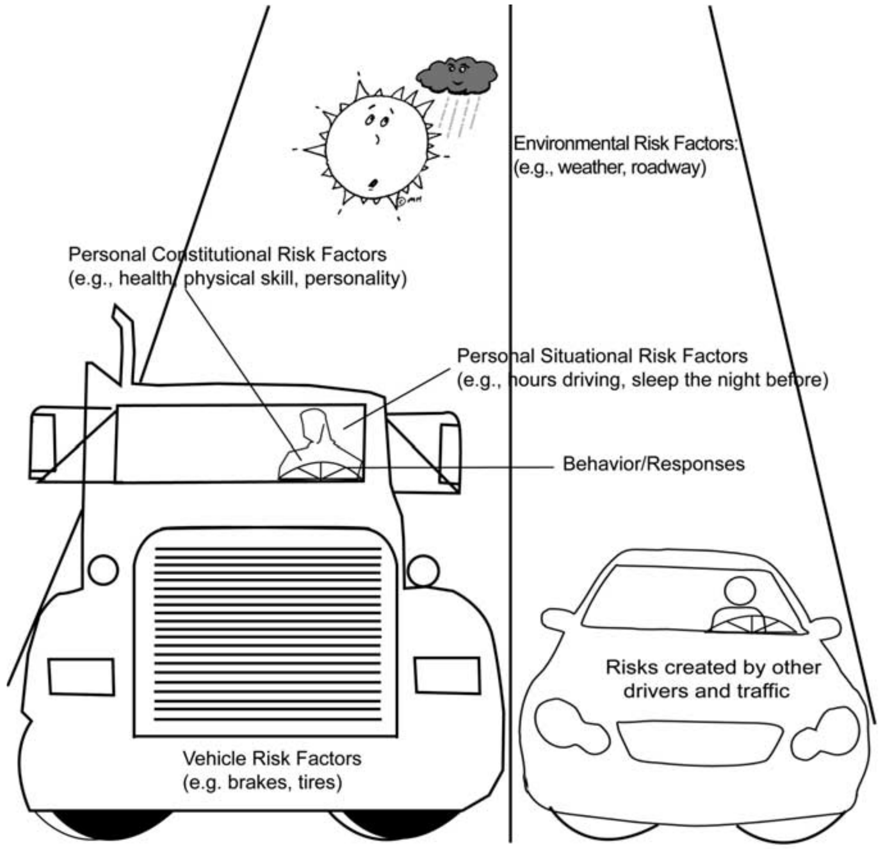


Figure 5. Major interacting factors affecting commercial driver crash involvement.

errors are often associated with rear-end crashes and some intersection crashes (Najm et al. 1995). Decision errors include conscious decisions to drive unsafely (e.g., speeding, tailgating) and also gap judgment errors resulting in a crossing-path-type crash. Performance errors are motor responses improperly executed (e.g., overcorrection following a lane departure). Critical non-performance includes both medical causes and asleep-at-the-wheel. Risk-taking behavior is most likely to result in decision errors, but any of these four categories could be sources of chronic driver risk. For example, a medical condition could leave one vulnerable to blackout and a non-performance crash. A follow-up analysis of the Indiana data found that young, unmarried males were the highest risk group and that most of their crashes were caused by poor decision-making, including overt risk-taking behaviors like speeding.

The FMCSA/NHTSA Large Truck Crash Causation Study (LTCCS) employs a causal classification similar to that of the Tri-Level Study. In 286 large truck crashes presented as preliminary LTCCS data (Craft and Blower 2003), 34% of the crashes had a "critical reason" assigned to the driver of the large truck. For the other 66%, the critical reason was assigned to another involved driver or to a vehicle or environmental factor. The truck-driver–associated "critical reasons" were classified according to the same human factors classification as used in the Indiana Tri-Level Study and occurred as follows:

- Recognition error: 14%
- Decision error: 15%
- Performance error: 2%
- Driver non-performance: 3%

Another common classification for driver errors resulting in crashes is as follows (Dewer and Olson 2002):

- Rule-based (failure to obey rules or regulations)
- Knowledge-based (failure to understand required safe behavior)
- Skill-based (lack of proper skills to perform the task)

Most fatal crashes involve misbehaviors or rule violations such as alcohol use and speeding. Drivers can also make mistakes without obvious misbehaviors, such as failure to see another vehicle or misjudgment of a gap in the traffic stream. Red-light running may be regarded as a rule-based misbehavior if it is intentional, a skill-based mistake if it is not.

Reason (1990) proposed three error categories: violations (deliberate deviations), mistakes (intended action with unintended consequences), and lapses/slips (execution of unintended action). Rimmo (2002) has expanded this by splitting the lapses/slips category into inattention errors (unintended action resulting from recognition failure) and inexperience errors (unintended action resulting from lack of knowledge or skill). Rimmo's classification, with examples, follows:

- Violations
  - – Deciding to drive when known to be very fatigued
  - – Deliberately exceeding speed limits
  - – Accelerating at green-to-yellow signal change
- Mistakes
  - – Misjudging gap when crossing traffic
  - – Misjudging speed of oncoming vehicle
  - – Misjudging stopping distance
- Inattention Errors
  - – Failing to notice red light at intersection
  - – Failing to see that vehicle has stopped in lane ahead
  - – Failing to notice sign
- Inexperience Errors
  - – Having to check gear with hand
  - – Driving in too low a gear
  - – Switching on wrong appliance in truck

Figure 6 shows a schematic of how the four error types contribute to driver risk. Rimmo's (2002) research on these variables employed questionnaires asking driver subjects to rate the frequency of various driving behaviors and errors in these categories. Analysis of the questionnaire data demonstrated that the four-factor model was applicable across different driver age levels. Studies of the intercorrelations among the four error types have found that the correlations between violation behavior (as measured by questionnaire) and the other three factors were less than the intercorrelations within the other three factors. Different individuals may be "violation prone" or "error prone," and both are associated with accident involvement. However, of the two, high violation scores are more predictive of crash involvement than high error scores.

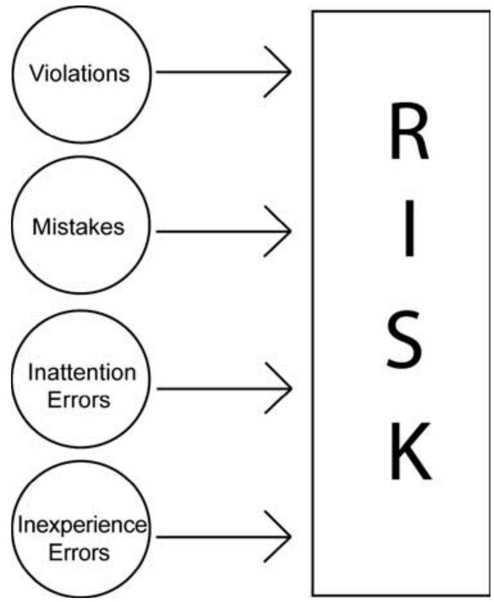


Figure 6. Simplistic model of how different types of error contribute to risk.

CHAPTER 4

FACTORS RELATED TO DRIVER RISK

This chapter reviews personal factors relevant to commercial driver crash risk, including driver age and gender, driving history, non-driving history, medical conditions and health, fatigue susceptibility, personality traits, sensory-motor performance capabilities, and several other personal crash risk factors.

4.1 DRIVER AGE AND GENDER

4.1.1 Age

For the overall driver population, age is one of the strongest personal factors affecting crash involvement (NHTSA 2000). Teenaged drivers, especially males, have crash involvement rates per mile traveled that are several times higher than those of the adult population. Driver errors seen in teenaged drivers include both risk-taking behaviors and misjudgments (Mayhew and Simpson 2003). Even drivers in their twenties—especially early twenties—have high crash rates. Across the spectrum of driver ages, crash rates reach their lowest levels for drivers in their 40s and 50s, remain relatively low for drivers in their 60s, and begin to rise for drivers in their 70s. Drivers aged 85 and older have crash rates (per mile traveled) that rival those of new teenaged drivers.

Inexperience is probably not the main factor elevating the crash risk of teenaged drivers. Pierce (1977) studied the crash rates of 16- to 19-year-olds and found evidence contrary to the hypothesis that experience is the primary factor. He found that 14.2% of drivers licensed at 16 years old had vehicle crashes, compared with 13.4% in their second year and 11.5% in their third year (at the age of 18). Drivers who waited until age 18 to receive their license had a comparable crash rate with those who had been driving for 3 years (i.e., 11.9%). Nineteen-year-olds who were licensed since the age of 16 had a crash involvement percentage of 10.2% while the same age group who were newly licensed had an involvement percentage of 10.5%. It appears that other characteristics such as immaturity or risk-taking play stronger roles in the high crash rates of young drivers than do lack of driving experience per se or any lack of physical ability. Ulleberg (2002) found that young, high-risk drivers demonstrated a risk-taking attitude that resulted in a propensity to engage in risky driving behaviors.

The above studies and statistics related to all drivers—commercial plus non-commercial. Regarding commercial drivers, in 2001, those aged 25 or younger constituted 6.9% of the large truck drivers involved in fatal crashes, 11.3% of those involved in injury crashes, and 13.8% of those involved in property damage only (PDO) crashes (FMCSA 2003). These statistics are hard to evaluate, because the relative mileage exposure of young commercial drivers is not known. In addition, younger truck drivers tend to be hired by smaller, shorter-haul companies and are more likely to drive large single-unit (straight) trucks than their older peers (Blower 1996, Corsi and Barnard 2003). So, even if rates and risk metrics could be generated, direct comparisons of them would not necessarily be valid.

A detailed statistical analysis of young truck driver involvement in crashes was conducted by Blower (1996) using Michigan and North Carolina crash and violation data. Young truck drivers (defined in this study as 18 to 21 years old) had moving violation rates that were almost twice those of the middle-aged drivers (30 to 49 years old) in the study. Speeding above the speed limit and unsafe speeds for conditions were the two top violations cited. The study did not report crash involvement rates, again due to lack of reliable mileage exposure data. However, the study did report that young commercial drivers were about 50% more likely than middle-aged drivers to be charged with a violation in a crash. In two-vehicle crashes with light vehicles, the young truck driver was twice as likely as the other driver to be charged with a hazardous action or traffic violation, which is opposite the trend for large truck/light vehicle crashes in general (FMCSA 2003). Major crash scenarios for these young truck drivers were loss of control/struck fixed object, backing into another vehicle, turning-related involvements, and rear-end (truck-striking) crash involvement.

In the local/short-haul study described earlier in the synthesis, Hanowski et al. (2000) analyzed factors (including both personal driver factors and situational factors) predicting truck driver involvement in critical incidents (caused by the truck driver). They evaluated driver age, ambient illumination, prior night's sleep, current drowsiness rating, physical work requirements for the day, and several other factors. They found that driver age was the strongest predictor of critical incident involvement.

In a study of driver attributes and rear-end crash involvement among the general driving population, Singh (2003) found that young drivers (younger than 25 years old) were over-involved in rear-end crashes in both striking and struck vehicle roles. The age effect was more pronounced for the striking vehicle (at fault) role than for the struck vehicle.

One possible solution to the younger commercial driver crash problem is graduated licensing, a technique that has been used successfully for novice non-commercial drivers in a number of countries and states (Mayhew and Simpson 2003). Of course, the graduated progression of driving privileges for commercial drivers would be quite different than that applied to teenaged novice drivers.

Corsi and Barnard (2003) found that 59% of high-safety fleets, and nearly two-thirds of large fleets, considered age 25+ to be an "important" or "very important" selection factor in driver employee hiring decisions. The percentage was even higher—69%—for hiring owner-operators. In this research project survey, carrier safety managers rated the factor "young driver (e.g., younger than 25 years old)" as having the 6th strongest association with crash risk of the 16 factors in the survey. Other experts rated it as having the 5th strongest association. In contrast, both groups rated "older driver (e.g., 60 years old or older)" as having the 12th strongest association with crash risk among the 16 factors.

There appears to be no major safety problem relating to older truck drivers. In 2001, those 56 years old or older constituted 14.3% of the large truck drivers involved in fatal crashes, 13.2% of those involved in injury crashes, and 11.2% of those involved in PDO crashes (FMCSA 2003). Again, mileage exposure levels are not known, so comparative crash rates cannot be generated.

The Trucking Research Institute and InterScience America (1998) published an FHWA-sponsored study of the effects of increasing age on commercial driver performance and safety. The study reviewed the scientific literature on the subject and measured the performance of different age groups of drivers on a variety of performance tests. The study found that

- Age alone is not a reliable predictor of job performance.
- Age is not a good predictor of sensory-motor abilities. While many perceptual, sensory-motor, and cognitive abilities do generally decline with advancing age, there are huge individual differences within age groups.
- Drivers past the age of 50 do begin to have slower reaction times, stiffer joints, and other physical signs of age. Nevertheless, these drivers are often among the safest and most reliable commercial drivers.

Among non-commercial drivers, older drivers have been found to purposely limit their exposure to driving situations they regard as more difficult (Ball et al. 1998). Those drivers with objectively determined difficulties in vision and attention would avoid situations that would increase these demands. In other words, they had self-regulating behavior. In commercial driving, it's likely that many older drivers resign from the profession if they find it too demanding or if they feel that their declining psychomotor skills are making driving dangerous.

The findings summarized here should reassure the industry that hiring older drivers, especially the "young old," does not generally create crash risks. Indeed, these drivers are often among the industry's finest. Survey findings echoed this view; both safety managers and other experts rated "Older Driver (e.g., 60 years old or older)" as among the factors with the least driver crash risk.

4.1.2 Gender

Among the general population of drivers, males have somewhat higher per-mile crash rates than females in most age brackets. Their per-driver crash risks (e.g., driver involvement rates per 100,000 population) are considerably higher than females', and their per-driver fatal crash risks are more than twice those of females (NHTSA 2000). However, per-driver crash risk statistics may be misleading because males drive significantly more miles and thus have far greater exposure risk than females. Per-mile crash rate statistics, when available, are more telling.

Women constitute a small percentage of commercial drivers. In 2001, females were 2.6% of the large truck drivers involved in fatal crashes, 4.5% of those involved in injury crashes, and 6.0% of those involved in PDO crashes (FMCSA 2003). Once again, mileage exposure levels are not known, so comparative crash rates cannot be generated. These data do show, however, that female commercial drivers are relatively less likely than males to be involved in more serious crashes.

In the Singh (2003) study of driver attributes and rear-end crash involvement mentioned above, both young males and young females 18 to 24 years old were more likely than older drivers to be involved in rear-end crashes. Comparing genders, young males and young females had about the same risk of involvement in the struck vehicle role. For the striking vehicle role, however, young males had about a 50% higher risk of involvement than did young females.

4.2 DRIVING HISTORY

4.2.1 Commercial Driving Experience

Experience driving a large truck or bus is clearly a factor in driver safety. In the research project survey, "inexperienced (new to commercial driving)" received identical high ratings for association with crash risk from the two respondent groups (i.e., an average of 3.2 on a 0–4 scale). This was the 4th highest-rated factor of the 16 presented. Not surprisingly, most motor carriers, particularly large carriers, require prior commercial driving experience for applicants to be considered for hiring (Stock 2001). Corsi and Barnard (2003) found that 85% of carrier safety managers consider driving experience with other carriers to be an important or very important hiring criterion. Similarly, Knipling, Hickman, and Bergoffen (2003) reported that 86% of their carrier safety manager respondents required a minimum number of years of commercial driving experience and that managers rated this age hiring criterion as the 4th most effective safety management technique of the 28 presented.

A contrasting view is that experience leads to complacency and unsafe practices for some drivers. One respondent claimed that "CMV drivers appear to become complacent after about 4 or 5 years on the job (regardless of age) and are less safe." While this may be true for some drivers, no evidence was found indicating that this is a general trend.

4.2.2 Longevity with Company

In the research project survey, "new to company" was not rated by either safety managers or other experts as a strong correlate of crash risk. Safety managers rated "new to company" as 13th of 16 factors, and other experts rated it 11th of 16. Studies have shown a relationship between employment longevity with a company and crash involvement. One safety manager respondent commented that, "The problem drivers are usually the bottom 10–20% who are a constant turnover in the industry. Often other employers do not give all information [about them]. . . ."

In a study of CMV driver retention and safety, Staplin et al. (2002) found that drivers with frequent job changes (three or more different carriers per year for 2 years or more) were more than twice as likely to be involved in a crash as the at-fault driver than drivers with less frequent job changes. One may ask whether job changes increase a driver's risk, or whether poor driving results in dismissal or other management actions resulting in job changes.

4.2.3 Crashes, Violations, and Incidents

A driver's history of involvement in crashes, violations, and other incidents is known to be a strong predictor of future crash involvement and the driver's role (e.g., at-fault vs. not-at-fault). For example, using a sample of more than 200,000 (mostly non-commercial) drivers in Kentucky, Chandraratna and Stamatiadis (2004) were able to use past data on driver crash involvement and violations to predict future crash involvement as the at-fault driver with 88% accuracy using a logistic regression model. One input to the predictive model was the time gap between successive crashes. If a driver was recently involved at-fault in a crash, he or she is more likely to be at-fault in a second crash event.

Miller and Schuster (1983) followed 2,283 drivers in California and Iowa for 10 to 18 years. They found that traffic violations were a better predictor (than were crashes) of future crashes. Their results indicate that violation behavior is more stable over time than crashes, thereby making them a better predictor of future crashes than crashes themselves. This finding may reflect that crashes are relatively rare and are the result of both at-risk driving behavior and chance. In contrast, violations and other unsafe driving acts are direct reflections of driving behavior.

Past crash involvement was not included in the list of the 16 driver risk factors in the research project survey, but the management practices sections did ask safety managers if they checked the MVR of crashes and violations for driver applicants. All 178 safety manager respondents (100%) indicated that they check the MVR as part of their hiring procedures, and both safety managers and other experts rated this driver hiring practice as No.1 in effectiveness among the eight listed. Similarly, 99% of the safety manager respondents reported that they continuously track their fleet drivers' involvement in crashes, violations, and incidents, and this performance evaluation practice was rated by both respondent groups as the No.1 evaluation practice of the four presented.

Example of Commercial Driver Risk Prediction Using Violation and Incident Data

A major insurance carrier for the CMV industry has developed a powerful methodology for relating past driver violations and incidents to current crash risk. This insurer has made significant efforts to assist their clients in identifying high-risk drivers. These efforts involved a three-part approach, which built a crash predictive index, assembled a comprehensive safety history, and included a ranking system comparing drivers' safety history with that of their peers.

Predictive Index. First, the insurer teamed with several insured clients to determine the ability of various safety infractions to predict crash and incident risk. For example, the insurer partnered with a major national motor carrier of bulk liquids and chemicals to monitor the roadside inspection results and crash/incident history of 1,682 drivers who were continuously employed over a 37-month period. For these 1,682 individuals, the insurer tracked the number and type of "risk-indicative" driver violations. Example violation types included the following:

- Traffic Enforcement: Speeding, following too close, and improper lane change.
- Log Out-of-Service: Exceeding hours-of-service limits and log falsification.
- General Log: Log not current, failure to retain previous 7 days' logs.
- Illegal Use of Radar Detector.
- Driving While Disqualified: Cited for driving with suspended or revoked license.
- Driver Violation Rate: Total number of risk-indicative violations per inspection.

The violation data were gleaned from FMCSA carrier profiles. Carrier profile reports, which can be obtained from FMCSA (www.fmcsa.dot.gov), contain tabulations of all state-reported crashes and roadside inspections. For each roadside inspection, these reports provide identifying information (e.g., time, date, and driver name) as well as a tabulation of cited violations.

Next, the insurer tracked these drivers' involvement in such events as crashes, spills, and mis-deliveries. These data were extracted from both the carrier's internal accident/incident register and the insurer's claim management system. The combined files yielded information regarding driver name, crash/incident type (e.g., preventable rear-end collision, sideswipe crashes, and chemical spills), and incident cost.

During the 37-month tracking period, the 1,682 drivers were involved in 4,662 roadside inspections, 1,102 risk-indicative violations and 836 claim incidents. Drivers were involved in an average of 0.50 crashes/incidents each. However, involvement rates ranged from 0 to 13 incidents per driver. Violation involvement rates ranged from 0 to 7 per driver. Interestingly, 20% of the drivers were involved in 79% of all crashes/incidents and 76% of all violations.

The insured carrier next examined the statistical relationship between violations and incident involvement. This determines the influence of the various factors (e.g., number of traffic enforcement actions, log out-of-service, general log, radar detector, and total driver violations) in the number of incidents. The findings indicated that the total number of driver violations was a very strong predictor of crash/incident involvement. For example, drivers with no violations averaged 0.41 crash/incident events each. In contrast, drivers with two violations averaged 0.64 crashes/incidents and drivers with four violations averaged 0.93 crashes/incidents.

The predictive ability of violation types was also calculated. Results indicated that "Driving While Disqualified" had nearly twice the predictive ability of the other violations. This was followed by "Traffic Enforcement" and "General Log" violations.

A similar process was used across a range of other safety violations, such as motorist complaints (e.g., "1-800-Hows-My-Driving") and MVR convictions (e.g., speeding, failure to yield right-of-way, and failure to obey traffic warning device).

Comprehensive History. Next, the insurer assisted its clients in developing a comprehensive safety history. Typically, this history comes from multiple files, similar to those shown in Figure 7.

The files are often stored in vastly different data formats. Driver rosters and accident registers, for example, are often maintained in a spreadsheet (e.g., Microsoft® Excel) format. MVR reports and motorist complaints are frequently in "hard copy" format and are kept within a driver's qualification file. Other information, such as customer complaints or observed incidents, is frequently maintained within operations or driver dispatching software programs.

Peer Ranking System. With the comprehensive safety history assembled, the insured assisted their clients in developing a total "Risk Index" score for each driver. This was

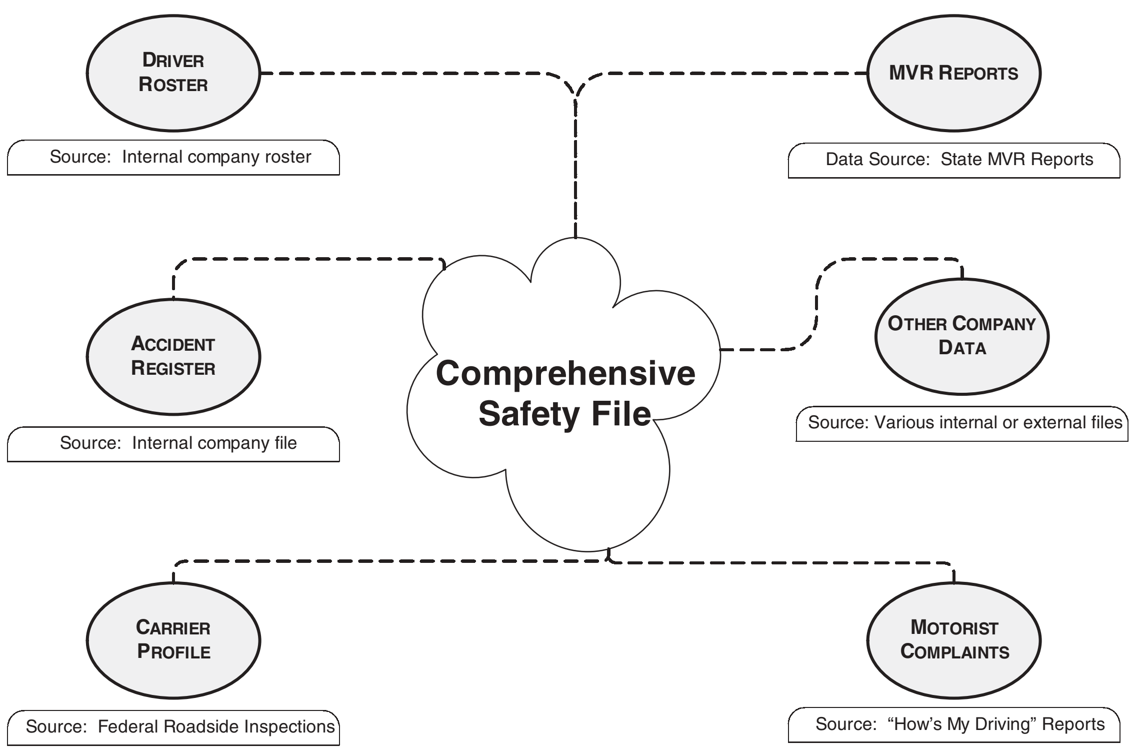


Figure 7. Assembling comprehensive safety history.

accomplished by calculating the point value for each recorded incident and then totaling driver-specific safety score summaries by driver name.

As shown in Figure 8, the insured then used this information to identify high-risk drivers. Once the pool (e.g., say, worst 25%) of high-risk drivers was identified, the client's managers then focused their intervention and training efforts on these individuals.

This approach toward identifying and managing at-risk behavior is new to the motor carrier industry, and the insurer reported that many clients had been using the system for less than 1 year. As a result, a validated sampling of reduced crash involvement was not available at the time this synthesis was prepared. Informal interviews of clients who used such an approach, however, reported such benefits as

- It allowed them to focus their "scare" safety intervention resources (e.g., limited field safety staff on those individuals who are most at risk for future crash involvement).
- It provided the opportunity for "pre-crash" intervention and management, which in many cases salvaged the careers of individuals who would not "float to the top" until their records would require immediate termination.

4.2.4 Defensive Driving

This synthesis focuses on commercial driver risk factors, but most analyses of driver-related factors in crashes between large trucks and passenger vehicles have indicated that passenger vehicle driver errors or other driver factors are cited much more often than truck driver factors. Most studies show that the ratio of passenger vehicle driver errors to truck driver errors in crashes, including fatal crashes, is at least 2:1 (Craft 2004, FHWA 1999, Blower 1998). An obviously important element of safe commercial driving is defensive driving (i.e., avoiding crashes that might be caused by other drivers).

Are there significant individual differences in commercial drivers' defensive driving skills? Data from the local/short-haul truck instrumented vehicle study (Hanowski et al. 2000) described earlier imply that there are such variations in truck drivers' abilities to avoid the mistakes of other drivers.

In the study, 42 truck drivers were involved in 137 CIs caused primarily by other drivers during 1,376 hours of driving, yielding an average rate of 0.12 such CIs per hour. Figure 9 shows the frequency distribution of rates of involvement in other driver CIs.

Of the 42 truck drivers, 10 had other driver CI/hour rates greater than 0.20. These 10 drivers drove 16% of the total driving hours of the study but were associated with 45% of all the other driver CIs (61 of 137). The correlation between truck driver involvement rate in other driver CIs and involvement rate in truck driver CIs was +0.24, suggesting some association between involvement risk for the two types of traffic incidents.

4.3 NON-DRIVING CRIMINAL HISTORY

Having a criminal record is likely to make it difficult for individuals to find work as a commercial driver. Of course, a driver's criminal record is relevant to other carrier concerns

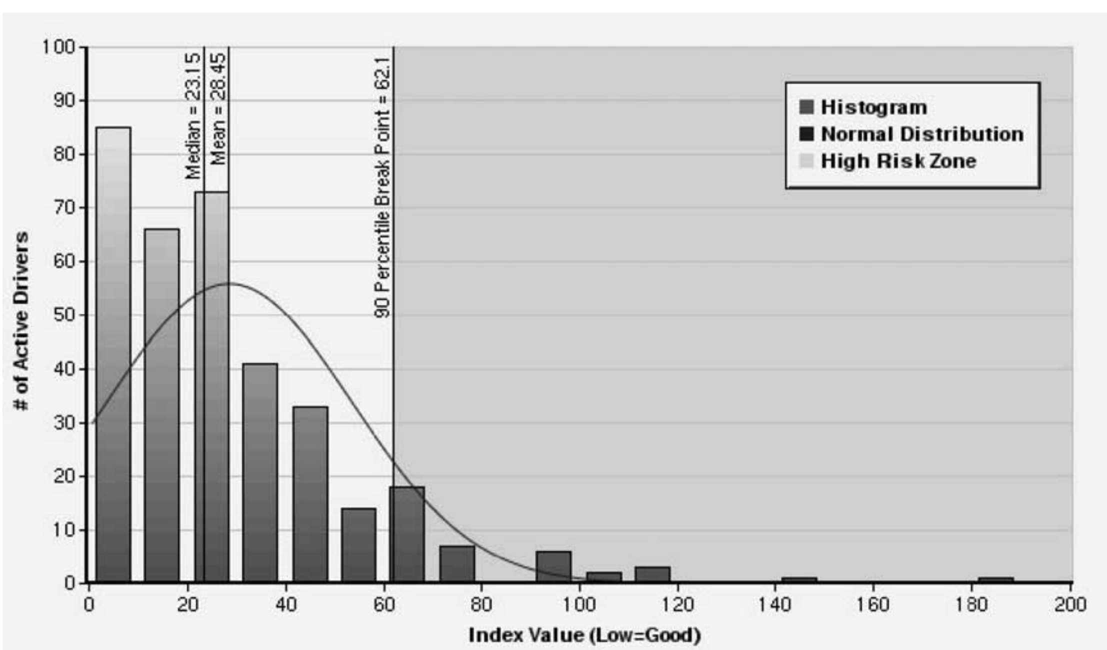


Figure 8. Comparative safety scores illustrating variation in driver risk prediction.

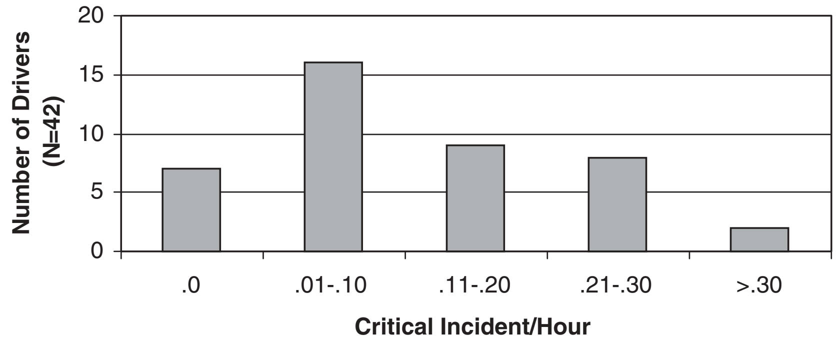


Figure 9. Frequency distribution of other driver critical incident rates among 42 local/short-haul truck drivers (adapted from Hanowski et al. 2000).

besides driving safety; most notably, it is relevant to cargo and other operational security. Sixty-one percent of responding safety managers check a driver applicant's criminal record, although this was not rated as among the most effective safety management practices. Checking a driver's credit history has been suggested as a way to assess dependability and stability, but only 21% of safety manager survey respondents reported doing this, and it was rated as the least effective practice of the eight presented.

4.4 MEDICAL CONDITIONS AND HEALTH

Driving is a task requiring various physical abilities for satisfactory safety performance. Medical conditions and health status can have a significant impact on drivers' performance if their cognitive, perceptual, and psychomotor skills are affected. Drivers must pass a medical examination to qualify for a commercial driver's license (CDL), and specific disqualifying medical conditions (per 49 CFR 391.41) include vision and hearing impairment, diabetes, and epilepsy.

4.4.1 Sleep Apnea

In the past decade, sleep apnea has been one of the most studied medical conditions in terms of its relationship to crash risk. Sleep apnea is a breathing disorder characterized by brief interruptions of breathing during sleep. Among the general population of drivers, sleep apnea has been shown to increase the likelihood of being involved in vehicular crashes anywhere from two- to sixfold (see Table 10). That is, drivers with sleep apnea are two to four times more likely to have a motor vehicle accident. Further, Young et al. (1993) estimated that approximately 4% of middle-aged male drivers, the predominant population of truck drivers, may have some form of sleep

TABLE 10 Elevated crash risks (odds ratios) associated with various medical conditions per various studies

Study	Sleep-Related Medical Condition	Odds Ratio: Crash Risk
Teran-Santos et al. (1999)	Sleep apnea (AHI ≥ 10)	6.3
Wu and Yan-Go (1996)	Sleep apnea	3.0
Young et al. (1997)	Sleep apnea: (AHI 5-15)	4.2
Young et al. (1997)	Sleep apnea: (AHI >15)	3.4
Connor et al. (2002)	Acute sleepiness	11
Masa et al. (2000)	Habitually sleepy drivers	13.3
Cummings et al. (2001)	Drowsiness	14.2

Note: All studies involved non-commercial drivers. AHI = Apnea/Hypopnea Index (a measure of sleep apnea severity).

apnea. A subsequent study by Young, Blustein, Finn, and Palta (1997) determined that the relative risk of being involved in a motor vehicle crash if one has sleep apnea is approximately four times normal risk.

Findley et al. (1989) conducted a driving simulator experiment in patients with and without sleep apnea. The patients with sleep apnea hit a greater number of obstacles during their 30-min simulated drive than did the control group (drivers with no known sleep apnea). However, studies have also shown that drivers who are successfully treated for sleep apnea reduced their crash risk significantly (George et al. 1996). Young et al. (1993) have also suggested that increased prevalence of sleep apnea occurs due to many factors that drivers could detect themselves, such as age, gender, weight, and snoring. However, commercial drivers may be reluctant to be screened or treated for sleep apnea due to cost and concerns of job security. Further, the method for treatment (e.g., continuous positive airway pressure [CPAP], surgery) can be considered costly, too obtrusive, or too burdensome if treatment is needed nightly (Flemons 2002). Long-term health consequences of sleep apnea and the long-term relationship of this disorder to crash risks are major concerns.

Pack et al. (2002) estimated the prevalence of sleep apnea among commercial drivers and quantitatively assessed the effects of sleep apnea on driving-related performance. The study found that mild sleep apnea occurs in 17.6% of those holding CDLs, moderate sleep apnea in 5.8%, and severe sleep apnea in 4.7%. Deficits in vigilance and various sensory-motor tasks were associated with the increasing severity of sleep apnea. Objective measures associated with sleep apnea severity included sleep latency (a standard measure of drowsiness), Psychomotor Vigilance Test (PVT) reaction time and lapses, and tracking errors on a divided attention task. Sleep apnea was associated with shorter sleep durations, but neither sleep apnea severity nor sleep duration was associated with subjective self-reports of sleepiness by driver subjects. Thus, driver self-monitoring of their levels of alertness and drowsiness is not likely to provide valid assessments.

Obesity is a prime risk factor for sleep apnea, and the incidence of obesity among CMV drivers is approximately twice that of the general population (Roberts and York 2000). Other health conditions and behaviors for which commercial drivers compare unfavorably with the general population include diet, exercise, hypertension, stress, and smoking.

4.4.2 Narcolepsy

Narcolepsy is principally characterized by a permanent and overwhelming feeling of sleepiness and fatigue. Other symptoms involve abnormalities of dreaming sleep, such as dream-like hallucinations and finding oneself physically weak or paralyzed for a few seconds. It impacts 1 in every 2,000 Americans (http://www-med.stanford.edu/school/Psychiatry/narcolepsy). While sleep apnea is more prevalent in drivers who are male, middle-aged, and slightly overweight, narcolepsy affects both men and women, can run in families, and can appear at an earlier age. Excessive daytime sleepiness occurs every day, regardless of the amount of sleep obtained at night and can therefore put drivers at an increased risk for crash involvement.

Findley et al. (1995) conducted a study on vigilance and automobile accidents in patients with narcolepsy as well as those with sleep apnea. A computer program simulating a long and monotonous highway drive was presented to drivers for 30 min. The patients with untreated narcolepsy hit a higher percentage of obstacles while performing on the simulator, indicating a greatly increased likelihood of crash involvement.

George, Boudreau, and Smiley (1996) also conducted a laboratory-based divided attention driving test (DADT) in a simulated environment on patients with narcolepsy and patients with sleep apnea. Their study showed that narcolepsy patients were sleepier than patients with obstructive sleep apnea, and tracking error was much worse in both sets of patients when compared with a control group.

Aldrich (1989) also conducted a study of automobile crashes in patients with sleep disorders, primarily narcolepsy and sleep apnea. Aldrich found the highest sleep-related crash rates in narcoleptics. Aldrich (1989) and Findley et al.'s findings suggest that both sleep apnea and narcolepsy are sleep disorders that need to be investigated further.

4.4.3 Diabetes

Diabetes, a common chronic disease, is of concern to licensing agencies because individuals with diabetes may experience periods of hypoglycemia when treated with insulin. Hypoglycemia can alter judgment and perception and can even lead to a loss of consciousness while driving. Laberge-Nadeau (2000) estimated the impact of diabetes on crash risk in a study consisting of commercial drivers and truck-permit holders. Data on permits, medical conditions, and crashes of 13,453 permit holders from 1987 to 1990 were used in the analysis as well as a telephone survey conducted from 1990 to 1991 that collected information on driving patterns and exposure. The findings showed that there was an increased crash risk for the permit holders and for the professional drivers with the same type of permit and with uncomplicated diabetes not treated with insulin. Permit holders for single-unit trucks who are diabetic without complications and not using insulin had an increased crash risk of 1.68 when compared with healthy permit holders of the same permit class. Commercial drivers with a single-unit truck permit and the same diabetic condition had an increased risk of 1.76. Surprisingly, the findings also showed that insulin use was not identified with higher crash risk. However, this could be due to the limited number of commercial drivers with severe diabetes. Many fleets screen their drivers and applicants for insulin-based diabetes.

4.4.4 Other Medical Conditions

Medical conditions having an impact on the crash severity of commercial motor vehicle crashes were identified by Laberge-Nadeau et al. (1996). In their study, crash severity was measured by the total number of injured victims. Their study indicated that truck drivers with binocular vision problems and bus drivers with hypertension had more severe crashes than healthy drivers. No other medical condition considered in this study—including diabetes, mellitus, and coronary heart disease—was significantly associated with crash severity.

A study done with non-commercial drivers indicates that other health problems, including heart disease and stroke, were also associated with an increased likelihood of being involved in both at-fault and not-at-fault automobile crashes (McGwin et al. 2000). The study also found an increased risk of crash involvement for drivers with arthritis and diabetic neuropathy. A confounding factor in this study is that many people with these conditions are taking prescription drugs that can impact their cognitive, perceptual, and psychomotor abilities.

4.5 ALCOHOL AND DRUG ABUSE

Commercial driver alcohol use while driving is infrequent, especially in comparison with non-commercial drivers. In 2001, alcohol use on the part of large truck drivers was involved in 2% of their fatal crashes, 1% of their injury crashes, and less than 0.5% of their PDO crashes. Alcohol use on the part of bus drivers represented 3% of their fatal crashes and less than 0.5% for both injury and PDO crashes. For passenger vehicles (cars and light trucks), the comparable percentages were 27% fatal, 5% injury, and 3% PDO (NHTSA 2002). Craft (2004) reported preliminary findings on 210 light-truck vehicle crashes from the FMCSA/NHTSA Large Truck Crash Causation Study. None of these 210 crashes involved alcohol or illegal drug use by truck drivers. Of the light vehicle drivers involved in these crashes, 11% were under the influence of alcohol and 9% had used illegal drugs.

Federal law requires all motor carriers employing commercial drivers to have drug and alcohol testing programs. The random testing rates are 10% for alcohol and 50% for controlled substances (illegal drugs). In 1999, 0.2% of CDL holders tested positive for alcohol use and 1.3% tested positive for controlled substances (FMCSA 2001).

These statistics indicate that commercial driver alcohol and illegal drug use are not major factors in the crashes. Nevertheless, any commercial driver identified as an alcohol or drug abuser should be considered a high-risk driver.

4.6 DRIVER FATIGUE

Drivers who are sleep deprived have significant deficits in vigilance and other cognitive abilities related to driving. McCartt et al. (2000) identified factors associated with why long-distance truck drivers reported falling asleep at the wheel. They found six underlying, independent factors, including (1) greater daytime sleepiness, (2) more arduous schedules, with more hours of work and fewer hours off-duty, (3) older, more experienced drivers, (4) shorter, poorer sleep on the road, (5) symptoms of sleep disorder, and (6) greater tendency to nighttime drowsy driving. The authors also suggest that if these six factors were to be ranked, a tendency toward daytime sleepiness was most highly predictive of falling asleep at the wheel, followed by an arduous work schedule and older, long-time drivers. Hakkanen and Summala (2001) found similar findings in an analysis they conducted on 567 professional drivers that included five different commercial driver types (long-haul drivers, short-haul drivers, bus drivers, drivers transporting wood, and drivers transporting dangerous goods). They found that regardless of the commercial driver type, sleepiness-related problems was strongly related to prolonged driving, sleep deficit, and driver's health status.

Sagberg (1999) conducted a study of crashes caused by drivers falling asleep. The study showed that fatigue was a strong contributing factor in nighttime accidents, run-off-road accidents, and accidents after driving more than 150 km on one trip. Although his study was conducted on non-commercial drivers, many findings were consistent with McCartt et al.'s study. In addition, Sagberg found that more males than females were involved in sleep-related accidents. Sagberg also suggests that drivers' lack of awareness of important precursors of falling asleep in addition to the reluctance to discontinue driving despite feeling tired contributed to sleep-related accidents.

Pack et al. (1995) investigated the characteristics associated with sleep-related crashes among the general population of drivers. They found that the crashes were primarily drive-off-the road type and took place at higher speeds. The crashes occurred primarily at two times of day: during the overnight hours (midnight to 7 a.m.) and during mid-afternoon (3:00 p.m.). Young drivers were overrepresented, especially in overnight crashes. The times of occurrence of fatigue-related crashes corresponded to the known circadian variation in sleepiness. There is a major peak during the night with a secondary peak during the mid-afternoon. When older drivers were involved in these crashes, it tended to be in the afternoon rather than in the overnight hours.

Lyznicki et al. (1998) present a comprehensive review of sleepiness, driving, and motor vehicle crashes in a report to the *Journal of the American Medical Association.* Their report indicates that drivers at high risk for fatigue or sleep-related crashes include (1) younger drivers who lack sleep due to demands from school and jobs, extracurricular activities, late-night socializing, and poor sleep habits, (2) shift workers, who may have reduced opportunities for sleep due to disruptions of the biological process that programs daytime wakefulness and nighttime sleepiness, (3) drivers who use alcohol and other drugs, and (4) drivers with sleep disorders.

In the landmark FHWA-sponsored Driver Fatigue and Alertness Study (DFAS, Wylie et al. 1996), 80 long-haul commercial drivers in the United States and Canada were monitored over a 4- to 5-day work week. In the study, there was continuous video monitoring of drivers' faces, which enabled judgments of alertness based on eyelid droop, facial expression, and muscle tone. Approximately 4.9% of the sampled video segments during the 4,000 hours of subject driving were scored as drowsy based on reviewers' assessments. One of the major observations of the study was the pronounced individual differences in the incidence of drowsiness among the 80 drivers. Twenty-nine of the drivers (36%) were never judged drowsy whereas, at the other extreme, 11 of the drivers (14%) were responsible for 54% of all the drowsiness episodes observed in the study. Figure 10 shows the frequency distribution of drowsiness episodes among the 80 drivers, plotted with five frequency ranges. The two drivers in the far right bin had 38 and 40 drowsiness episodes, respectively. Their total of 78 was greater than the total drowsiness episodes exhibited by the best 51 of the DFAS drivers. This distribution differs very significantly from the distribution expected from chance variation alone.

Personal factors possibly related to the high-drowsiness incidence for the two driver subjects were not identified in the DFAS report. Interestingly, two of the 80 drivers were diagnosed as having sleep apnea, but they were not the two highest-drowsiness subjects.

As noted, each DFAS driver drove for only 1 week, so the study did not address the question of whether individual differences in drowsiness incidence were enduring. Enduring individual differences in fatigue susceptibility would imply the existence of a fatigue susceptibility *trait* (i.e., a long-term characteristic), whereas the lack of such enduring differences would imply that situational or other factors lead to short-term differences in driver states.

An instrumented vehicle study of long-haul drivers using sleeper berths yielded a similar positively skewed distribution of high-drowsiness episodes. Figure 11 shows the distribution of high-drowsiness episodes per hour for 27 drivers. Of the 27 truck drivers, 7 drivers had high-drowsiness episode rates of greater than 0.30/hour. These 7 drivers drove 25% of the total driving hours of the study but were responsible for 226 (70%) of the 323 high-drowsiness episodes. In contrast, the 9 most alert drivers (the first bar in Figure 11) drove 24% of the driving hours but had no high-drowsiness episodes. Among the 27 drivers, there was a moderate correlation between driver high-drowsiness rates and other CI involvement rates. In the study, a situational factor contributing to the dispersion of driver drowsiness incidence was team versus solo driving. The study included both types, and the solo drivers exhibited significantly more drowsiness than the team drivers.

Indeed, there are numerous situational factors that increase the probability of drowsy driving, such as night driving, irregular schedules, sleeper berth use (versus sleep in a bed), length of working shift, delivery schedule pressure, and amount of sleep. "Sleep hygiene" refers to sleep and alertness-related personal habits and schedules. In a survey of 511 commercial drivers, Abrams, Schultz, and Wylie (1997) identified many sleep hygiene-related variables, including work shift length, sleeper berth use, split sleeper berth sleep, hours resting, frequency and duration of napping, drowsiness episodes in the past month, willingness to forgo sleep when behind schedule, and other health-related behaviors (i.e., diet and exercise). A wide range of responses were given on most of these topics, indicating the sleep hygiene practices of drivers vary widely. One question relating directly to fatigue risk asked how often drivers had dozed or fallen asleep at the wheel in the past month. The distribution of responses was as follows: 0 incidents, 72.0%; 1 to 5 incidents, 22.8%; 6 to 15 incidents, 4.0%, and >15 incidents, 1.4%. Of the seven drivers constituting the highest category, four reported 30 episodes in the past month and one reported 60.

Of course, the above survey data are subject to a number of vagaries, including variations in driver memory, candidness, criteria for "dozed or fallen asleep," and self-assessment of drowsiness level. On the latter point, the DFAS and other studies (e.g., Itoi et al. 1993) have found that drivers are not very good judges of their own levels of drowsiness, in particular the probability of imminent sleep episodes. The Itoi et al. study found variations in sleepiness across subjects for the same level

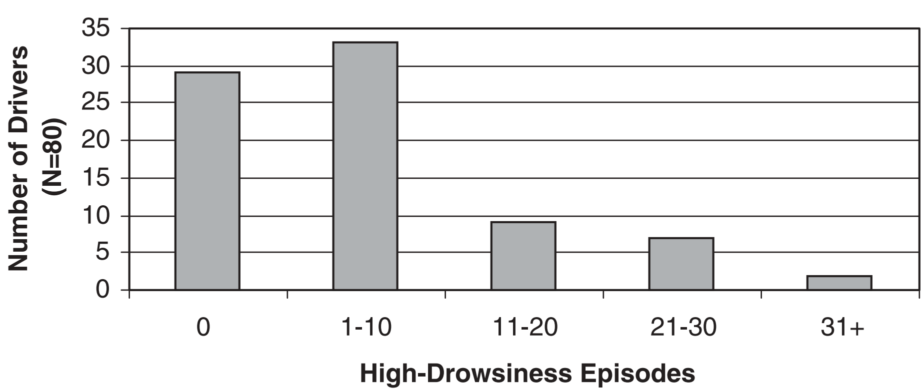


Figure 10. Frequency distribution of long-haul truck driver high-drowsiness episodes among 80 drivers of the DFAS.

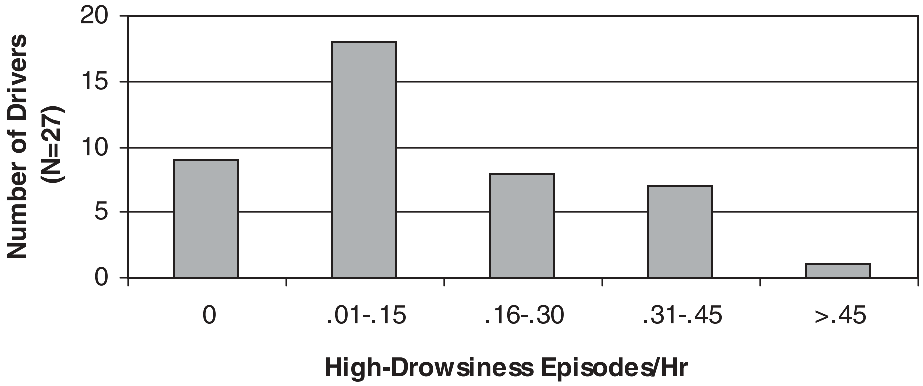


Figure 11. Frequency distribution of long-haul truck driver high-drowsiness episode rates among 27 drivers of the sleeper berth study (Dingus et al. 2001).

of sleep deprivation and also variations in the ability of sleep-deprived subjects to accurately *predict* the imminent occurrence of involuntary sleep. Of 31 subjects, accurate predictions of imminent involuntary sleep (i.e., "I will fall asleep in the next two minutes.") ranged from 25% to 97%. Accurate predictions of non-sleep (i.e., "I will not fall asleep in the next two minutes.") ranged from 9% to 84%. Several of the 31 subjects performed at or near chance levels of accuracy in predicting the imminent occurrence of involuntary sleep.

In a large FMCSA-sponsored study of sleep apnea, Pack et al. (2002) recorded amounts of nightly sleep for 340 commercial drivers, including drivers at high risk and low risk for sleep apnea. For both groups, they found wide ranges in average hours of nightly sleep, from less than 6 hours for about 10% (both subsamples combined) to more than 8 hours for about 24%. The study employed four subjective measures of sleepiness (e.g., Stanford Sleepiness Scale) and four objective tests (e.g., PVT) and found that average sleep duration significantly affected measures on all scales. Clearly, variations in amount of nightly sleep are a major source of variations in commercial driver alertness and performance.

Are there large individual differences in alertness for individuals with controlled amounts of sleep? In a major FMCSA-sponsored controlled experiment on the effects of different amounts of sleep, Balkin et al. (2000) permitted driver subjects 3, 5, 7, or 9 hours in bed nightly for 1 week. As expected, it was found that, between groups, alertness and performance varied directly with amount of sleep and that these differences increased over successive days. Another finding, however, was that sleepiness and alertness performance varied significantly between subjects within the same rest duration group. For example, mean sleep latency, a standard measure of drowsiness, varied widely among subjects, from about 1 to 20 minutes. At the extremes, some 3- and 5-hour subjects had sleep latencies of more than 10 minutes, whereas some 7- and 9-hour subjects had sleep latencies of 1 minute. Individual sleepiness was not a direct function of the amount of sleep; marked individual differences and distribution overlaps among groups were observed.

The Balkin study also included a field study where 25 long-haul and 25 short-haul commercial drivers wore wrist actigraphs for 20 days to assess their amount of sleep and factors influencing it. Not surprisingly, they found that total off-duty period had a strong effect on principal sleep duration. Some drivers had highly variable sleep durations from night to night, whereas others were very consistent in their sleep routines.

Overall sleep hygiene habits may be long term and thus a source of enduring individual differences among drivers in their levels of alertness. And the Balkin et al. sleep deprivation study showed that the effects of sleep deprivation may vary widely among drivers during a week of partial sleep deprivation. But, over a longer period of time, would different drivers respond characteristically differently to lack of sleep? Dinges et al. (1998) deprived 14 subjects of sleep over 40 hours in a test of different physiological measures of alertness. A principal, and previously validated, performance measure of alertness in the study was the frequency of subject lapses (non-responses) on the PVT. The PVT was administered during 20 "bouts" in the 40 hours. To test the physiological measures of alertness more rigorously, the researchers created two subject subgroups post hoc: six "high lapsers" and eight "low lapsers." The high lapsers were 42% of the subjects but accounted for 69% of the lapses observed in the study. The researchers split the 40 hours in half—2 to 22 hours and 22 to 42 hours—and observed the marked lapse-frequency differences between the subject groups during both halves of the sleep deprivation. Indeed, the high-lapser lapse incidence during the first 20 hours of sleep deprivation was almost as high as the low-lapser incidence during the second 20 hours. The best physiological measure of alertness in the study was found to be Percent Eyelid Closure (PERCLOS), a measure of eyelid droop associated with drowsiness. PERCLOS was almost equally accurate across both the high and low lapser groups and across both halves of the deprivation period. This implies that the same or similar physiological processes are occurring among all the subjects, but that the rate of alertness deterioration is different for different subjects.

A separate follow-up experiment in the study brought back four of the subjects (4 to 7 months later) for the same 40 hours of sleep deprivation, but this time with occasional auditory and vibrotactile alerting stimuli. These stimuli were found to have no overall effect on the time course of alertness deterioration for any of the subjects. Remarkably, each subject nearly duplicated their original time course of alertness deterioration as measured by PVT lapses. "There is an apparently reproducible 'fingerprint' quality to the overall bout-to-bout profile of PVT lapses for each of the subjects between experiments I and II" (Dinges et al. 1998, Page 91). Figure 12 shows bout-to-bout PVT lapses for a single typical subject during the first experiment without alerting stimuli and the second experiment with them. Although this part of the study involved only four subjects, the individual differences in fatigue susceptibility were significant and remarkably reliable.

Important new research findings (Van Dongen et al. 2004) strongly corroborate the view that there are significant "trait-like" individual differences in susceptibility to alertness loss as a result of sleep deprivation. In the study, 21 healthy adults were sleep-deprived in a laboratory for 36 hours three different times, separated by intervals of at least 2 weeks. Every 2 hours they underwent "neurobehavioral" testing consisting of 13 objective and subjective measures of alertness. There were two main factors under examination in the study: inter-individual variation and variation due to prior sleep history. A striking finding of the study was that there were stable inter-individual differences in the response to sleep deprivation for all the tests employed. That is, individual subjects tended to respond similarly on all tests during their three sleep deprivation periods, but differed considerably among each other. Intraclass correlation coefficients (used to quantify trait-like inter-individual variance in of each of the tests) showed that, across the 13 tests, 68% to 92% of the variance in the neurobehavioral data were explained by stable individual differences. The effect of the amount of sleep obtained in days before (i.e., prior sleep history) on performance during sleep deprivation was statistically significant, but modest in comparison with the observed inter-individual differences. Although each subject tended to show a stable response on specific tests, those showing the greatest deficits on one test did not necessarily show the same level of impairment on other tests. In particular, inter-individual differences in subjective measures of alertness did not correspond well with inter-individual differences in objective measures of alertness.

Figure 13 provides a sample of these results for one measure (PVT) and two of the sleep deprivation periods. In the figure, data for 18 subjects are plotted. The horizontal axis is the average PVT lapses in the last 24 hours of the first sleep deprivation session, and the vertical axis is the corresponding measure for the second sleep deprivation session. The scatter plot shows huge differences (about a sixfold difference) between the best and worst performances. The scatter plot also illustrates a high correlation between the first and second sleep deprivation PVT

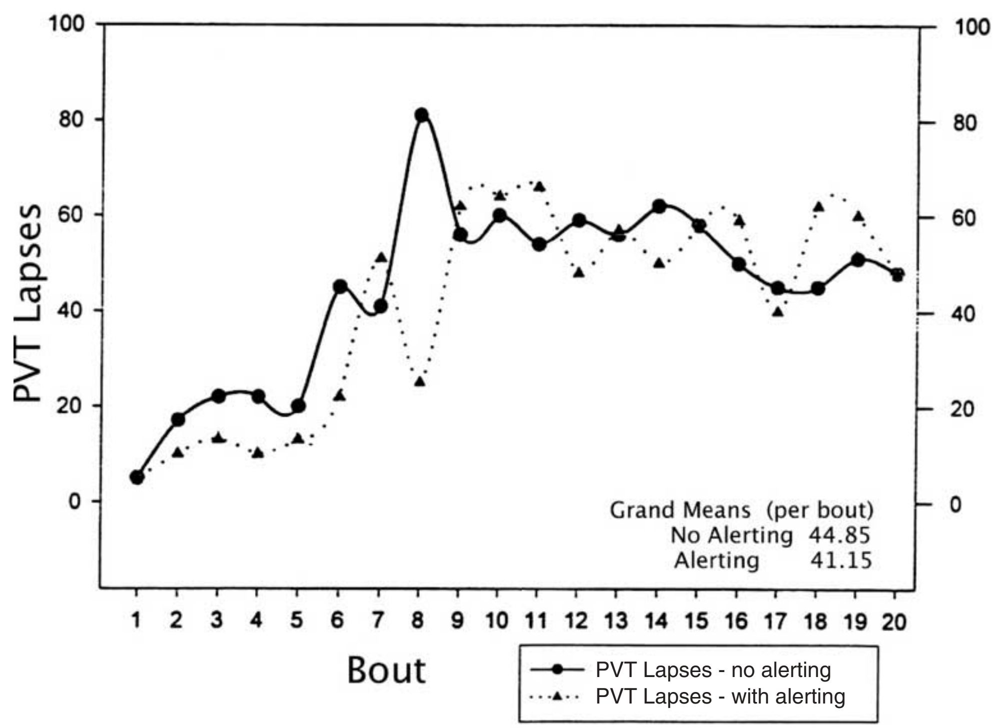


Figure 12. Time course of vigilance deterioration for a single subject sleep deprived twice several months apart, once without alerting stimuli and once with alerting stimuli.
(SOURCE: Dinges et al. 1998.)

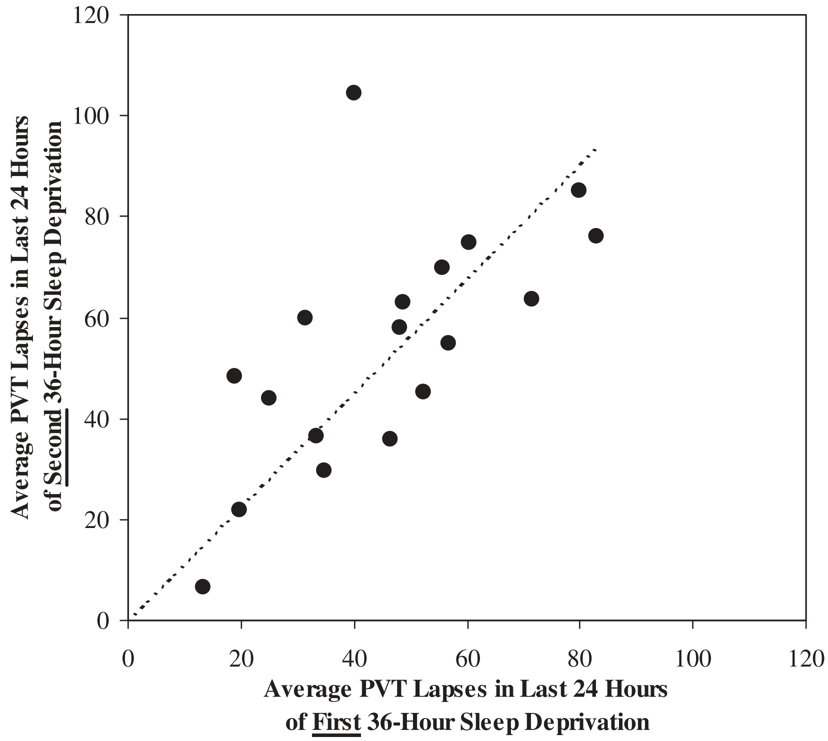


Figure 13. Scatter plot showing large variations in vigilance (alertness) among 18 sleep deprivation subjects, but high similarities between individuals' performance during the first and second sleep deprivation periods.
(SOURCE: Van Dongen et al. 2004)

scores for the 18 subjects. Only one of the 18 subjects performed substantially differently across the two sessions, and many subjects performed almost identically.

A factor analysis of scores on the 13 neurobiological measures revealed three common personal factors underlying the score differences: self-evaluation (sleepiness and mood), cognitive processing (ability to engage in complex thinking), and vigilance (behavioral alertness). Intuitively, one would predict that hours of sleep deprivation would be a stronger predictor of subject performance than individual differences, but this was not the case. On every measure, the influence of individual differences was stronger than the influence of sleep deprivation duration. The authors summarized their study findings as follows:

> In this study involving repeated exposure to sleep deprivation under carefully controlled laboratory conditions, we found that neurobehavioral impairment from sleep loss was significantly different among individuals, stable within individuals, and robust relative to experimental manipulation of sleep history. Thus, this study is the first to demonstrate that inter-individual differences in neurobehavioral deficits from sleep loss constitute a differential vulnerability trait (Van Dongen et al. 2004).

In summary, it appears that there are significant individual differences among commercial drivers in the incidence and susceptibility to drowsiness. This was illustrated by the FHWA-sponsored DFAS and by a study of fatigue associated with the use of sleeper berths. Studies have shown that humans are generally not very good judges of their own levels of sleepiness, but there are even large individual differences in the accuracy of self-assessment. Variations of amount of nightly sleep are one obvious source of individual differences in alertness, but significant differences are seen even when subjects receive controlled amounts of sleep. Moreover, a person's ability to stay awake and perform during sleep deprivation seems to be remarkably consistent over time, even though there are large differences among different people.

4.7 PERSONALITY

In the present context, "personality" refers to enduring personal traits or tendencies that affect behavior. Personality is most often viewed in relation to interpersonal interaction (e.g., introversion-extroversion), but personality traits can also be associated with driving and other safety-related behaviors. In the survey, personality traits such as aggressiveness, impulsivity, and inattentiveness were rated by both respondent groups as having the highest associations with risk of the various factors listed, which included demographic, experience, personal/family, and medical factors. Corsi and

Barnard (2003) found that driver personality traits such as honesty, patience, reliability, self-discipline, and self-motivation were highly valued by fleets. The driver personality trait "sociable" was also valued by fleets, but to a lesser degree. The remainder of this section discusses some specific personality traits with possible relationships to driving safety.

4.7.1 Impulsivity and Risk-Taking

Impulsivity is characterized by behavioral instability and an inability to control impulses, sometimes including threatening behavior and violence. Impulsivity has been suggested to be related to an increase in crash risk. Logically, it is easy to assume that if an individual reacts quickly and without adequate forethought, he or she will be at higher risk for errors and vehicle crashes. Schuman, Pelz, Ehrlich, and Seltzer (1967) assessed 288 unmarried male drivers and found that both a high-crash/other accident group and high-violation group scored higher on a measure of impulsivity than those with a low number of crashes/other accidents and violations. Crashes in this study were defined as vehicle incidents that caused property damage or injuries (whether or not the respondent was at fault). Traffic violations were defined by self-reported traffic violations over the prior year.

Risk-taking in driving obviously creates unsafe situations and increases the probability of crash involvement. Dewer (2002) makes a distinction between "high-level" and "low-level" risk-related decisions. In driving, a "high-level" decision might relate to the decision to drive or not drive under particular conditions, such as during adverse weather or after inadequate sleep. "Low-level" decisions refer to choices made while driving, such as decisions to speed or tailgate. Turns across a stream of traffic are a test of driver judgment and decision-making, and driver tendencies toward impulsivity and risk-taking obviously increase crash risk. Dewer (2002) discusses sensation-seeking as a related individual characteristic, and cites an analysis by Jonah (1997) documenting correlations between sensation-seeking and risky driving behaviors such as speeding, frequent lane changes, alcohol use, and failure to wear safety belts. Rimmo (2002) noted that sensation-seeking is strongly associated with misbehaviors (violations of rules) but only weakly associated with driving errors not associated with rule violations, for example, failure to see another vehicle.

As many vehicle crashes are the result of at-risk behaviors, such as speeding, improper following distance, and driving fatigued, it appears that drivers' subjective risk of their actions determine the extent to which drivers engage in at-risk behaviors. For example, few would doubt that speeding is more risky than not doing so; yet, there are situations where the risk of crash or injury while speeding is minimal. The accumulation of these instances may confound a driver's evaluation of crash or injury potential because he or she may be basing individual conclusions on prior outcomes (e.g., no crash) rather than on objective risk (Haight 1986).

This explanation fits well within a behavioral framework, which surmises that people are motivated to behave based on the expected consequences of their actions. Behavior can be explained by its antecedents (events prior to behavior that direct behavior) and consequences (events after behavior that motivate behavior) of specified behavior(s). For example, being late for a delivery (antecedent) may prime a commercial driver to speed (behavior). The consequences of speeding may be positive (deliver on time) or negative (receive a speeding ticket, cause a crash). Behaviors followed by positive consequences are more likely to be repeated in the future and those followed by negative consequences are less likely to be repeated in the future. The immediate and reliable positive consequence of making the delivery on time may outweigh the low probability of a negative consequence of getting a ticket or being involved in a crash (Daniels 1989, Geller 2001). A behavioral approach to commercial driver safety management would emphasize the use of rewards (e.g., bonuses, positive recognition) for safe driving behaviors as a way of counteracting unsafe driving practices.

4.7.2 Social Maladjustment and Aggressive/Angry Personalities

Social maladjustment is a set of behaviors and personality characteristics that have been found to be related to accident rates in a variety of settings. People are often considered socially maladapted if they have a general tendency to disregard laws and rules. Behaviors may include law breaking, disregard for other people, hostility or aggression, irresponsibility, self-centeredness, problem drinking, and authority problems. In the research project survey, the adjective "aggressive/anger" was among the factors with the highest-rated association with crash risk. Dishonesty as a personality trait was considered by respondents to have a relatively weak association with crash risk.

When comparing 20 taxi drivers with a poor crash record (more than four crashes in the past 15 years) with 20 taxi drivers with low crash rates, Tillman and Hobbs (1949) found that drivers in the high-crash group were significantly more likely to be violent, to be delinquent, to have frequent job changes, to report themselves as being unfaithful, and to have a general lack of responsibility. In a more controlled study, McGuire (1972) matched two groups of 67 non-commercial drivers on age, driving experience, miles driven, and marital status. One group had a crash in the previous 3 months, while drivers in the other group did not have a crash in the last 3 months. Drivers in the crash group were described as less mature, holding negative views toward laws and authority, and having poor social adjustment. When studying South African bus drivers with repeated crashes, Shaw and Sichel (1961, 1971) described these individuals as being selfish, self-centered, overconfident, resentful and bitter, intolerant, and having antisocial attitudes and criminal tendencies. Sweeney (1998) correlated a number of "temperament" scales with the 3-year crash records of a group of U.S. Army soldiers and found "dependability" to have the highest (negative) correlation with crash involvement.

The Dula Dangerous Driving Index (DDDI, Dula and Ballard 2003) is a 28-item pencil/paper measure used to assess the driver's level of aggression, hostility, and impatience when driving. The DDDI is made up of four subscales, including aggressive driving, angry driving, risky driving, and negative emotions while driving. The DDDI was used to examine the relationship between dangerous driving and aggressive personality and anger among 119 male and female college students. Scores on each driving behavior subscale were significantly and positively correlated with measures of aggression and anger. A statistical analysis indicated that dispositional (personality) aggression and anger, driver history variables, and gender accounted for a significant portion of the variance in all DDDI scales. Further, males displayed significantly more aggressive, risky, and angry driving than females. Males and females reported similar levels of dangerous driving (DDDI total scores) and negative emotions while driving. Dangerous driving was positively related to self-reported traffic citations and at-fault crashes.

There appears to be strong support for the view that deviant or social maladjustment characteristics are associated with higher crash risk. As noted, survey respondents corroborated this conclusion by their high crash association ratings for the "aggressive/angry" personality trait. In addition, many had written comments about driver "attitude," including the following:

- "A driver's attitude dictates his compliance with company policies and his behavior behind the wheel."
- "Attitude is everything!! Getting rid of the 'King of the Road' syndrome is key to defensive driving."
- "A driver's attitude and his attention to detail are the main indicators of safe driving."
- "High-risk guys need to be found before employment, not after. Their behaviors are generally [caused] by personal psychology that is ingrained and difficult to change."
- "High-risk drivers . . . tend to be 'hot tempered' and in contest with others on the road."
- "Emotional instability for any reason equals high risk."
- "I no longer hire for experience. I hire for 'heart.' I find that the more 'heart' a driver has, the better employee he or she will make. 'Heart' means caring for other people."
- "Ninety percent of the time, high-risk drivers think they are very good drivers."

4.7.3 Introversion-Extroversion

Eysenck (1947) proposed the personality dimension introversion-extroversion (I-E). This construct exists along a continuum. Introversion is defined as a person's preference to attend to his/her inner world of experience with an emphasis on reflective, introspective thinking. Conversely, extroversion is defined as a person's preference for attending to the outer world of objective events with an emphasis on active involvement in the environment. Individuals who are associated with extroversion are predicted to have higher accident rates because of their lower level of neural activation. Introverted individuals place more value on being in control of their actions and would therefore tend to be more vigilant (Keehn 1961). Fine (1963) found that drivers with high extroversion scores were disproportionately more likely to be involved in traffic crashes. This finding was later supported by Smith and Kirkham (1981). They reviewed the crash and traffic violation records of 113 young male drivers. They found a significant correlation between extroversion and traffic crashes and violations. Powell, Hale, Martin, and Simon (1971) found that extroversion and accident rates were highly correlated in a variety of industrial settings. Finally, Schenk and Rausche (1979) showed that differing levels of extroversion predicted groups with no accidents, one accident, and more than one accident. Studies of this personality dimension have not universally supported a correlation to crash involvement, however; Lancaster and Ward (2002) reviewed several reports with contradictory or inconclusive findings. In the research project survey, respondents were asked to rate the association of "introverted/unsociable" with crash risk. The rated association for both respondent groups was among the lowest of the factors rated; indeed, the work of Eysenck and others on this topic may indicate that introverted drivers are as safe as, or safer than, extroverted ones.

4.7.4 Locus of Control

The locus of control personality construct was developed by Rotter (1966), whose theory differentiates individuals with an internal or external locus of control. An individual with an internal locus of control is defined as someone who believes he/she has the power to achieve mastery over life events. Conversely, an individual with an external locus of control has the belief that his/her efforts to effect change are useless. A driver who believes he/she has little control over his/her involvement in a vehicle crash should have a higher probability of incurring a vehicle crash.

This is exactly what Bridge (1971) found when assessing the rate of automobile driver crashes. Mayer and Treat (1977) found that young drivers with three or more vehicle crashes in a 3-year period were more external than drivers with no vehicle crashes. In a more controlled study, Jones and Foreman (1984) classified bus driver applicants with two or more moving violations into a high-risk group and those with no moving violations into a low-risk group. Of those in the high-risk group, 79% scored high external locus of control, versus only 31% in the low-risk group.

4.7.5 Extreme ("Dichotomous") Thinking

"Dichotomous" thinking is the tendency to think in "all or none" terms and thus have views that might be considered extreme or strongly opinionated. Plummer and Das (1973) studied two groups of drivers. A frequent-crash group comprised drivers who had been in two or more vehicle crashes in the preceding year, while an infrequent-crash group comprised drivers who had not been involved in a vehicle crash in the previous year. The frequent-crash group displayed more dichotomous thinking than the infrequent-crash group. Dichotomous thinking involves polarizing events so that more extreme choices are selected as the appropriate course of action. The dichotomous thinker is more likely to make an inappropriate choice in favor of extreme action when presented with a dangerous driving situation. This study lends moderate support for the view that extreme thinking is associated with crash risk.

4.8 SENSORY-MOTOR PERFORMANCE

As a dynamic sensory-motor task, driving performance is obviously affected by physical abilities. Reliable perception, quick response, and accurate maneuvering are essential features of safe driving (Dewer 2002). However, if physical prowess were the primary factor influencing crash involvement, then teenagers and young adults would likely be the safest drivers, and individual athletic prowess would correlate with driving safety.

A 1998 study by Trucking Research Institute and InterScience America provided an extensive and detailed list of driving-related sensory-motor abilities, as follows:

- Perceptual
  - Static visual acuity (stationary objects)
  - Dynamic visual acuity (moving objects)
  - Contrast sensitivity
  - Useful field of view (area of visual field in which information is acquired)
  - Field independence (ability to perceive targets embedded in a complex scene)
  - Depth perception
- Cognitive
  - Decision-making
  - Selective attention (ability to attend to one stimulus while filtering out "noise")
  - Attention sharing
  - Information processing (ability to acquire information and perform mental operations on it)
- Psychomotor
  - Reaction time
  - Multi-limb coordination
  - Control precision
  - Tracking (follow a path or pursue a moving target)
  - Range of motion

This study on five different older commercial driver groups was conducted to examine the impact of increasing age on perceptual, cognitive and psychomotor abilities, and driving performance. Age, in and of itself, was not reliably predictive of driving performance. One reason was that the individual variation within age groups was much greater than the variation across groups. Tests comparing driver performance on the above sensory-motor tasks with performance on an interactive commercial truck driving simulator indicated that the most predictive abilities were depth perception, useful field-of-view, field independence, attention sharing, and range of motion. Sensory-motor tests such as these may be helpful in assessing medical conditions as well as alcohol and drug impairment (Llaneras et al. 1995).

4.9 OTHER RISK FACTORS

4.9.1 Stress

Stress is generally seen as a human response to an aversive or threatening situation, not as an enduring personal trait. However, if stressful situations are long-lasting or recurrent, stress can become an individual characteristic. Heightened stress has been implicated in increasing the risk of vehicle crashes. Brown and Bohnert (1968) reported that 80% of drivers involved in fatal crashes, but only 18% of controls, were under serious stress involving interpersonal, marital, vocational, or financial areas prior to the crash. Finch and Smith (1970) reported similar findings. Among the general population of drivers, the association of alcohol with crash involvement may reflect life stress as well as its direct deleterious effects on driving. Seltzer and Vinokur (1974) administered self-report questionnaires assessing stressful life events (Holmes and Rahe's Life Events Checklist), alcohol abuse (Michigan Alcoholism Screening Tests), several personality variables (aggressions, paranoid thinking, depression, and suicidal tendencies), and driving history (exposure, violations, and accidents and crashes) with two groups of drivers. The general group comprised drivers renewing their drivers' licenses or completing driver safety school. The other group, called the alcohol group, comprised drivers receiving in-patient or outpatient treatment for alcoholism. The Seltzer and Vinokur found that drivers under greater social stress (regardless of group) were correlated with more crashes and other accidents. Subjective stress to life events was more highly correlated with prior crashes and accidents than either demographic and personality variables. McMurray (1970) found divorce to be a significant predictor of crash risk. In his study of 410 drivers involved in divorce proceedings, drivers had twice as many crashes during the year of their divorce than during 7 previous years. This rate was even higher for the period 6 months before and after the divorce. These studies provide support for an association of life stressors and crash risk, with alcohol use as a frequent concomitant factor.

In the research project survey, the stress-related driver situations, "unhappy/disgruntled with job or company," "debt or other financial problems," and "unhappy marriage or other family problems" were generally rated near the middle of the 16 surveyed factors in terms of their association with crash risk.

4.9.2 Recent Involvement in Other Crashes

One source of stress might be recent involvement in a crash. A recent crash might also be an indication that a driver is not performing safely during the time period in question. Blasco, Prieto, and Cornejo (2003) have presented evidence that vehicle crashes tend to be clustered more than would occur by chance alone. They analyzed the crash rates of 2,319 bus drivers in a Spanish city over a period of 8 years from 1976 to 1983. No personality or other personal characteristics that might be associated with crashes were identified or studied. The authors compared their empirical evidence with models of crash rates predicted by chance and by equal probabilities. Analysis of the crashes indicated that they tended to occur closer together than can be explained by chance; the occurrence of a crash seemed to increase the probability of a driver having another crash.

4.9.3 Safety Belt Use

Section 392.16 of the Federal Motor Carrier Safety Regulations (FMCSRs) requires commercial drivers to wear safety belts while driving. Nevertheless, 311 of 588 fatally injured large truck drivers in 2002 were not wearing safety belts. One hundred thirty-four fatally injured drivers of large truck crashes were ejected (FMCSA web page; www.fmcsa.dot.gov/safetybelt). Most of these ejections occur during rollover crashes, a particularly injurious type of crash for large truck occupants.

In 2003, FMCSA completed a study of safety belt use by truck drivers (3,909 trucks were observed). Of nearly 4,000 commercial vehicle occupants observed, the usage rate was 48%. This compares unfavorably with a current passenger vehicle occupant usage rate of 79% (U.S. DOT 2003). Accordingly, FMCSA has announced a goal of increasing commercial driver safety belt use.

The most obvious connection between safety belt use and injury risk is the occupant protection afforded by safety belts. However, there is also evidence among the general population of drivers that non–safety belt use is associated with various risky driver attitudes and behaviors. Lancaster and Ward (2002) reviewed studies indicating that driver non–safety belt use is associated with speeding, short headways (tailgating), alcohol use, red light running, more previous traffic violations, and sensation-seeking personalities. Eby, Kostyniuk, and Vivoda (2003) observed that safety belt use among drivers using hand-held cell phones was lower in every age group studied than among comparable non–cell phone users. Thus, non–belt use by a commercial driver should probably be regarded as a safety “red flag.”

4.10 RISK FACTORS IDENTIFIED IN OTHER TRANSPORTATION MODES

The research project also scanned other transportation modes to identify research on high-risk operators. This included maritime, rail, and air operations. The majority of research focusing on operator safety seems to have been focused on fatigue and generally emphasizes situational determinants of behavior rather than individual constitutional differences. For example, there have been many studies of night-shift transportation operators and other workers and the effects of shift changes or jet lag (Comperatore, Kirby, Kingsley, and Rivera 2001a). Night-shift workers perform worse on tasks of vigilance and reaction times when compared with day workers, and aviators flying in flight simulators at night have reduced hand-eye coordination, poorer vigilance and calculation proficiency, and impaired flight performance compared with day fliers (Rothblum et al. 2002).

The identification of high-risk individuals has focused on personal readiness or fitness for duty. According to Rothblum et al. (2002, p. 34):

> Personal readiness failures occur when individuals fail to prepare physically, mentally, or physiologically for duty. For instance, violations of work-rest rules, use of intoxicants and certain medications, and participating in exhausting domestic or recreational activities prior to reporting for duty can impair performance on the job and can be preconditions for unsafe acts.

Rothblum et al. (2002) point out that screening tests have been used for many years to select suitable employees for safety-sensitive professions such as law enforcement and fire safety. However, this is a controversial area with test validity and reliability being at issue. Tests are available for determining if someone is under the influence of drugs or alcohol or severely fatigued, and simulator-type tests have been used to analyze driver readiness. Further research is needed to identify valid, reliable methods across modes.

4.10.1 Maritime Operations

After the March 1988 Exxon Valdez accident, Exxon assessed the performance of all its ships’ masters and mates. Most did very well, but it was determined that proficiency tests for individuals should take place early in the selection and training process rather than after they are on the job. Some ship operating companies do use screening tests to identify risk factors in individuals, but more research is needed to validate them (Alex Landsburg, Maritime Administration, personal communication February 6, 2004).

Crew endurance programs are also used in the maritime environment (Comperatore et al. 2001b). This type of program educates personnel on how fitness for duty can affect not only job performance but long-term health. These programs assist personnel in controlling the hazards that affect fitness for duty (Rothblum et al. 2002). Comperatore et al. (2001a) state that operators of Coast Guard systems should be monitored following the principles set out by crew endurance management (CEM) practices, in which “endurance refers to the ability to maintain performance within safety limits.” Signs of stress include alienation, withdrawal, and lack of participation. Other behaviors that should be monitored include visible daytime sleepiness and degradations in performance (i.e., low energy, lack of motivation, depression, irritability, introversion, reduced and unclear communication with coworkers, problems with decision-making ability and performance of mental function requiring logical ability, apathy, reduced attention to detail, degraded endurance, and reduced safety).

Further, according to the International Maritime Organization (IMO) (2001), some of the more recognizable symptoms of fatigue found in pilots (operators) are stress, mood swings, headaches and gastro-intestinal problems. Fatigue can affect pilot performance by impacting pilots' ability to think clearly or make decisions, to concentrate, to focus attention appropriately, to assess risky situations, or to act as quickly as necessary. Other impairment signs include poor memory (failure to remember task sequences), slow response (to emergencies), loss of bodily control (slurred speech), and mood or attitude changes (irritable or a "don't care" attitude). One of the most alarming consequences of fatigue is uncontrollable micro-sleeps that may last a few seconds to a couple of minutes, and of which drivers may be unaware. Micro-sleep lapses have been well documented as causing a number of maritime and other transportation incidents (IMO 2001). As discussed earlier, there is evidence of large individual differences in susceptibility to micro-sleeps and other manifestations of fatigue.

4.10.2 Rail

In 2002, 14,404 railroad accidents/incidents occurred in which there were 11,103 nonfatal injuries and 951 fatalities (Federal Railroad Administration 2003). Of the 2,944 train accidents for which a major cause was identified, "human factors" was assigned as the principal causal category for 1,050 (36%). In terms of operator violations, stop signal violations were the most common, followed by speeding violations (Coplen, 2004).

The process of becoming a certified locomotive engineer (operator) is outlined in CFR 240. Railroad employee records and driving records (within 36 months concerning alcohol/controlled substances) are reviewed (CFR 240 115 b1). Vision and hearing acuity are evaluated by a medical examiner. Specific training, knowledge (of the railroad's rules and practices for the safe operation of trains), and skills (operating, equipment inspection, and train handling practices, and compliance with federal safety rules) are also tested before certification.

No research focusing on individual differences and high-risk rail operators could be identified. Perhaps most relevant is research planned by England's Rail Safety and Standards Board of signals passed after danger (RSSB 2002). This project will establish a method of assessing existing driver workload, including risk associated with overload/underload with a goal of establishing control measures to reduce driver workload (RSSB 2002). The program will also develop methods of quality assurance for (1) staff skills, training, and management and (2) incident investigation and analysis methods to identify contributing situational factors and factors associated with particular drivers.

4.10.3 Aviation

In 2002, there were approximately 4,000 airspace incidents, the majority of which were categorized as operational errors, pilot deviations, or surface incidents. Each year approximately 1,000 aviation-related fatalities occur (FAA 2003). Operator performance is a prominent issue in aviation incidents, but a single "operator profile" is difficult to ascertain. Airplane and helicopter pilots have a variety of training backgrounds (e.g., high-performance military aircraft combat or training or more conservative modes of air transport). As with rail, airline pilots are trained in accordance with federal regulations.

Violations involving drugs or alcohol are a basis for immediate grounding and dismissal. A pilot who reports to fly with a blood-alcohol content (BAC) > 0.06, or whose unannounced urine test displays traces of prohibited drugs, can be relieved of duty, grounded, or fired, with little or no recourse. Similarly, a pilot who receives a driving under the influence (DUI) citation while driving a vehicle may be grounded, punished, or fired (Phil Olsen, personal communication, January 30, 2004).

The primary infractions that result in license suspension or revocation generally fall into a few broad categories:

- Runway incursion (caused by disorientation, distraction, or inattention)
- Failure to follow company or aircraft operating procedures
- Failure to follow air traffic control guidance (altitude, heading, airspeed, taxi instruction)
- Violation of airspace restrictions

In a large fraction of the cases, it is pilot distraction or inattention that starts the chain of events that leads to an infraction (Jim Chadwick, personal communication, February 2, 2004).

Adams, Koonce, and Hwoschinsky (2002) surveyed 4,000 pilots in an attempt to characterize the decision-making styles of accident-free and accident-prone pilots. They reported that accident-prone pilots were more likely to expose themselves to unsafe flying experiences, feel time pressure when making decisions, have a false sense of their ability to handle a situation, and not review alternative options or solutions.

The concept of crew resource management (CRM) is seen in aviation as well as maritime transport. In aviation, the dictatorial pilot command concept has been replaced by CRM, which trains aircrews to encourage discussion and evaluation by the entire cockpit crew in emergency avoidance and management prior to an ultimate decision by the pilot (Phil Olsen, personal communication, January 30, 2004).

CHAPTER 5

OPERATIONAL SAFETY MANAGEMENT METHODS

This chapter presents management techniques and practices to improve CMV driver safety performance and, in particular, reduce the problem of high-risk drivers.

5.1 CONCEPTUAL MODELS OF DRIVER IMPROVEMENT

Conceptually, there are at least two distinct ways that the overall safety performance of a group of drivers may improve. Figure 14 illustrates these. In Figure 14a, the highest-risk drivers are eliminated from the distribution (e.g., they are never hired), thus "cutting off the tail" of the driver risk distribution. Even if other drivers are not affected, this intervention would have the effect of improving the performance of the average driver of the group by eliminating the greatest source of risk. In Figure 14b, the safety performance levels of all, or most, drivers in a group are improved through some intervention. The entire curve shifts toward lower risk. Here again the overall average safety level of the fleet improves, but it is through "across the board" improvement. Any safety management practice directed at all the drivers in a fleet would have this effect if it is effective. Of course, the ideal would be to employ both kinds of interventions and get both kinds of benefit.

5.2 RECRUITING/SELECTION/HIRING

As one safety manager respondent put it, "Don't hire yourself a problem . . . Driver selection is critical." The central premise of this research project is that there are very significant individual differences among commercial drivers in driving safety and that much of the variation in risk is related to constitutional or other long-term driver traits. A major implication is that the best way to reduce the impact of high-risk drivers is to improve driver selection and hiring so that these individuals can be eliminated before they become a liability or management problem for the fleet. Another safety manager respondent commented, "We try to recognize the risk-taking drivers AHEAD of time through background checks, MVRs, DAC [data arc consulting], past employers—and then NOT HIRE them."

5.2.1 Systematic Hiring

There are many potential benefits of a systematic driver recruiting, selection, and hiring process, including the following:

- Reduced crashes and incidents
- Reduced driver turnover
- Increased driver satisfaction
- Increased customer satisfaction
- Ensuring proper process for all applicants
- Increased quality of the drivers hired
- Increased company profitability

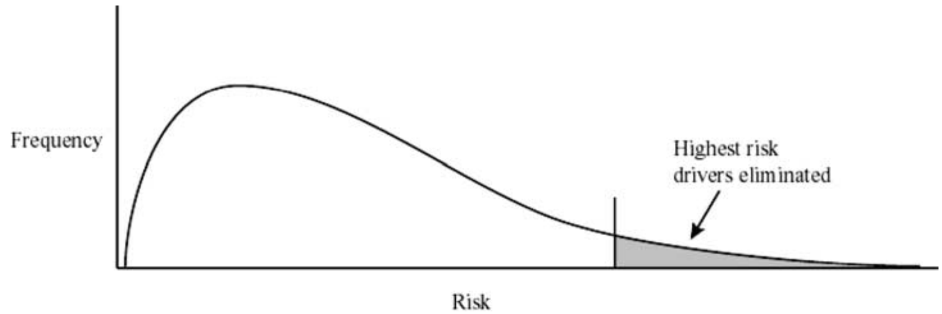
Elite motor carriers are able to establish rigorous selection processes resulting in a small selection ratio; that is, a small percentage of applicants are selected and hired. A fundamental principle of personnel selection is that low selection ratios (the ratio of hires to applicants) result in higher quality employees. One goal of the staffing function in organizations is to attract enough potential employees (e.g., applicants) so that those selected represent a small percentage. Schneider National (Osterberg 2004) is one large carrier that has been able to attract a large number of driver applicants and be highly selective in its hiring. Figure 15 below demonstrates its highly selective process.

Achieving this degree of selectivity is difficult or impossible for most motor carriers because of the nationwide shortage of commercial drivers and the fact that most fleets cannot offer sufficiently attractive salaries, benefits, and job conditions to attract a surplus of applicants. Nevertheless, companies can institute systematic processes, such as those described in the following subsections. Appendix F provides additional information, job aids, and sample forms relating to driver selection and hiring.

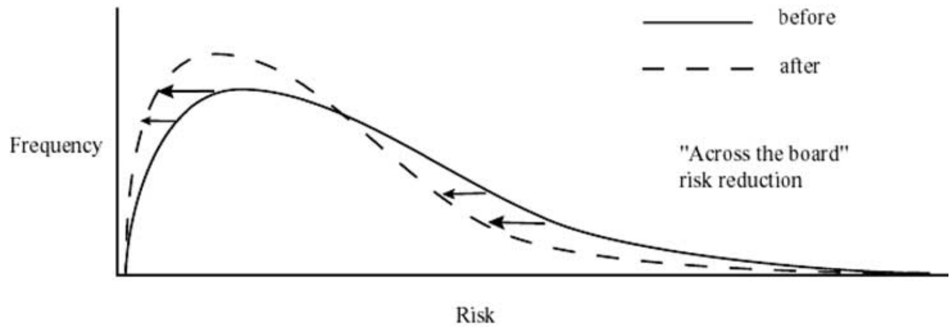
Advertising Open Positions. Advertising can be in both local newspapers and national trade publications. Include information on positive aspects of the job (to attract applicants) but also on minimum qualifications (to accomplish initial screening). Minimum requirements might include the following:

- Be at least 21 years old
- Have at least 2 years commercial driving experience
- Pass DOT physical
- Have a clean driving record
- Pass a substance abuse test
- Have a commercial driver's license (CDL)

Telephone/Walk-in Interview. Interested persons will typically telephone or visit the company. Whoever takes the call or handles the visit should be as friendly and cordial as



(a) "Cut off the tail" of the distribution, e.g., eliminate high-risk drivers.



(b) Move the distribution; e.g., reduce risk for all drivers

Figure 14. Two conceptual mechanisms of improvements to a group of drivers.

possible, but also should make sure the individual understands the minimum requirements and the need to submit a fully completed application.

Driver Application. Generally, a driver must meet the following requirements (per FMCSR 391.11):

- Have good health
- Be at least 21 years of age

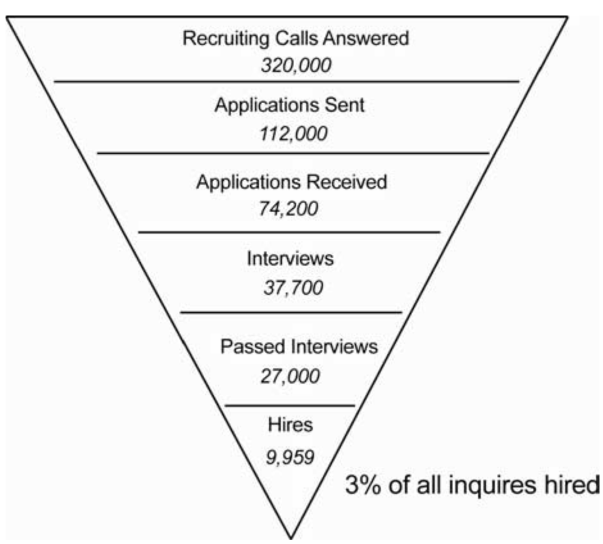


Figure 15. Selectivity of Schneider National driver hiring.

- Speak and read English well enough to function in the job and respond to official questions
- Be able to drive the vehicle safely
- Be able to transport passengers and/or cargo safely
- Have only one current valid commercial driver's license
- Take a road test or present evidence of a road test
- Not be disqualified from driving a commercial motor vehicle

Carriers are required to maintain a qualification file for each employee, which includes performing mandatory checks with past employers (previous 3 years for all jobs, previous 10 years for commercial driving jobs) and obtaining the driver's motor vehicle report (MVR) of past crashes and violations. Careful review and verification of all the information on the driver's application are critical to hiring good drivers and avoiding hiring mistakes. Third-party services can, for a fee, assist companies in compiling pre-employment screening information on applicants. Among the services that these companies can provide are background checks of criminal history and credit history and rating. These may be related to fleet and cargo security as well as to safety. The safety rationale for them is that criminal records and bad credit may be signs of irresponsible or socially maladjusted behavior patterns.

Selection Tests. Various selection tests can be administered to applicants if they are validated. These are discussed in the Section 5.2.2.

Structured Personal Interviews. Loose, unstructured interviews are no longer acceptable as selection procedures; courts have held that interviews are subject to the same validity standards as tests. Instead, a structured interview following a prescribed set of questions should be employed. Appendix F-3 is a sample of a structured personal interview. In-person interviews are preferred to phone interviews because they convey more information and lead to more accurate decisions. They also provide a better opportunity to establish rapport with the applicant.

DOT Physical Examination. This exam is required of every commercial driver every 2 years. If possible, establish a working relation with a trusted local physician to ensure that federal standards, as well as any additional company standards, are met.

Road Test. The road test is also required by federal regulations, but it should be conducted near the end of the hiring process. The well-administered road test should assess driver skills and attitudes. It should include the pre-trip vehicle inspection. Maneuvering skills to be tested include steering, stopping, shifting, and backing exercises. The company road test is ordinarily similar to the state CDL road test, but should include assessment of courteous and sound defensive driving as well as minimum required maneuvers. A written certificate of the road test is required; one copy is provided to the driver and one is kept in the driver's company file.

Because of the driver shortage and the many other tasks and responsibilities that carrier safety managers have, it may be tempting to cut corners to expedite the hiring process. Safety experts believe, however, that systematic processes and rigorous standards pay off by reducing risk, driver turnover, and the lost time and money associated with driver turnover.

Checking the MVR, contacting past employers, testing for alcohol and drugs, and on-road driving tests are federally required protocols that were rated high in effectiveness by the survey respondents. Less frequent practices included checking criminal record, checking credit history and rating, and using selection tests.

5.2.2 Selection Tests

Chapter 4 described various individual traits associated with or thought to be associated with crash risk. These included personality factors such as impulsivity, aggressive/angry personalities, introversion-extroversion, and sensory-motor performance factors such as visual acuity, field independence/dependence, selective attention, and tracking. As described in Sections 4.7 and 4.8, measures of these and other personal factors can potentially be employed as selection tests for commercial drivers.

The research project survey results support the idea that certain personality and performance factors are strongly related to risk. In the survey, the factors "aggressive/angry," "impatient/impulsive," and "inattentive" were the three factors of the 16 rated that had the strongest associations with risk by both carrier safety managers and other experts. Further evidence of an industry consensus on the importance of driver personality and character was provided by Corsi and Barnard (2003), who found that all surveyed segments of the CMV industry highly valued such driver personal traits as patience, reliability, self-discipline, and self-motivation.

Selection tests are intended to provide objective and predictive measures of personality traits and performance capabilities. To be employed legally by organizations, selection tests must meet certain criteria established by federal regulations to prevent discrimination against ethnic or other groups. Since 1964, pre-employment screening has been subject to restrictions imposed under Title VII of the Civil Right Act. As such, employers are prohibited from using measures that have an adverse exclusionary impact on minority groups based on sex, race, or a particular ethnic group. A pre-employment selection measure will be labeled as "adverse" if the selection rate for any race, color, or ethnic group is less than 4/5 (i.e., 80%) of the rate for the group with the highest rate (Equal Employment Opportunity Commission [EEOC] 2003). If a pre-employment measure is found to violate Title VII, affirmative action steps must be implemented to remedy the situation with the underrepresented minority. These steps may include (a) a recruitment program designed to attract the underrepresented minority, (b) revamping selection instruments to eliminate exclusionary effects, (c) initiation of measures designed to ensure members of the affected group (who are qualified) are included within the group of potential candidates, and (d) systematic efforts to redesign or revamp jobs in a way that provides opportunities for the underrepresented group (Department of Labor [DOL] 2003).

The DOL (2003) indicates that pre-employment measures must conform to the American Psychological Association's (APA) *Standards for Educational and Psychological Testing* (APA 1985). The APA recognizes three basic methods for test validation: content-, construct-, and criterion-based validation. Content validation involves analyzing the content of tests and demonstrating that it corresponds to the job tasks as set out in a complete job analysis. For example, any simulated driving task would likely qualify as having content validity in relation to commercial driving. Construct validation involves showing that the test measures specific personnel characteristics that are shown to be necessary for performance of the job. For example, performance tests of sustained vigilance would likely be considered valid for hiring commercial drivers because driving is a sustained vigilance task. Criterion validation involves showing a statistical correlation between performance on the test and actual performance measures by specific criteria (APA 1985, DOL 2003). Ideally, this would be demonstrated by research studies showing a strong correlation between performance on the test and performance on the job.

The first step in designing a pre-employment screening measure is to perform a job analysis, that is, delineation of specific work behavior or performance that is relevant to the job in question (EEOC 2003). The results may include the following: job function or duties, work tasks, skills or competencies, work-related knowledge, work environment factors, decision-making authority, educational requirements, communication, training, and physical abilities. However, skills or knowledge that can be learned through regular training or on-the-job experience may not be used to exclude potential applicants. Although physical abilities may be assessed, the ADA requires that qualified individuals with a disability be provided with reasonable accommodations. The job analysis should be helpful in determining what "reasonable accommodations" could be made for an individual to perform the job (DOL 2003).

Ideally, the potential measure is then given to a representative sample of participants. The sample should be representative of the candidates for the job in question and should include the races, ethnic groups, and sexes normally available in the relevant job market. The relationship between the selection procedure and the criterion measure (e.g., crash or violation rate) should be shown to be statistically significant (DOL 2003). The EEOC requires full documentation of the validity of any pre-employment screening measure.

In the research project surveys, a small percentage of carriers—26%—indicated that they use selection tests in hiring. Moreover, their effectiveness rating was near the bottom (7th) of the eight methods presented. Respondents answering yes on this question were also asked to name the tests they used. Most respondents answering this question gave a general answer rather than naming a specific test. Moreover, many of the tests mentioned were not personality or performance tests but were tests of specific job-related knowledge or skill. The various responses included the following:

- Entrance test
- Screening process
- Performance test
- Predictive index
- Random evaluations
- Talent and behavioral interviews
- Math aptitude
- In-house developed
- Personality
- Smith System
- Hours-of-service
- Load securement

Various selection tests are marketed for use by motor carriers. Additionally, several of the personality and performance measures described in Chapter 4 have potential use as selection tests. The following are selection tests known to the authors:

- The Daecher Driver Profile is a questionnaire that measures the beliefs, attitudes, personality, opinions and other personal characteristics of the driver to determine how he/she approaches the world and deals with different situations. According to company materials, it was validated in accordance with APA Division 14 principles for validation of personnel selection procedures as a way to differentiate good drivers from bad ones.
- The Dula Dangerous Driving Index (Dula and Ballard 2003) was created to measure drivers' self-reported tendencies to driver dangerously. Subscales include aggressive driving, negative emotional driving, and risky driving. Validation studies have shown positive correlations between these scale scores and traffic citations and at-fault crashes.
- The Scheig Hiring and Performance System (www.scheig.com) is a selection instrument that includes scales on driver interest and willingness to perform tasks related to commercial driving, responses to situations truck drivers face, and a self-rating checklist of personal characteristics. The candidate's answers are benchmarked against those of experienced, safe commercial drivers.
- The All Scan Driver Battery, developed by TestMaster, Inc. (http://testmaster.rio.com), is a questionnaire consisting of approximately 300 true-false and multiple-choice questions. It measures three broad factors related to the psychological profile of a truck driver: intelligence, factual knowledge, and "trucker" personality.
- The Hogan Personality Inventory (HPI, www.hoganassessments.com) is a questionnaire designed to predict job performance on a variety of jobs, including commercial driving. It includes scales on driver attitudes and personality traits, including service orientation, stress tolerance, reliability, social adjustment, ambition, sociability, likeability, prudence, intellect, and school success.
- ProScan and JobScan, by PDP Management Systems, are multi-scale questionnaires that can be benchmarked to a variety of professions. PhD, Inc. (phdassessments.com), reports development of truck driver selection profiles using ProScan and a computer program called SURE. The developed model enabled greater than 90% identification of both high-risk and low-risk commercial drivers where risk was measured based on 5-year crash and violation records.
- The MindData Attitude Index by Minddata (www.minddata.com) uses questionnaires that are validated against a company's successful employees, based on the view that a company's successful employees are the best benchmark to judge prospective employees. Scale scores are generated for work-relevant personal traits such as adaptability, aggressiveness, compliance, concentration, drive, organization, stamina, and trust.
- The RoadRISK Assessment (www.vfrm.net) is an online assessment of driver attitude, hazard perception, safety-relevant knowledge, behavior, personality, and other risk measures such as driving mileage and times

(e.g., late night driving). Its website claims that drivers with the worst scores are 3 to 16 times more at risk for crashes than those with the best scores.

- Waypoint is a short sensory-motor test that requires subjects to connect numbered and alphabetized boxes presented in random spatial patterns of increasing complexity. The Waypoint website (waypointresearch.com) cites studies of five over-the-road trucking fleets involving more than 200 drivers. Claimed "hit rates" ranged from 43% to 75%, false alarm rates ranged from 6% to 12%, and projected crash reductions ranged from 23% to 54%.

(Note: The above list represents those commercial driver selection tests known to the authors at the time of synthesis publication. The tests were not evaluated and no endorsement of any test is implied by this presentation.)

5.3 DRIVER PERFORMANCE EVALUATION

Of course, once drivers are hired, their in-service safety performance must be continuously monitored and evaluated. Continuous tracking of driver crashes, incidents, and violations was practiced by virtually all (99%) the survey safety manager respondents, and they rated this as the most effective of the four evaluation practices presented. Other experts also rated this as the most effective evaluation practice. Carriers are required by the FMCSRs to annually check the MVRs of their drivers, but many companies check them more frequently. Moreover, many managers feel that incidents (e.g., damage to cargo or loading areas) are important events to track along with crashes, traffic violations, and inspection violations. One safety manager respondent stated, "A number of small incidents will eventually result in a major incident." Appendix F-5 and F-6 provide a sample driver safety record and performance coaching job aid, respectively, for employee evaluation and feedback.

The *Truck Driver Risk Assessment Guide* (American Trucking Associations Foundation [ATAF] 1999a) recommends systematic monitoring of numerous indicators of driver activity and performance, including (a) driving skills, (b) driving habits (including health and wellness-related), (c) hours-on-duty, (d) miles driven, (e) MVR reviews, (f) traffic violations, (g) crashes, (h) cargo loss, (i) vehicle inspection and maintenance, and (j) non-driving activities such as loading/unloading practices and connecting/disconnecting. A number of performance evaluation-related job aids are provided in appendices to the guide. A survey conducted as part of the I-95 Corridor Coalition Coordinated Safety Management study (Stock 2001) found that "driver monitoring" was considered important by more than 90% of their carrier respondents. Knipling, Hickman, and Bergoffen (2003) also found that tracking both individual driver's crashes/incidents/violations and overall fleet safety statistics were practiced by about 90% of safety manager respondents. Continuous tracking of drivers' crashes, incidents, and violations was rated as one of the most effective safety management practices.

"Periodic observation of driving" was the second most practiced driver evaluation method at 82%. Its effectiveness was rated about average compared with the other evaluation methods presented. Such observations can be in the truck ("ride alongs"), or can be from outside the truck (from a "shadow vehicle"). Both manager and senior driver ride-alongs were included as items in Part 5 of the present survey. Less than 50% of respondents employ these methods, and they were rated near the bottom of the 12 safety management methods presented. Nevertheless, ride-along observations can be a way of providing one-on-one instruction and behavioral counseling to drivers. They should include explicit feedback on driving behaviors. FMCSA participants in the project focus group noted the importance of feedback and the fact that immediate feedback directly to the driver is generally more effective than delayed feedback. Limitations of ride-alongs and other driving observations include the fact that they are time-consuming for managers and that they may not provide accurate appraisals of drivers' actual on-road behavior.

Two other driver evaluation practices addressed in this research project survey were less frequently employed. These were "How's My Driving?" placards and on-board safety monitoring (OBSM). The use of "How's my Driving?" safety placards was the lowest rated of the four evaluation methods presented in the current survey and was also relatively infrequently practiced and poorly rated by Knipling, Hickman, and Bergoffen (2003). The use of safety placards has some advantages and several disadvantages. It is a method for identifying risky driving behavior by drivers before these behaviors result in a crash. Corrective management actions (e.g., reprimands, counseling, retraining) can follow a report from the public about a driver's unsafe driving. Third-party companies providing placards and receiving 800-number calls from the public claim that their use results in fleet crash rate reductions. Disadvantages include the fact that it's a "hit or miss" technique; that is, there is no guarantee that risky driving will be reported. Callers may or may not describe the incident accurately, leading to possible disputes with drivers. Most of the phone calls from the public, and therefore the feedback received by drivers, will be negative, perhaps leading drivers to resent the method and believe that they have been unlucky rather than that they have misbehaved.

OBSM would seem to be a technique with tremendous potential to assess commercial driver safety performance and identify unsafe drivers. Many safety-critical driving behaviors (e.g., speed, acceleration, brake use, driving times associated with hours-of-service compliance) can be continuously monitored electronically. Emerging technologies can measure forward headway (to detect tailgating), rollover risk on curves, lane tracking, lateral encroachments toward adjacent vehicles (e.g., during lane changes), and even driver alertness and attention (Knipling, Hickman, and Bergoffen 2003). Such technologies may provide safety performance feedback, both to drivers and their managers, in addition to providing collision warnings (Knipling and Olsgard 2000). OBSM data can serve as the basis for short- and long-term safety performance feedback and counseling to drivers and can be employed in support of fleet behavior-based safety (BBS) and safety incentive programs.

In spite of this safety potential, commercial drivers and fleet safety managers have not widely embraced the use of OBSM. A major issue is driver acceptance. A 1995 study sponsored by the Office of Motor Carriers (OMC; the predecessor agency to FMCSA) and conducted by Penn + Schoen Associates found that OBSM was not well accepted by commercial drivers because they perceived it as an invasion of privacy and/or as a sign of disrespect for their professionalism as drivers. Ironically, drivers in this study generally acknowledged the potential safety benefits of its use. A recent commercial driver focus group study conducted by the Liberty Mutual Research Institute (Roetting et al. 2003) found that drivers were willing to be monitored and to receive feedback from on-board technologies, but only if the feedback were specific, constructive, individualized, and implemented within a positive and supportive management environment.

Knipling, Hickman, and Bergoffen (2003) found that OBSM was one of the least used of the 28 fleet safety management practices reviewed. Among those managers who actually used it, however, OBSM was often ranked as one of the more effective safety management methods. These survey results were similar—only 31% of the safety manager respondents used the method, but its effectiveness ratings from those who used it were second only to continuous tracking of crashes, violations, and incidents.

As discussed by Knipling, Hickman, and Bergoffen (2003), it is ironic that carrier safety managers almost universally monitor driver crashes, incidents, and violations, but do not typically monitor the source safety behaviors that create these outcomes. Involvement in safety outcomes such as crashes, incidents, and violations is obviously affected by chance, and reports of these events may be misleading or inaccurate. Potential advantages of continuous OBSM include the following:

- It provides objective, naturalistic data on driving behaviors that are the "source" of crash risk.
- It is continuous, and thus potentially can provide real-time, daily, weekly, or long-term evaluations of drivers.
- If multiple measures are employed, the data can selectively address specific safety behaviors (e.g., tailgating, hard braking).
- Feedback to drivers can be provided in a timely manner.
- It can be the basis of reward programs as well as disciplinary action.
- It can be used to address safety behavior and performance issues before a crash, incident, or violation occurs.

In short, OBSM is a technology and management approach with tremendous potential, but this potential is not being realized in the commercial motor transport industry. Behavioral, analytic, and technological advancements could make this technique more acceptable to drivers and easily used by managers. Also, OBSM needs to be seen as data support for management actions rather than as an end in itself; as one respondent noted, "Use of on-board monitoring needs to occur with one-on-one feedback to drivers." It also needs to be integrated with enlightened behavioral safety management methods.

5.4 DRIVER EMPLOYEE MANAGEMENT

5.4.1 Training and Counseling

Training for new hires on driving skills, company rules for driving (e.g., speed policy), other company procedures and policies, loading and unloading, and customer relations is an important part of the hiring process for most safety-conscious fleets (ATAF 1999b; Knipling, Hickman, and Bergoffen 2003). Most fleets hire new drivers in a probationary status and then have them train with a driver trainer or senior driver. Some companies conduct apprenticeship and "finishing" programs for new drivers, and many conduct regular refresher training for their experienced drivers. Most carrier safety managers rate their in-house training programs as being important to carrier safety (Stock 2001). According to one safety manager, "Training/retraining of all drivers is a must. Consistent driver quarterly safety meetings are also a must. Keep safety a constant."

Of greatest interest here are remedial training programs for problem drivers. The research project survey and a similar previous survey (Knipling, Hickman, and Bergoffen 2003) yielded almost identical results. In both surveys, 69% of carrier safety manager respondents employed remedial training for problem drivers, and its effectiveness was rated about average of the methods presented. The term "remedial training" may cause resentment among some drivers; an option is give it a more benign name such as "refresher training." Like most industrial training, remedial training for commercial drivers should focus on specific safety-related knowledge, skills, and attitudes. If conducted by a manager or senior driver, it affords an opportunity for one-on-one counseling and building a rapport that can lead to better compliance with fleet safety rules.

One large mid-western fleet employs a high-fidelity truck driving simulator to provide remedial/refresher training to its problem drivers. The simulator enables realistic training on special roadway conditions (e.g., upgrades, downgrades, and slippery roads) and emergency maneuvers (e.g., responding to a jackknife or tire blowout).

Unfortunately, few studies have documented the effectiveness of remedial driver training. Unless evaluation studies are carefully controlled, it can be difficult to separate genuine improvement from random improvement that would have occurred without training. A recent review of 24 studies of post-license non-commercial driver education found "no evidence that post-license driver education is effective" (Ker et al. 2004). In motor carrier fleets, its effectiveness depends on how systematically it is conducted and on follow-up monitoring of a driver's safety performance. One respondent noted that, "Proactive programs and one-on-one dialog have the best chance of improving poor performance."

5.4.2 Rewards and Punishment

Several survey questions addressed management practices relating to behavioral consequences—positive or negative. Several questions asked respondents to rate reward-based practices and punishment-based practices. Other questions asked respondents to weigh the effects of rewards and "discipline." Both groups of respondents rated monetary rewards as among the most effective of management techniques, and non-monetary rewards were also rated relatively high by other experts. More than 90% of safety managers employ reprimands—both verbal and written—as a form of punishment, but their effectiveness was rated by both groups as relatively low. Eighty-four percent of safety managers employ suspension from service as a punishment and, not surprisingly, they rate it as one of the most effective interventions. One respondent expressed frustration with any efforts to discipline problem drivers, commenting that, "Most high-risk drivers have little sense of responsibility and respond little to disciplinary action."

The results of questions on the relative merits of rewards and discipline (presented in Table 7) are reproduced in Table 11. For drivers in general, both respondent groups rated rewards as more effective than discipline, although many respondents in each group rated the two approaches as having equal impact. For problem drivers, responses shifted toward discipline as the more effective intervention, although here again a number of respondents rated the two approaches as having equal impact.

Financial rewards as incentives for safety are widely employed in North American CMV fleets. Barton and Tardif (1998) reported that 70% of trucking firms surveyed had an incentive/reward program. Their pilot evaluation of incentive programs found that they resulted in significant crash and incident reductions and, in particular, substantial reductions in driver turnover rates. In one example (reported in Barton and Tardif 2002), a less-than-truckload (LTL) fleet with 80 power units was experiencing a nearly 100% driver turnover rate annually. The implementation of a driver incentive program reduced the turnover rate to about 20% annually, at an average cost of about $2,000 in incentive rewards per driver. For each retained driver, the company saved about $8,000 in recruiting, training, and management costs. Another company gave bonuses to drivers for improvements in fuel economy (which is also associated with improved safety). Over an entire year, the program resulted in fuel savings of approximately $15,000 per vehicle, while fuel efficiency bonuses averaged about $6,000 per driver. Thus, the fleet saved $2.50 for every dollar spent on the program.

In the I-95 Corridor Coalition "Best Practices" study (Stock 2001), 25% of small fleets (1 to 9 vehicles) had financial reward programs for safe driver performance, but more than 80% for larger fleets (51+ vehicles) had them. Most safety managers surveyed rated such programs as effective. In *SafeReturns* (ATAF 1999b), 41% of all fleets surveyed, and 66% of "award winning" fleets, provided cash bonuses to drivers for safe driving. Of the carrier safety managers surveyed by Knipling, Hickman, and Bergoffen (2003), 73% used incentive programs for driver safety outcome measures (e.g., crash-free miles), but these programs were rated as only moderately effective compared with other fleet safety management practices. In the current survey, only 38% of safety managers used "monetary rewards," but it was rated third-highest in effectiveness of the 12 methods presented. Other experts rated these programs as the most effective method of the 12.

As noted, the use of disciplinary actions in response to commercial driver crashes, violations, and incidents is widespread. Many behavioral scientists discourage the use of negative consequences as a principal method to reduce at-risk safety-related work behaviors (Daniels and Rosen 1988, Geller 2001, Krause 1997, McSween 1995). Punishment can significantly reduce unwanted behaviors if the punishment is severe, certain, and immediate. However, there are several undesirable side effects and limitations associated with its use, such as escape, aggression, apathy, and "counter-control" (Daniels and Rosen 1988, Geller 2001, McSween 1995).

Escape. People tend to avoid situations and people associated with negative consequences. Reliance on punishment may lead people to avoid reporting injuries or near-misses. Further, those that do have an injury, near-miss, or crash are

TABLE 11 Which has stronger influence: rewards or discipline?

RESPONSE CHOICE	SAFETY MANAGERS		OTHER EXPERTS	
	Drivers in General	Problem Drivers	Drivers in General	Problem Drivers
Rewards	28%	15%	52%	12%
Discipline	12%	45%	9%	46%
Equal Impact	60%	40%	39%	42%

likely to report they were behaving safely to avoid being punished. This may make it difficult to identify at-risk behaviors associated with the violation or crash. Also, negative consequences produce unpleasant emotions and attitudes. When people feel controlled they are only motivated to do what is expected, and not to go beyond the call of duty for safety (Geller 2001, McSween 1995).

Aggression. Rather than escaping from negative consequences, people may choose to attack those associated with them. During the last decade, violence in the workplace has become more commonplace. Physical aggression toward management or coworkers associated with negative consequences is only one example of aggression. Disgruntled workers may also slow down production, sabotage safety or production programs, steal supplies, or vandalize company property. Worse, employees may take out their feelings of frustration on family members (Geller 2001).

Apathy. Punishment may suppress other, non-targeted behaviors. It may stifle communication and foster a failure-oriented approach. People feel better about achieving success rather than avoiding failure (Geller 2001).

"Counter-control." People do not like being controlled. They may not comply with discipline if they believe they will not be caught performing the punished behavior. An excellent example is provided by general driver behavior on U.S. highways. Fines and other punishments for speeding do not effectively deter speeding. Drivers may slow down when they see a patrol car, but they resume speeding as soon as the police car is out of sight. Some motorists go to great lengths to avoid being caught speeding by investing in radar detectors and radar jammers. When people feel controlled, they look for ways to beat the system.

A non-transportation study by Zohar, Cohen and Azar (1980) provides some support for the use of positive consequences over negative consequences. Zohar, Cohen, and Azar (1980) used a positive feedback intervention to significantly increase ear plug use at a metal fabrication plant. During the intervention, management decided to also punish workers who were observed not wearing their earplugs. Workers caught not wearing ear plugs were required to leave their work stations for several hours with a resultant loss of pay. The enforcement program was in effect for three months but failed to produce any changes in ear plug use. In fact, workers actually wore their ear plugs less while the enforcement program was imposed (less than 10%) compared with ear plug use during the baseline phase (20%). During the same time, workers receiving positive feedback for ear plug use continued to wear their ear plugs nearly 90% of the time compared with a 35% baseline.

This is not to say that punishment should never be used. People who routinely violate safety rules and endanger themselves and others should understand that they are required to comply with safety regulations. However, negative consequences may inhibit learning and constructive interaction. Geller (2002) recommends trying "positive discipline" rather than punishment. For example, workers observed violating an organization's safety regulations may be sent home with pay to evaluate the infraction and decide what can be done to reduce the reoccurrence. The employee has two options: (1) not returning to work if the employee and his/her supervisor believe the work culture is not consistent with the employee's personal priorities or (2) return to work and develop an action plan for avoiding the at-risk behavior in question. Continued violations may warrant a shift toward more negative consequences such as fines, suspension, or termination.

5.4.3 Behavior-Based Safety

Over the last 20 years, BBS has become increasingly popular in many organizations to combat employee injures and their associated costs. The BBS approach is to intervene systematically and directly on safety-related target behaviors. Target behaviors are defined in an observable and measurable way and then observed and recorded in the work setting. When a relatively stable baseline measure of the frequency, rate, or duration of behavior is obtained, an intervention is implemented to change the behavior in beneficial directions. Interventions typically involve modifying target behavior antecedents (situations prior to behavior that set the stage for the behavior) and/or consequences (events after behavior that motivate behavior). Consequences may include tangible (e.g., monetary) rewards, but often the emphasis is on non-monetary rewards such as recognition and praise for improvement and safety goal attainment. In group settings, the development of a safety esprit de corps among workers is an important motivational method. To determine intervention effectiveness, the incidence of target behaviors is recorded during and/or after the intervention and compared with baseline measures of behavior (e.g., Daniels and Rosen 1988, Geller 2001, Geller and Williams 2001).

One of the primary tools used to influence behavior in BBS is peer observation and feedback (Geller 2001, Geller and Williams 2001). Coworkers systematically observe fellow workers and record the occurrence of safe and at-risk work behaviors on a checklist. The results can be based on individual or group performance. The feedback can be given publicly or privately, and it is often combined with education or training (Zohar, Cohen, and Azar 1980).

BBS approaches have a number of advantages, including (a) they can be administered by individuals with minimal professional training, (b) they can reach people in the setting where the problem occurs (i.e., the work site), and (c) worker-leaders can be taught the behavior-change techniques most likely to work under specific circumstances (Baer, Wolf, and Risley 1987; Daniels and Rosen 1988; Geller 2001).

BBS programs have been used successfully to increase safety-related work behaviors in a variety of organizational settings, including pizza delivery (Ludwig and Geller 1991, 1997), paper mills (Fellner and Sulzer-Azaroff 1984), mines (Fox 1987), pipeline operations (McSween 1995), and manufacturing (Reber and Wallin 1984). Guastello's (1993) review of occupational safety and health studies found that BBS had the highest average reduction of injury rate (59.6%) compared with other safety approaches, including personnel selection, technological interventions, group problem solving, government action, stress reductions, near-miss reporting, poster campaigns, and quality circles. Sulzer-Azaroff and Austin (2000) reported that 32 of the 33 published articles they reviewed on BBS studies showed reductions in work-related injuries.

Beyond the traumatic personal consequences of occupational injuries and fatalities, there are also critical social and economic consequences to consider. Behavioral Science Technology, Inc. (BST), studied workers' compensation rates at 11 sites following the introduction of a BBS intervention and reported a 39% reduction (compared with a 4-year baseline) in compensation claims in year 1, 46% reduction in year 2, and a 70% reduction in year 3 (BST 1998). Similarly, Hantula et al. (2001) showed reductions in workers' compensation claims at two manufacturing organizations after the introduction of a BBS intervention and substantial cost reductions (one organization had a 10.53:1 return on its investment).

BBS views individual employee differences in safety in terms of the interventions required to change that behavior. Some people are likely to benefit from the most simple and least expensive interventions, while others (such as high-risk drivers) may require more intrusive interventions to influence behavior change. Geller (1998, 2001) developed the multiple intervention level (MIL) hierarchy to summarize the impact, intrusiveness, and cost of various interventions. Figure 16 displays the MIL hierarchy. Interventions at Level 1, such as posters, signs, and other safety messages or slogans, are the least expensive and intrusive. People not influenced by Level 1 interventions "fall through the cracks." These people require more intrusive and expensive interventions, such as peer-to-peer coaching or an incentive/reward program. The height of each intervention box indicates the financial cost to implement the intervention. The length of each box represents the probability that a person will be affected by the intervention (i.e., result in behavior change). The width of each intervention level (marked A, B, C) indicates repeated applications of the same intervention. In this model, high-risk drivers will "fall through the cracks" until a more aggressive and comprehensive intervention influences their behavior.

In spite of its obvious emphasis on behavior, BBS does not necessarily assume a one-dimensional view towards safety. Interventions aimed solely at reducing at-risk safety-related work behaviors without acknowledging the system in which they occur may have limited long-term success (Geller 2001,

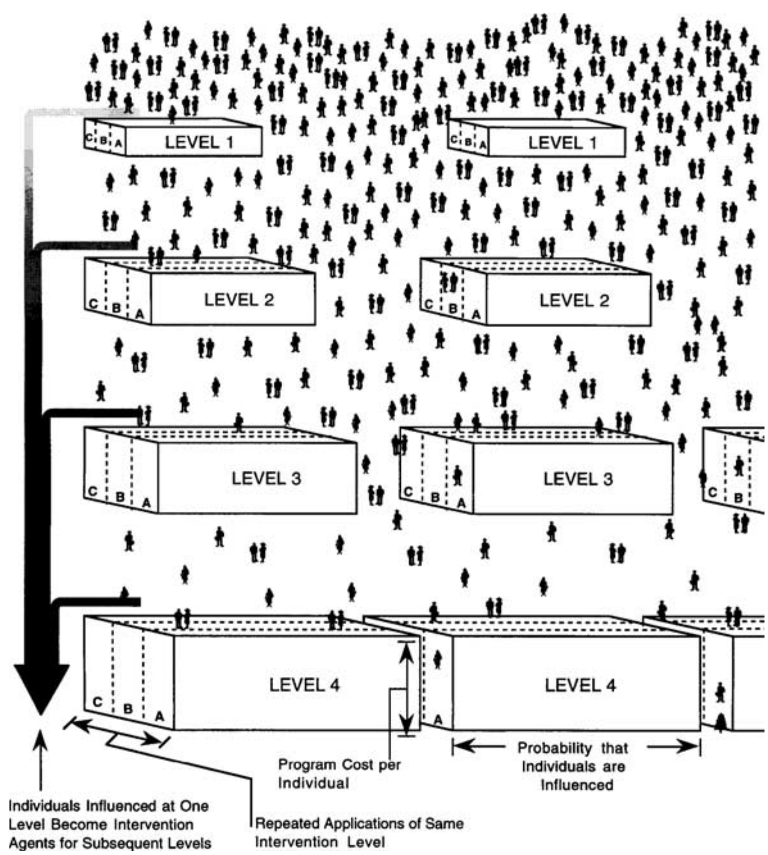


Figure 16. Multiple intervention level (MIL) hierarchy (Geller 1998).

Geller and Williams 2001, Krause 1997). Geller (2001) suggests there are three dynamic and interactive factors in a safety culture (i.e., system), called the "Safety Triad." Changes in one factor usually impact the other two. As depicted in Figure 17, a successful BBS approach requires continual attention to all three factors in the Safety Triad.

Unfortunately, because of its emphasis on direct behavioral observation and feedback, BBS is most applicable to settings where employees work in groups (e.g., manufacturing, maintenance) rather than alone. In the trucking industry, BBS is likely to be more effective when applied to loading and unloading safety than when applied to solitary driving. Driver self-management, described in Section 5.4.4, is an attempt to transfer the principles and benefits of BBS to solitary work settings.

5.4.4 Driver Self-Management

The effectiveness of behavioral self-management has been documented in numerous clinical settings. Self-management techniques documented include the reduction of alcohol consumption (Garvin, Alcorn, and Faulkner 1990; Sitharthan, Kavanagh, and Sayer 1996), the control of personal weight (Baker and Kirschenbaum 1993), exercise (Konradi and Lyon 2000), and the cessation of smoking (Curry 1993). Unfortunately, the potential benefits of using self-management techniques to improve safety-related driving behaviors have received little attention and have only recently been evaluated systematically.

Self-management is an improvement process whereby individuals change their own behavior in a goal-directed fashion (Mahoney 1972) by (a) manipulating behavioral antecedents, (b) observing and recording specific target behaviors, and (c) self-administering rewards for personal achievements (Geller and Clarke 1999, Kazdin 1993). Research indicates that five self-management procedures can facilitate behavioral improvement, including (a) activator management (Heins, Lloyd, and Hallahan 1986), (b) social support (Stuart 1967), (c) goal setting (Locke and Latham 1990), (d) self-monitoring and self-recording (Lan, Bradley, and Parr 1993), and (e) self-rewards (Sohn and Lanal 1982).

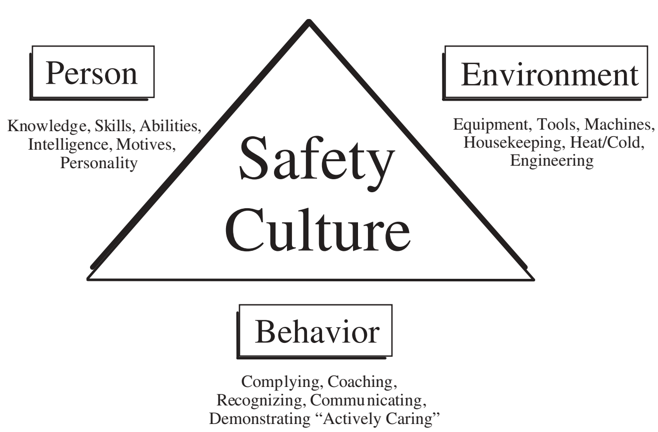


Figure 17. The Safety Triad (Geller 2001).

Several studies have successfully used self-management techniques to increase the safety-related driving behaviors of bus divers (Olson and Austin 2001), short-haul truck drivers (Hickman and Geller 2004), and CMV drivers (Krause 1997). Olson and Austin (2001) used a combination of self-monitoring and feedback with commercial bus drivers to influence a 12.3% increase in safe driving performance, with individual increases in performance ranging from 2% to 41%. Hickman and Geller (2004) used an intervention package composed of training, self-monitoring, feedback, and goal setting with short-haul truck drivers and reported reductions in two targeted at-risk driving behaviors—overspeeding and extreme braking. Krause (1997) used a combination of self-monitoring and feedback with CMV drivers and reported a 66% reduction in injuries and crashes.

Since most commercial drivers operate their vehicles alone, there may be substantial benefits from the development and widespread application of practical self-management techniques for them. If driver self-management practices could be integrated with other fleet safety-promoting activities, it may become an effective CMV safety management tool. For example, as discussed earlier in this chapter, the use of self-management relating to driving safety parameters recorded on OBSMs could be a particularly powerful intervention because of the many safety-critical behaviors (e.g., speed, acceleration, headway maintenance) that can be captured by OBSMs. Unfortunately, a minority of carriers encourage driver safety self-management (36% in the survey), and it was not rated as highly effective by either carrier safety managers or other experts. Safety self-management, like BBS in general, appears to be a technique with great but unrealized potential in the CMV industry. Moreover, since the whole concept of safety self-management presupposes some level of worker self-motivation and conscientiousness, it may be a technique that is more effective in making good drivers better than in correcting the unsafe behaviors of the worst drivers.

5.4.5 Termination

The fleet management methods described above are various ways to improve the performance of problem drivers within a fleet. The widespread success of behavioral approaches demonstrate that undesirable behavior can be changed. Nevertheless, termination is always an option and may be the prudent decision for many problem drivers. No survey questions asked directly about termination, but "suspension from service" as a driver disciplinary method was practiced by 84% of respondents and rated by them as one of the most effective management practices. In their comments, survey respondents minced no words in their comments on necessary management actions when dealing with their worst drivers:

- "Problem drivers are generally unresponsive to efforts to make them safer. The only option that will enhance safety is removal."

- "Bad drivers are bad drivers. You can't change them. Just get rid of them."
- "Worst 10% tend to stay that way, whatever you do– unless caused by inexperience, youth, or medical/sleep condition."
- "The ultimate goal of the safety manager is to eliminate the bottom 10% of drivers."
- "Once identified, high-risk drivers must totally convince me they are capable of change, or you must get rid of them."
- "A poor employee has little or no regard for policies and laws no matter what the task. These employees need to be removed from service."

The U.S. EEOC, which enforces laws and provides oversight of federal employment regulations, does not prescribe any standard procedures for termination or layoff of employees. Yet, the federal government has established laws and regulations prohibiting job discrimination based on ethnic group, race, color, sex, religion, or national origin.

The Age Discrimination in Employment Act of 1973 prohibits discrimination against qualified individuals 40 years old or older. In addition, many states and local jurisdictions have enacted protections against discrimination based on sexual orientation, status as a parent, marital status, and political affiliation.

The Americans with Disabilities Act of 1990 prohibits discrimination against qualified individuals with disabilities. A disability is defined as a physical or mental impairment that substantially limits major life activities. Employers are required to provide reasonable accommodations (e.g., making work facilities more accessible) to disabled persons to facilitate their performance of essential job tasks. Yet, an employer is not required to make special accommodations if so doing requires significant expense or hardship to the company.

To avoid becoming embroiled in civil or criminal cases involving charges of discrimination, employers should (a) not engage in such discrimination and (b) keep extensive and precise records documenting job-related reasons for hiring and firing actions.

CHAPTER **6**

RESEARCH AND DEVELOPMENT NEEDS

This synthesis has presented survey results and statistical findings from a number of studies supporting the view that commercial drivers differ greatly in their levels of crash risk and that a relatively small percentage of drivers (perhaps 10 to 15%) account for a disproportionate percentage of total fleet risk (perhaps 30 to 50%). Questions remain about these findings, however. One question is whether the findings are reliable or just the result of random variation. Most of the findings cited appear to be reliable (statistically significant), but any systematic new studies on the issue should incorporate rigorous designs and statistical analyses to ensure the reliability of the findings.

The findings presented in this synthesis generally imply, but do not verify, that relative driver risk (general and specific, e.g., fatigue, aggressive driving) endures across long periods of time. In other words, "risk" is to some extent a long-term personal trait, in addition to being obviously related to specific situations and conditions. A pressing research need is to perform studies to provide answers to the "trait versus state" debate or to incorporate these questions into various other motor carrier safety studies. The term "accident prone" means different things to different people and thus has not generally been used in this synthesis. However, there clearly is some truth to the idea, and future research could increase the understanding of it.

This synthesis (especially Chapter 4) has presented an array of personal factors that may be underlying dimensions or correlates of commercial driver crash risk. The most pressing R&D need is systematic and quantitative determination of the role that the many factors discussed play in commercial driver risk. A truly systematic approach would review all major human characteristics potentially associated with driver crash risk, select the best available tests to measure them (or develop new tests), and empirically determine the relation of each factor to commercial driver crash, violation, and incident involvement in the same group of drivers. Of course, the study sample should be broadly representative of commercial drivers. Both prospective and retrospective comparisons with criterion safety measures could be made. Instrumented vehicles that continuously monitor driver performance might be employed to provide stronger statistical comparisons, because observed driver errors and other incidents are likely to be far more numerous than reported crashes and traffic violations. Instrumented vehicle studies might also enable researchers to assess the relationships of various personal factors to various kinds of driver mistakes and misbehaviors, such as tendencies to make recognition errors (failure to recognize a crash threat) or tendencies to drive aggressively and take risks. A case-control crash risk study design (e.g., systematically comparing crash-involved with non–crash-involved drivers) would be one way to associate each factor studied with the probability of crash involvement (Boyle et al. 2002). Many factors could be included in the study, and statistical methods like multiple regression could be used to combine factors to derive the best possible predictions of driver risk. Study data could serve as the basis for developing and validating practical selection tools to be used by fleets to improve the safety quality of drivers hired. In addition to findings on personal traits, study results related to situational factors might help carriers to identify and avoid risky situations such as various schedules, roadway types, and environmental conditions.

There is a specific development opportunity relating to the identification of individuals with high susceptibility to fatigue while driving. As discussed in Chapter 4, there is compelling evidence of wide individual differences in fatigue susceptibility and further evidence that these differences persist over time. Given the essential role played by vigilance in driving, it is likely that some individuals are simply constitutionally ill-suited to long-haul commercial driving because they cannot sustain alertness under the rigors of commercial transport operations. Conversely, there are low-susceptible individuals who are unlikely to be involved in fatigue-related incidents and crashes. Ideally, a diagnostic tool (e.g., a physiological or performance test) could be developed to efficiently and accurately assess a candidate driver's level of fatigue susceptibility. Such a tool would not diminish the importance and value of improved fatigue management by drivers and fleets; rather, the combination of driver selection and alertness-supportive management techniques would combine to dramatically reduce drivers' risks of attentional lapses and falling asleep at the wheel.

The various personality and performance variables discussed almost all have some potential for increased use in selecting drivers. In most cases, tests of the various personality and performance factors have already been developed. While refinements to the various tests would certainly be beneficial, the principal development need for most psychological tests is validation in relation to driving safety criteria and practical application to actual fleet settings.

Chapter 5 of this synthesis addressed carrier management approaches to addressing the high-risk driver problem and capitalizing on the fact that most commercial drivers are not high risk. R&D is needed in relation to all major driver management functions: selection, evaluation, and management intervention. Selection-related studies might focus on validating the use of specific selection procedures or instruments, such as selection tests. Criterion-based test validation requires the use of safety performance criteria (e.g., crash, violation, and incident involvement) to validate the predictive power of questionnaires, sensory-motor tests, and other types of assessment tools. Several different CMV industry operations types (e.g., long-haul, short-haul, motor coach) might be employed to ensure that test validity generalizes to different segments of the industry, or to determine if some tests work better in some operations than in others. Also, as noted in Chapter 4, any research on underlying factors has the potential to be applied to the practical goal of improving driver selection.

In the area of driver performance evaluation, a particular R&D opportunity relates to OBSM. OBSM can potentially measure multiple safety-critical driving behaviors that are the source of safety outcomes such as crashes. A systematic study addressing the safety applications of OBSM might include the following:

- Assessment of the safety significance of different on-board performance measures.
- Evaluation of in-vehicle displays and warnings; what is the best way to communicate information to the driver?
- Approaches to reducing, analyzing, and benchmarking the data.
- Management approaches to providing feedback, positive rewards and incentives, and, as necessary, negative discipline to drivers based on OBSM data. In other words, what are the best ways to change behavior in positive ways?
- Legal and litigation risk issues relating to the recording of safety performance and behavior-related data.

Behavioral safety management in general would be a worthy topic for motor carrier safety management research. BBS has been highly successful in other industries, but has not been widely applied to truck and bus safety, perhaps because of the solitary nature of commercial driving where drivers do not work in groups. A systematic long-term study might assess the applicability and effectiveness of BBS techniques in CMV operations. This could include the use of BBS for drivers in general as well as its use to target the driving behavior of problem drivers. Study findings might form the basis for an educational program to teach carrier safety managers how to effectively employ behavioral management methods.

The behavioral MIL (Geller 1998) is a positive, heuristic model of how different workers respond to behavioral management interventions. Determination of specific fleet management practices associated with these levels might help carrier safety managers to use BBS with greater confidence and authority. Individuals who do not respond to the most vigorous behavioral management interventions are probably constitutionally unsuited to commercial driving and should be encouraged to leave the profession.

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APPENDIX A

GLOSSARY

Acronym	Term
ABA	American Bus Association
ATA	American Trucking Associations
BAC	Blood-alcohol content
BBS	Behavior-based safety
BSM	Behavioral safety management
CDL	Commercial driver's license
CI	Critical incident
CMV	Commercial motor vehicle
CPAP	Continuous positive airway pressure
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
CVO	Commercial vehicle operations
DFAS	Driver Fatigue and Alertness Study
EEOC	Equal Employment Opportunity Commission
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMCSRs	Federal Motor Carrier Safety Regulations
GES	General Estimates System
HOS	Hours-of-service
LSH	Local/Short-Haul
LTCCS	Large Truck Crash Causation Study
MIL	Multiple intervention level
MVR	Motor vehicle record
NHTSA	National Highway Traffic Safety Administration
OBSM	On-board safety monitoring
OMC	Office of Motor Carriers [predecessor agency to FMCSA]
ORD	Observer rating of drowsiness
PVT	Psychomotor Vigilance Test
TRB	Transportation Research Board
VTTI	Virginia Tech Transportation Institute

APPENDIX B

PROJECT STATEMENT OF WORK

INDIVIDUAL DIFFERENCES AND THE "HIGH RISK" COMMERCIAL DRIVER

Background and Problem Statement

Numerous studies indicate that a relatively small percentage of commercial drivers (10 to 20%) are involved in a disproportionate percentage of crashes (approximately 50%). Specific statistics vary, but the rule seems to hold true across various CMV operation types and per various dependent measures including crashes, incident involvements, and fatigue/drowsiness episodes. This project will elucidate this phenomenon and identify ways that the high-risk driver can be targeted by various safety programs and practices, both at the fleet and industrywide levels.

Objectives and Scope

The required study will

1. Summarize available information on the individual differences in commercial driver safety performance and alertness and examine the reliability and validity of various metrics and tests that are employed to hire better drivers and, perhaps more important, to avoid hiring high-risk drivers.
2. Identify safety management techniques that are currently used by commercial vehicle carriers to target problem drivers and their specific risky behaviors.
3. Conduct a scan of other industries that employ safety-sensitive individuals (e.g., airlines, nuclear power, railroads, maritime, and the military) and summarize key techniques used to identify and address high-risk individuals/employees.
4. Identify and discuss the institutional and regulatory issues that affect the ability of an employer to address potential or current high-risk employees.

One central question the synthesis study will examine is the degree to which individual differences in commercial driver safety reflect long-term, enduring personality traits (pointing to the need for better classification and screening), versus learned behaviors that may be readily changed by appropriate behavior-based safety management (e.g., training, performance feedback, rewards, and punishments). The study will also identify needs for (a) research to delineate CMV individual driver differences and (b) tools to aid fleet safety managers in better managing their human resources from the safety perspective.

CMV fleet safety managers will be the principal audience for this study. In addition, the study should be useful in guiding future research and technology in this area. As such, it will be useful to the FMCSA, industry trade association researchers, and other motor carrier safety researchers.

In addition to an extensive literature review, it is anticipated that this research project will conduct surveys of the FMCSA, National Highway Traffic Safety Administration, American Transportation Research Institute, Motor Freight Carriers Association, major commercial truck and bus carriers, and other relevant organizations, as appropriate.

APPENDIX C

CARRIER SAFETY MANAGER SURVEY FORM

CARRIER SAFETY MANAGER SURVEY

Individual Differences and the "High Risk" Commercial Driver

Commercial (truck and bus) drivers are generally safe drivers. For example, most car-truck crashes are caused by the car driver, not the truck driver. However, not all commercial drivers are safe. This survey, which takes about 15 minutes to complete, focuses on problem commercial drivers – the ones with the highest crash risk. Sections deal with the size of the problem, associated factors, and management solutions.

Thanks for your participation and support!

Part 1: How Important Is the Problem?

For the questions below, CIRCLE THE LETTER of the statement you agree with the most.

1. Fill-in two percentages (totaling 100%) that best explain differences in crash rates and risk among commercial drivers.
   Differences in crash risk among commercial drivers are about __________% due to differences in **behavior** or **skill**, and about __________% due to **uncontrollable factors (i.e. luck)**.

2. This is a hypothetical question. Suppose that you managed a large fleet with drivers similar to your current fleet. Suppose also that you managed the same group of drivers in this company for a long period of time – say, 10 years. Given this hypothetical situation, which statement would most likely be true about the worst 10% of your drivers? *(circle the appropriate letter)*
   a. The worst 10% of drivers would have about 10% of the safety problems; in other words, there would be no particular "high-risk" drivers in the fleet.
   b. The worst 10% of the drivers would have about 20% of the safety problems.
   c. The worst 10% of the drivers would have about 30% of the safety problems.
   d. The worst 10% of the drivers would have about 40% of the safety problems.
   e. The worst 10% of the drivers would have about 50% or more of the safety problems.

3. How **consistent and enduring** are individual differences in driver safety? Which statement do you agree with the most? *(circle the appropriate letter)*
   a. A driver's risk, relative to other drivers, can change dramatically over time. This year's best drivers can be next year's worst.
   b. There is some tendency for drivers' relative risk levels to stay about the same, but this can change over time due to luck or other factors.
   c. There is a strong tendency for drivers' risk levels to stay about the same year-to-year relative to other drivers; this year's problem drivers will likely also be next year's problem drivers.

Part 2: Driver Factors Associated with Risk

The following driver characteristics or behavioral tendencies might correlate with crash risk; that is, they might be associated with crash risk to varying degrees. In general, HOW STRONG IS THE ASSOCIATION of each of the following factors with driver crash risk? *(Circle the appropriate number on the scale to the right of each factor)*

		No Association		Moderate Association		Strong Association
4.	Young driver (e.g. less than 25)	0	1	2	3	4
5.	Older driver (e.g. 60 or older)	0	1	2	3	4
6.	Inexperienced (new to commercial driving)	0	1	2	3	4
7.	New to company	0	1	2	3	4
8.	Did not attend formal truck driving school	0	1	2	3	4
9.	Aggressive/angry	0	1	2	3	4
10.	Impatient/impulsive	0	1	2	3	4
11.	Inattentive	0	1	2	3	4
12.	Introverted/unsociable	0	1	2	3	4
13.	Dishonest	0	1	2	3	4
14.	Unhappy/disgruntled with job or company	0	1	2	3	4
15.	Debt or other financial problems	0	1	2	3	4
16.	Unhappy marriage or other family problems	0	1	2	3	4
17.	Obese/overweight	0	1	2	3	4
18.	Sleep Apnea or other sleep disorder	0	1	2	3	4
19.	Heart or other medical condition	0	1	2	3	4

Instructions for Parts 3, 4, and 5: For each of the safety management methods or approaches listed below, please CIRCLE "**YES,**" if your organization currently uses the safety management system. Then, IF "YES," CIRCLE YOUR RATING of its level of safety effectiveness in your organizations' fleet safety. In other words, do you believe the safety management method is a viable and effective tool in identifying high-risk drivers and generally increasing safety in your fleet?

Part 3: Which Driver Hiring Practices and Tools Do You Regularly Use?

If "Yes," please rate effectiveness.

			Highly Ineffective	Ineffective	Not Sure/Neutral	Effective	Highly Effective
20. Check MVR	Yes	No	0	1	2	3	4
21. Check criminal record	Yes	No	0	1	2	3	4
22. Check credit history and rating	Yes	No	0	1	2	3	4
23. Contact past employers	Yes	No	0	1	2	3	4
24. Test for alcohol/drugs before hiring	Yes	No	0	1	2	3	4
25. On-road driving test before hiring	Yes	No	0	1	2	3	4
26. Selection tests (e.g. personality, performance)	Yes	No	0	1	2	3	4
If yes to #26, which test(s) do you use:________________							
27. Use third-party service (e.g. DAC Services) to assist screening and hiring	Yes	No	0	1	2	3	4

Part 4: How Do You Evaluate Drivers in Your Fleet?

If "Yes," please rate effectiveness.

			Highly Ineffective	Ineffective	Not Sure/Neutral	Effective	Highly Effective
28. Continuous tracking of driver crashes, incidents, violations	Yes	No	0	1	2	3	4
29. Periodic observation of driving	Yes	No	0	1	2	3	4
30. "How's My Driving" placards with call-in phone numbers	Yes	No	0	1	2	3	4
31. On-board electronic monitoring	Yes	No	0	1	2	3	4

Part 5: How Do You Manage Your Problem Drivers, once Identified?

If "Yes," please rate effectiveness.

			Highly Ineffective	Ineffective	Not Sure/Neutral	Effective	Highly Effective
32. Remedial training	Yes	No	0	1	2	3	4
33. Manager ride-alongs for evaluation/ feedback	Yes	No	0	1	2	3	4
34. Senior driver ride-alongs for evaluation/feedback	Yes	No	0	1	2	3	4
35. Suspension from service	Yes	No	0	1	2	3	4
36. Verbal reprimand	Yes	No	0	1	2	3	4
37. Written reprimand	Yes	No	0	1	2	3	4
38. Monetary penalties	Yes	No	0	1	2	3	4
39. One-on-one counseling by manager	Yes	No	0	1	2	3	4
40. Mentoring/counseling by a senior driver	Yes	No	0	1	2	3	4
41. Monetary rewards for improvement	Yes	No	0	1	2	3	4
42. Non-monetary rewards for improvement (e.g. recognition, praise)	Yes	No	0	1	2	3	4
43. Teaching self-management to driver (e.g. self-monitoring, goal setting)	Yes	No	0	1	2	3	4

For questions 44-45, CIRCLE THE LETTER of the statement you agree with the most.

44. For *drivers in general*, which has a greater influence on driver safety? *(circle the appropriate letter)*
    a. Rewards for safe driving (praise, merchandise, cash)
    b. Disciplinary actions for unsafe driving
    c. The above two have equal impact

45. For *problem drivers (e.g., worst 10%)*, which has a greater influence on driver safety? *(circle the appropriate letter)*
    a. Rewards for safe driving (praise, merchandise, cash)
    b. Disciplinary actions for unsafe driving
    c. The above two have equal impact

Part 6: Comments

46. Any comments on high-risk commercial drivers or any part of this survey?

____
____
____

Part 7: Information about You and Your Fleet

47. The approximate number of years you have been a safety manager (for carrier motor operations)? ____________

48. Your approximate total years experience in commercial vehicle operations? ______________

49. The number of power units currently in your organizations' fleet? ____________________________

50. How would you characterize your fleet's primary operation? (*Circle or underline the operation type that best characterizes your fleet)*

    a. For hire: long haul/truckload
    b. For hire: long-haul/less-than-truckload (LTL)
    c. For hire: local/short haul (most trips less than 100 miles from home base)
    d. Private industry: long haul
    e. Private industry: local/short haul (most trips less than 100 miles from home base)
    f. Passenger carrier: long haul/motor coach
    g. Passenger carrier: local/transit
    h. Other: ____________________________

Please mail your survey form in the enclosed self-addressed envelope to: Dr. Ron Knipling, VA Tech, 7054 Haycock Road, Falls Church, VA 22043. Dr. Knipling can also be contacted via phone at 703-538-8439, fax at 703-538-8450, and email at rknipling@vtti.vt.edu.

Should you wish to provide your contact information (as noted on the cover letter), you will be sent a FREE copy of the project final report to be published in Summer, 2004, and an Adobe (pdf) copy of a completed report entitled, *Effective Commercial Truck & Bus Safety Management Techniques*.

Thank you again for your participation in this study!

APPENDIX D

OTHER EXPERT SURVEY FORM

EXPERT SURVEY

Individual Differences and the "High Risk" Commercial Driver

Commercial (truck and bus) drivers are generally safe drivers. For example, most car-truck crashes are caused by the car driver, not the truck driver. However, not all commercial drivers are safe. This survey, which takes about 15 minutes to complete, focuses on problem commercial drivers – the ones with the highest crash risk. Sections deal with the size of the problem, associated factors, and management solutions.

Thanks for your participation and support!

Part 1: How Important Is the Problem?

For the questions below, CIRCLE THE LETTER of the statement you agree with the most.

1. Fill-in two percentages (totaling 100%) that best explain differences in crash rates and risk among commercial drivers.
   Differences in crash risk among commercial drivers are about __________% due to differences in **behavior** or **skill**, and about __________% due to **uncontrollable factors (i.e. luck)**.

2. This is a hypothetical question. Suppose that you managed a large long-haul fleet. Suppose also that you managed the same group of drivers in this company for a long period of time – say, 10 years. Given this hypothetical situation, which statement would most likely be true about the worst 10% of your drivers? *(circle the appropriate letter)*
   a. The worst 10% of drivers would have about 10% of the safety problems; in other words, there would be no particular "high-risk" drivers in the fleet.
   b. The worst 10% of the drivers would have about 20% of the safety problems.
   c. The worst 10% of the drivers would have about 30% of the safety problems.
   d. The worst 10% of the drivers would have about 40% of the safety problems.
   e. The worst 10% of the drivers would have about 50% or more of the safety problems.

3. How **consistent and enduring** are individual differences in driver safety? Which statement do you agree with the most? *(circle the appropriate letter)*
   a. A driver's risk, relative to other drivers, can change dramatically over time. This year's best drivers can be next year's worst.
   b. There is some tendency for drivers' relative risk levels to stay about the same, but this can change over time due to luck or other factors.
   c. There is a strong tendency for drivers' risk levels to stay about the same year-to-year relative to other drivers; this year's problem drivers will likely also be next year's problem drivers.

Part 2: Driver Factors Associated with Risk

The following driver characteristics or behavioral tendencies might correlate with crash risk; that is, they might be associated with crash risk to varying degrees. In general, HOW STRONG IS THE ASSOCIATION of each of the following factors with driver crash risk? *(Circle the appropriate number on the scale to the right of each factor)*

	No Association		Moderate Association		Strong Association
4. Young driver (e.g. less than 25)	0	1	2	3	4
5. Older driver (e.g. 60 or older)	0	1	2	3	4
6. Inexperienced (new to commercial driving)	0	1	2	3	4
7. New to company	0	1	2	3	4
8. Did not attend formal truck driving school	0	1	2	3	4
9. Aggressive/angry	0	1	2	3	4
10. Impatient/impulsive	0	1	2	3	4
11. Inattentive	0	1	2	3	4
12. Introverted/unsociable	0	1	2	3	4
13. Dishonest	0	1	2	3	4
14. Unhappy/disgruntled with job or company	0	1	2	3	4
15. Debt or other financial problems	0	1	2	3	4
16. Unhappy marriage or other family problems	0	1	2	3	4
17. Obese/overweight	0	1	2	3	4
18. Sleep Apnea or other sleep disorder	0	1	2	3	4
19. Heart or other medical condition	0	1	2	3	4

Instructions for Parts 3, 4, and 5: For each of the safety management methods or approaches listed below, please CIRCLE YOUR RATING of its level of safety effectiveness in fleet management. In other words, do you believe the safety management method is a viable and effective tool in identifying high-risk drivers and generally increasing safety in your fleet?

Part 3: Driver Hiring Practices and Tools

	Highly Ineffective	Ineffective	Not Sure/Neutral	Effective	Highly Effective
20. Check MVR	0	1	2	3	4
21. Check criminal record	0	1	2	3	4
22. Check credit history and rating	0	1	2	3	4
23. Contact past employers	0	1	2	3	4
24. Test for alcohol/drugs before hiring	0	1	2	3	4
25. On-road driving test before hiring	0	1	2	3	4
26. Selection tests (e.g. personality, performance)	0	1	2	3	4
27. Use third-party service (e.g. DAC Services) to assist screening and hiring	0	1	2	3	4

Part 4: Driver Evaluation

	Highly Ineffective	Ineffective	Not Sure/Neutral	Effective	Highly Effective
28. Continuous tracking of driver crashes, incidents, violations	0	1	2	3	4
29. Periodic observation of driving	0	1	2	3	4
30. "How's My Driving" placards with call-in phone numbers	0	1	2	3	4
31. On-board electronic monitoring	0	1	2	3	4

Part 5: Driver Management

	Highly Ineffective	Ineffective	Not Sure/Neutral	Effective	Highly Effective
32. Remedial training	0	1	2	3	4
33. Manager ride-alongs for evaluation/ feedback	0	1	2	3	4
34. Senior driver ride-alongs for evaluation/feedback	0	1	2	3	4
35. Suspension from service	0	1	2	3	4
36. Verbal reprimand	0	1	2	3	4
37. Written reprimand	0	1	2	3	4
38. Monetary penalties	0	1	2	3	4
39. One-on-one counseling by manager	0	1	2	3	4
40. Mentoring/counseling by a senior driver	0	1	2	3	4
41. Monetary rewards for improvement	0	1	2	3	4
42. Non-monetary rewards for improvement (e.g. recognition, praise)	0	1	2	3	4
43. Teaching self-management to driver (e.g. self-monitoring, goal setting)	0	1	2	3	4

For questions 44-45, CIRCLE THE LETTER of the statement you agree with the most.

44. For *drivers in general*, which has a greater influence on driver safety? *(circle the appropriate letter)*
    a. Rewards for safe driving (praise, merchandise, cash)
    b. Disciplinary actions for unsafe driving
    c. The above two have equal impact

45. For *problem drivers (e.g., worst 10%)*, which has a greater influence on driver safety? *(circle the appropriate letter)*
    a. Rewards for safe driving (praise, merchandise, cash)
    b. Disciplinary actions for unsafe driving
    c. The above two have equal impact

Part 6: Comments

46. Any comments on high-risk commercial drivers or any part of this survey?

____

____ _

____

Part 7: Information about You

47. Approximately how many years of professional experience do you have relating to motor carrier safety? __________

48. Please circle or underline **all** experience areas below for which you have one year or more experience relating to motor carrier safety. (*Circle or underline all experiences which you have had one or more years experience)*

   a. Government enforcement
   b. Other government (e.g. rulemaking)
   c. Industry trade association
   d. CMV driver
   e. Carrier safety manager
   f. Other carrier management position
   g. Safety consultant or vendor to fleets
   h. Accident investigation/data analysis
   i. Motor carrier safety research
   j. Journalist
   k. Driver trainer
   l. Insurance for motor carriers
   m. Other: ___________________________

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Should you wish to provide your contact information (as noted on the cover letter), you will be sent an Adobe (pdf) copy of the project final report via email when it is published in Summer, 2004, and a copy of the completed report entitled, *Effective Commercial Truck & Bus Safety Management Techniques: A Synthesis of Safety Practice*.

Thank you again for your participation in this study!

APPENDIX E

RELEVANT STATISTICAL CONCEPTS

This appendix summarizes some basic statistical concepts relevant to individual differences, the association of various factors with risk, and quantifying risk.

E.1 BASIC STATISTICS OF DISTRIBUTIONS AND CORRELATIONS

The concept of high-risk drivers and differential driver risk implies that there is significant variation in the occurrence of crashes or other incidents among drivers in a group and that differential risk may be predicted by various personal factors. Some basic statistical distribution types are shown in Figure 18. The "normal" distribution (part **a**) is bell-shaped and symmetrical. Both the mean (arithmetic average) and median ("middle") values of the distribution are located at the center of the distribution indicating that the largest number of subjects is located in the center, also. For example, height (within a gender) and IQ scores are two human traits that are generally normally distributed. If commercial driver's crash risk were normally distributed, most drivers would have risk levels near the center, a few would be much lower, and a few would be much higher.

However, this appears not to be the case. Instead, there are many commercial drivers with very low crash risks and some with elevated risk related to various factors to be discussed in this synthesis. In these situations, the mean is higher than the median since a few high-risk scores raise the overall arithmetic average. This is the distribution that seems to most frequently characterize driver risk within a group of drivers. Part **b** shows how the distribution would be "positively skewed" due to these high-risk drivers. In this distribution, using risk as an example, there are many low-risk scores but some very high-risk scores.

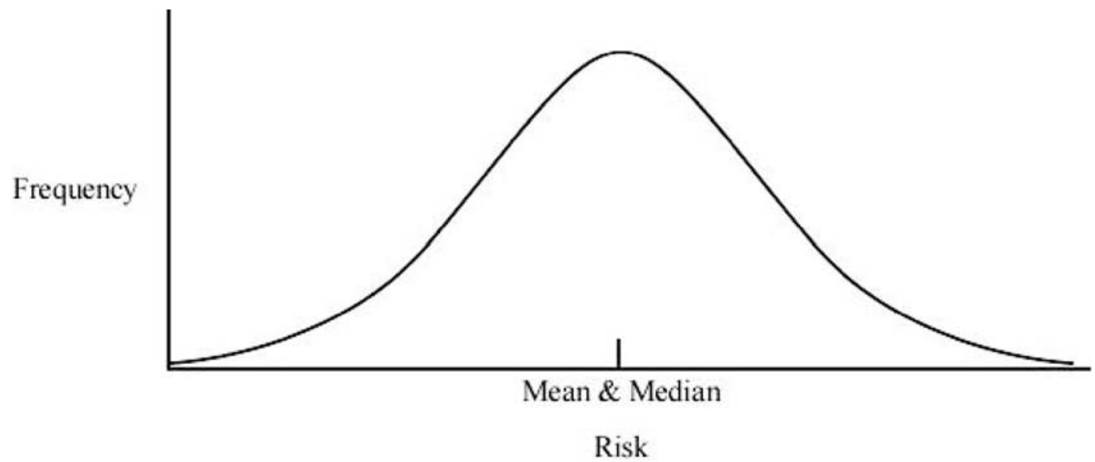
Finally, part **c** shows a "negatively skewed" distribution. This distribution would apply if a few drivers had very low relative risk, while the majority was at a relatively high level. In such a distribution, the mean is lower than the median. This distribution does not seem to frequently describe the variation of driver risk or its associated factors.

The second type of statistical relationship important for understanding and analyzing driver risk is the correlational relationship. Correlates range from −1.0 (a linear *inverse* relation) through zero (no relation) to +1.0 (a linear direct relation). Risk factors or predictive measures (e.g., the score on a personality or performance test) are often stated in terms of their degree of correlation with a safety criterion measure (e.g., crashes or incidents). Scatter plots are shown in Figure 19 below illustrating (a) a moderate +0.5 correlation and (b) a high +0.9 correlation. Correlations of psychological variables are often in the moderate range such as the +0.5 correlation shown.

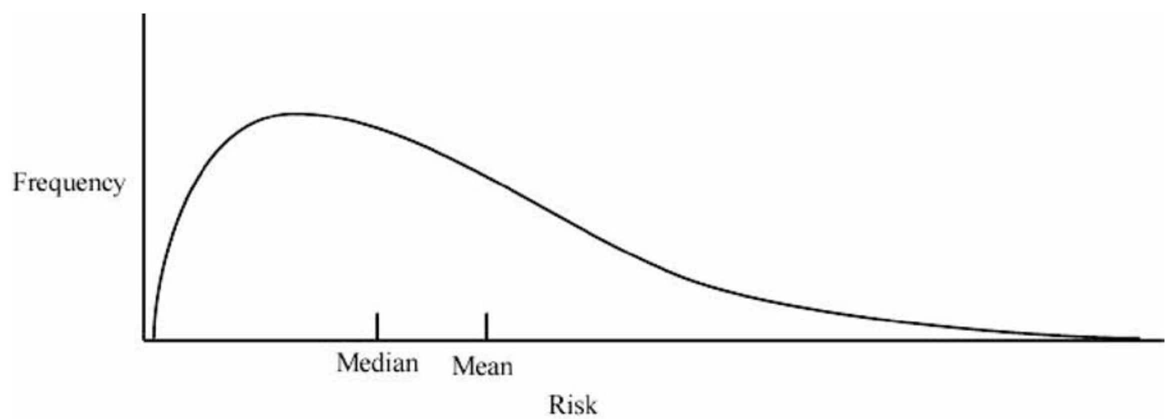
E.2 DIFFERENTIAL RISK AND RANDOM EVENTS

Crashes, violations, and incidents are examples of discrete events that can be described in relation to a Poisson distribution. This distribution applies to a situation where events occur by random chance. If observed variation does not follow this distribution, there are factors other than chance impacting the outcome.

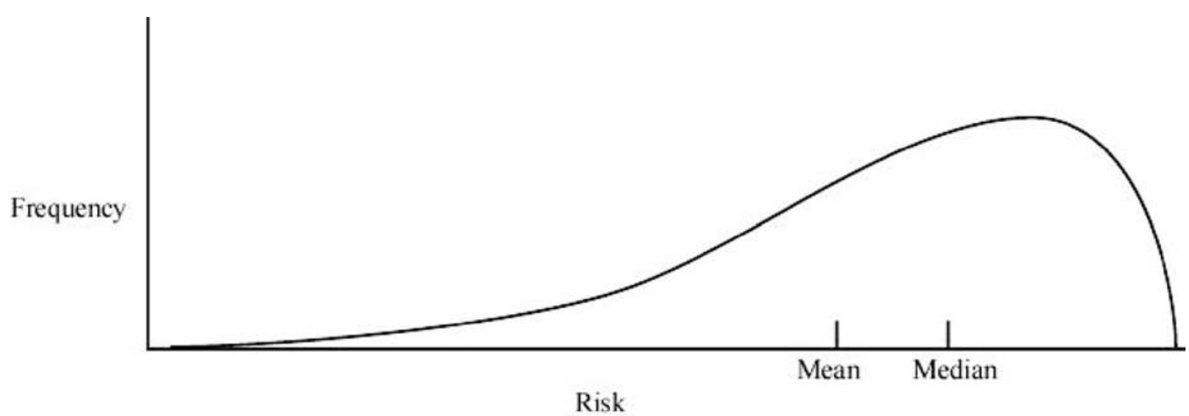
A research example illustrates how chance variation could be distinguished from variation not explainable by chance alone. The FMCSA Driver Fatigue and Alertness Study (DFAS; Wylie et al. 1996) used instrumented vehicles equipped with in-cab videos that permitted driver drowsiness to be rated over a week of normal operational driving. Eighty drivers had an average of 6.7 drowsiness episodes each. There were pronounced individual differences in the number of observed drowsy episodes; 29 of the DFAS drivers (36%) were never judged drowsy while, at the other extreme, 11 of the drivers (14%) were responsible for 54% of all the drowsiness episodes observed in the study. Figure 20 shows the distribution of drowsiness episodes among the 80 drivers that one would expect if only chance variation were operating. It illustrates a Poisson statistical distribution used to evaluate a situation where there is variation in the occurrence of discrete events (e.g., crashes) for a group of subjects. The actual distribution differs very significantly from the "chance only" Poisson distribution (chi-square test; $p < 0.00001$, meaning that there is less than one chance in 100,000 that the result could have occurred by chance alone). Figure 21 shows the chance and actual distributions. Most notably, many of the drivers had more drowsiness episodes than could likely have occurred by chance. It's clear that other factors besides chance impacted the number of drowsy epochs. Comparing the two distributions shows one driver group has a larger number of drowsy episodes than would be expected based on chance, while another driver group has a lower number than would be expected by chance.



(a) "Normal" Distribution

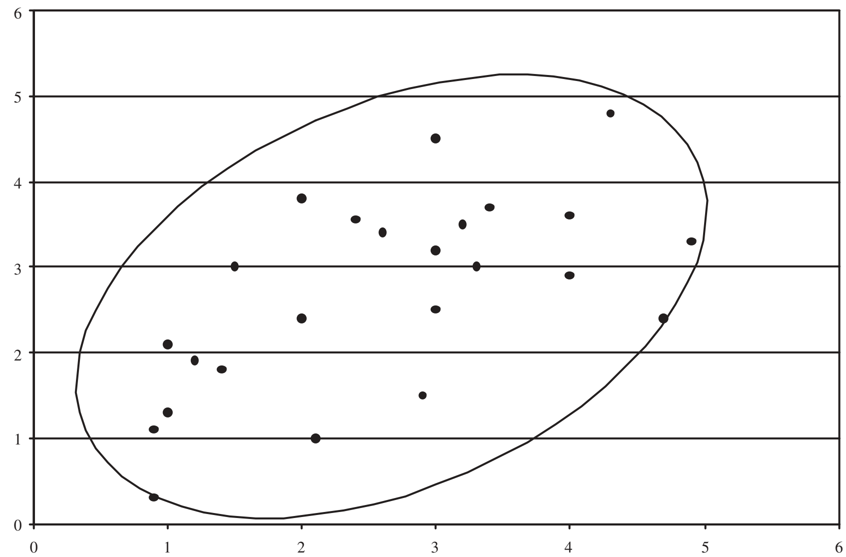


(b) Positively Skewed Distribution

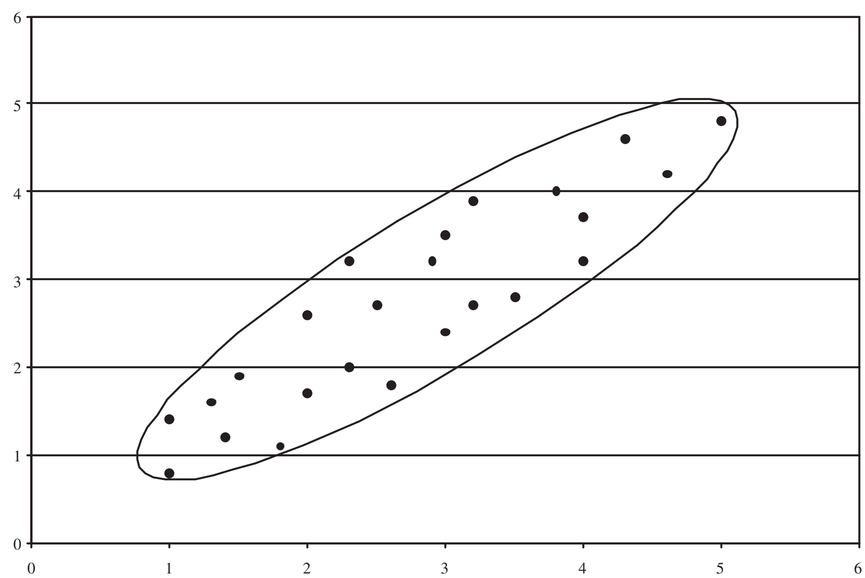


(c) Negatively Skewed Distribution

Figure 18. Three hypothetical risk distributions.



(a) r = +0.5



(b) r = +0.9

Figure 19. Hypothetical correlational relationships.

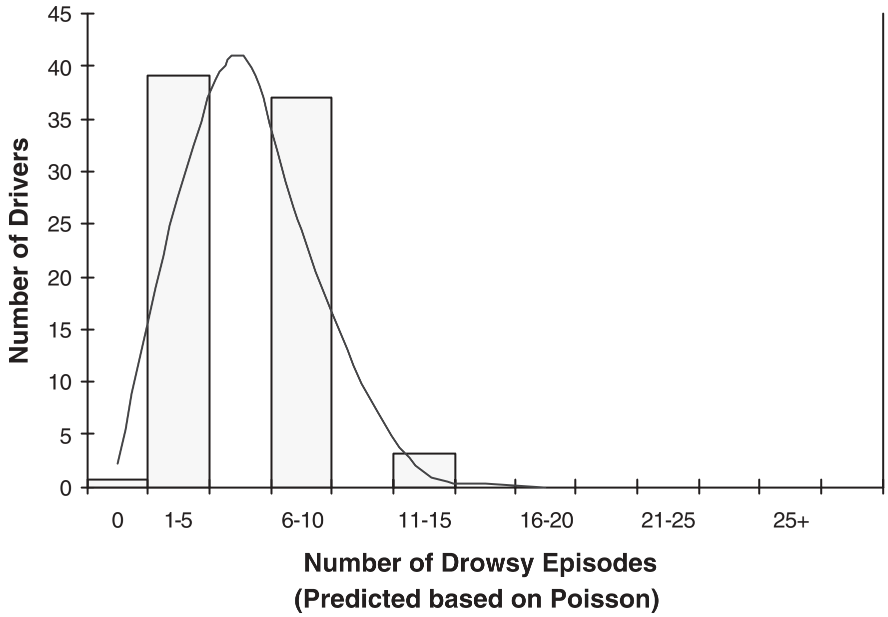


Figure 20. *Predicted number of drowsy episodes for the sampled group based on the Poisson distribution (assuming that only chance is operating)*

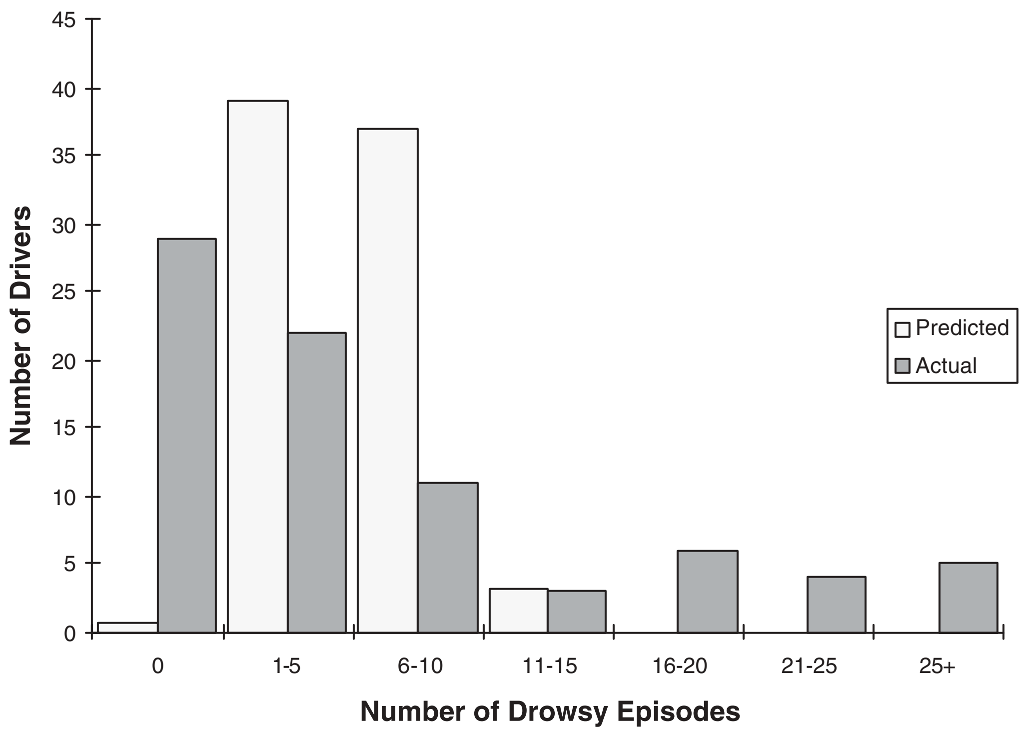


Figure 21. *Comparison of the actual number of drowsy episodes with the predicted number of episodes for the sample group.*

TABLE 12 Variables from simple regression model predicting likelihood of severe crash

Driver Characteristic	Coefficient	Probability (chi-square)
Identified as Drowsy	1.679	$p < 0.0001$
Uses Safety Belt	-1.153	$p < 0.0001$
Intercept	-2.82	

E.3 DEMONSTRATING FACTORS AFFECTING RISK

To determine whether correlating factors should be viewed as having true relationships with risk, and not as being the result of a chance occurrence, one must understand how researchers investigate and analyze the data. The determination of crash risk factors can be made using statistical models that predict the likelihood of crash involvement based on various factors (e.g., hours driving, drowsiness, safety belt usage, age). The outcomes of these models are numbers measuring the relative risk of crash involvement. These numbers have a probability associated with them that indicates whether the resulting risk is occurring due to chance alone. In most scientific studies, p-values of less than 0.05 are required to discount chance as a principal factor underlying the results.

A simple example, generated by a commonly used statistical software package (Statistical Analysis Software [SAS]) using NHTSA General Estimates System (GES) data (on the overall population of crashes), is shown in Table 12. This model was developed to predict the likelihood of being involved in a severe crash based on whether or not the driver was cited as being drowsy at the time of the incident and on safety belt usage. A severe crash was defined as a crash that resulted in a fatality or incapacitating injury. A non-severe crash was defined as a crash that resulted in no injury or injuries that were not incapacitating. In this example, drowsiness and safety belt non-use were found to be significant indicators of severe crash involvement. The negative coefficient for "uses safety belt" indicates an inverse relationship, that is, use was associated with low crash severity, non-use with high severity. The probability of these variables having an impact on crash severity by chance are less than 0.0001 (or very slim) as indicated in the chi-square probability value that was generated.

Writing these variables in the form of a predictive regression equation, the model would look like

$$\textbf{Probability (Severe Injury)} = -2.82 + 1.68\ \textbf{Drowsy} - 1.15\ \textbf{Safety Belt}$$

The coefficients of this model can be used to approximate the relative risk or odds ratio of being involved in a severe injury. These approximations based on logistic regression odds calculations would be:

- Drowsy
  - Odds Ratio: 5.36
  - 95% Confidence Interval: 5.24 to 5.48
- Safety Belt
  - Odds Ratio: 0.32
  - 95% Confidence Interval: 0.31 to 0.32

What do these relative risks indicate? These values indicate that drivers who tend to be drowsy are more than 5 times more likely to be involved in a severe crash (versus a low-severity or non-injury crash). The corresponding confidence interval indicates that a driver who is drowsy will have a risk factor somewhere between 5.2 and 5.5.

These regression-type models have been used to investigate the likelihood of crashes given driver age, gender, driving time and day, alcohol use, fatigue, and medical related conditions. Regression models can encompass both objective and subjective variables, as long as they can be quantified. Objective predictive measures include driver physical characteristics, average hours of sleep nightly, number of crashes or violations, and age. Subjective predictive measures include driving preferences, self-assessments of fatigue, and self-assessments of driving stress. In addition to personal driver factors associated with risk, there are also many non-driver (vehicle and roadway) and situational (weather, traffic) factors that can be predictive of crash involvement.

APPENDIX F

SAMPLE "TOOLS" FOR IMPROVED DRIVER SELECTION AND MONITORING

This appendix contains a variety of safety management "tools" developed for use by fleet safety managers and CMV drivers. The material in this appendix has been contributed by co-authors Carmen Daecher and James S. York.

1. Driver Hiring Process. Contributed by the Daecher Consulting Group.

2. Application for Employment. Contributed by the Daecher Consulting Group.

3. Structured Personal Interview. Contributed by the Daecher Consulting Group.

4. Minimum Driver Eligibility Criteria. Contributed by Jim York of Zurich Services Corporation.

5. Driver Safety Record. Contributed by Jim York of Zurich Services Corporation.

6. Performance Coaching Job Aid. Contributed by Jim York of Zurich Services Corporation.

APPENDIX F-1

DRIVER HIRING PROCESS

(Contributed by Daecher Consulting Group)

Step 1
- ❍ Recruiting
- ❍ Newspaper
- ❍ Radio
- ❍ Referrals
- ❍ Employment Service
- ❍ State Job Service
- ❍ Trade Schools
- ❍ Truck Stops

Step 2
- ❍ Telephone or Personal visit
- ❍ Position requirements
- ❍ Prequalification form
- ❍ Company information and job description

Step 3
- ❍ Terminal manager instructs applicant on how to complete application
- ❍ Applicant completes application
- ❍ Terminal manager reviews it

Step 4
- ❍ Confirm information on application
- ❍ Study application carefully
- ❍ Discuss with applicant

Step 5
- ❍ Finish application process and begin testing
- ❍ Do driver analysis, MVR, DAC, road test
- ❍ Do background checks

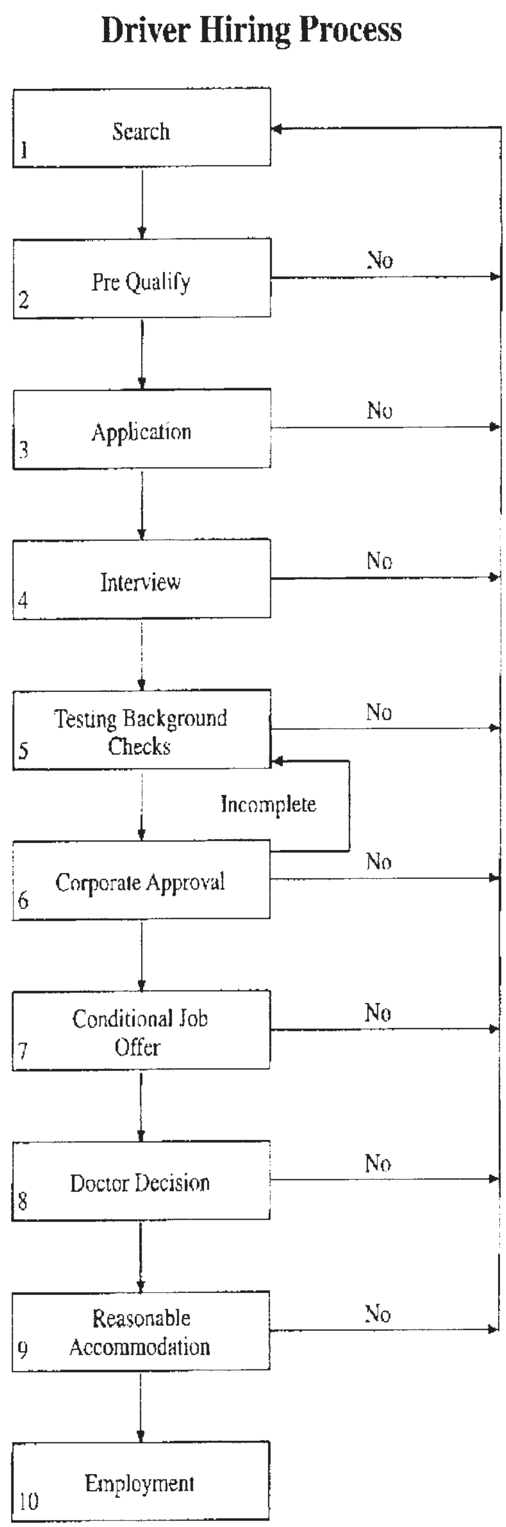
Step 6
- ❍ If yes, notify field, go to step 7
- ❍ If no, dismiss applicant, send copy of file to dead files
- ❍ If incomplete, hold until missing documents received

Step 7
- ❍ Offer job conditional on meeting DOT physical requirements
- ❍ Quote wages
- ❍ Have potential employee complete medical history form
- ❍ Send for physical - include:
  - ❍ medical history form
  - ❍ job description
  - ❍ Physical Exam/Drug Screen
  - ❍ Back Evaluation Form

Step 8
- ❍ Get doctor evaluation based on
  - ❍ physical
  - ❍ back evaluation
  - ❍ medical history
  - ❍ job description
- ❍ Have doctor send results to terminal manager
- ❍ Terminal manager checks for DOT compliance
- ❍ Terminal manager sends to human resources department
- ❍ Results may be
  - ❍ hire, no limitations
  - ❍ hire, with limitations
    - ❍ accommodations
    - ❍ confidential files
  - ❍ no hire

Step 9
- ❍ Contact human resources

Step 10
- ❍ Complete Files
- ❍ Receive negative drug screen
- ❍ Put on payroll



APPENDIX F-2

APPLICATION FOR EMPLOYMENT

(Contributed by Daecher Consulting Group)

APPLICATION FOR EMPLOYMENT

Name & Address of Motor Carrier Must Appear. DATE______________

Motor Carrier
Name____

Motor Carrier
Address____
(NUMBER & STREET) (City) (STATE & ZIP CODE)

Name in Full____

Phone #_________________

Current Address____

How Long?_______

List addresses for
past three years:____

How Long?_______

(Attach sheet if more space is needed)____

How Long?_______

Are you at least 21 years of age? □ Yes □ No

Social Security Number___________________________________

Date available:__________________________

In case of emergency notify___________________________

Have you worked for this company before? □ Yes □ No

If yes, where?___________________________________

Dates: From______________ To _______________

Reason for leaving:____________________________

Have you been convicted of a misdemeanor or felony within the last 5 years? □ Yes □ No

(Such conviction will not automatically bar you from employment. All Circumstances will be considered.)

PHYSICAL HISTORY

Do you have any physical or other condition which may limit your ability to perform the job applied for? □ Yes □ No

If yes please explain____

Date of last DOT examination______________________

Have you ever been granted a waiver under Section 391.49 of the Federal Motor Carrier Safety Regulations pertaining to the loss of a foot, leg, hand, or arm? □ Yes □ No

EDUCATIONAL HISTORY

SCHOOLS	NAME OF SCHOOL	ADDRESS	GRADUATE OR DEGREE?
Grade School			
High School			
College or University			
Business or Technical			
Other			

EMPLOYMENT RECORD

(Please provide a complete list of all employment for periods of unemployment during the past 10 years. Start with the most recent position first.)

EMPLOYER (LIST LAST ONE FIRST)	ADDRESS	POSITION	EMPLOYED FROM TO	SALARY	REASON FOR LEAVING

DRIVING EXPERIENCE RECORD

CLASS OF EQUIPMENT	TYPE OF EQUIPMENT (VAN, TANK, FLAT, ETC.)	FROM	TO	APPROX. NO. MILES (TOTAL)

EXPERIENCE AND QUALIFICATION

(All driver licenses held last 3 years.)

STATE	LICENSE NO.	CLASS	EXPIRATION DATE

A. Have you ever been denied a license, permit or privilege to operate a motor vehicle? ☐ Yes ☐ No

B. Has any license, permit or privilege ever been suspended or revoked? ☐ Yes ☐ No

C. Have you ever been disqualified subject to Section 391.15 of the Federal Motor Carrier Safety Regulations? ☐ Yes ☐ No (if the answer to A, B, or C is yes, attach statement providing details)

ACCIDENT RECORD FOR PAST THREE YEARS

MO.-YR.	TYPE ACCIDENT	TYPE EQUIPMENT	DEATH OR INJURIES	STATE	NIGHT OR DAY	EXPIRATION DATE

APPLICANT: READ AND SIGN BEFORE COMPLETING THIS APPLICATION:

I hereby give authority to the employer or his agents to investigate my background in order to ascertain any and all information of concern to my record, whether same is of record or not, and I release employers and persons named herein from all liability for any damages on account of his furnishing such information.

I understand that misrepresentation or omission of facts asked for on this employment application may, if I am hired, result in my immediate discharge.

It is also agreed and understood that I will furnish such additional information and complete such examinations as may be required to complete my employment file.

I understand that this application does not represent an employment contract and that, if hired, my employment can be terminated, with or without cause, at any time at the option of either the Company or myself.

This certifies that this application was completed by me, and that all entries on it and information in it are true and complete to the best of my knowledge.

Date________________________

Applicant's Signature____

APPLICANT, DO NOT WRITE BELOW THIS LINE. FOR COMPANY USE ONLY.

Interview date________________

Hire Date____

If not hired, note reason why____

Remarks____

Date________________________

Interviewer's Signature____

APPENDIX F-3

STRUCTURED PERSONAL INTERVIEW

(Contributed by Daecher Consulting Group)

Personal interviews are used to determine both the skills and the attitudes of applicants. Usually, the interviewer assesses the applicant on a variety of subjective items. Although the approach is not scientifically reliable, many employers have developed a skill in selecting employees appropriate for their organizations.

Loose, unstructured interviews are no longer an acceptable selection protocol. A recent Supreme Court decision (Watson vs. Fort Worth Bank and Trust) held that subjective promotion and selection systems are subject to the same scientific standards of job relatedness and validity as more formal tests. For this reason, structured interviews which follow a prescribed set of questions should be used in lieu of informal and unstructured interviews. The questions included in a structured interview should have empirical, logical or theoretical connections with the position for which the interview takes place. That is, there has to be a direct connection between the questions asked and the job responsibilities.

The interviewer should be trained in the use of the structured interview process and should have a working knowledge of the requirements of the job for which the applicant is interviewing. All information gathered up to this point should be available to the person who conducts the interview. Any questions or concerns that arise because of information obtained during the review of previously collected information should be addressed during this personal interview.

Finally, we believe structured face-to-face interviews yield more consistent and accurate results than informal or unstructured interviews.

Like advertising an open position and the telephone interview, the face-to-face structured interview has several functions:

- Detect any undesirable employment traits of applicants
- Select only the best qualified applicants
- Sell the applicants on accepting a job offer

Generally, driver applicants aren’t comfortable in a job interview setting. The interviewer is responsible for managing the interview. This begins with a warm welcome in an atmosphere conducive to conversation. Remember, the applicant is forming an impression of your company. Be friendly, but also be precise in what you say. Leave little room for interpretation.

You should begin with an overview of your company, your mission, strategy, size, areas of operation, and stability. Next discuss the personality of your company and how the drivers fit into that personality. Explain the duties and responsibilities of the job and ask the applicant if he or she feels comfortable with them.

Happiness or unhappiness is often the result of improperly developed expectations. Do not oversell the job. If you paint a rosy picture of the day-to-day life the driver can expect and it turns out something less than that, you will eventually lose him or her anyway. On the other hand, don’t speak of the job in such negative terms that the applicant loses interest. Your task is to identify qualified applicants. Remember, misrepresented or miscommunicated expectations are a root cause of turnover and occasionally result in legal action.

HOW TO USE THE STRUCTURED INTERVIEW FORM

1. Complete the sections describing your organization. You can add, delete, or edit as appropriate for your needs.

2. Make enough copies so that one form can be used for each interview.

3. Before the interview begins, review the information on the form. Complete the following spaces:
    a. Applicant's name
    b. Your name and title
    c. Date of interview
    d. Time started.

4. Conduct your interviews as discussed in the previous section.

5. As the applicant responds, take notes. It will not be possible to write out every word - just jot down key points.

6. Review the information recorded with each question and rate the individual's response per the following scale:

    5: Superior (significantly above criteria required for successful job performance)
    4: Good (generally exceeds criteria relative to quality and quantity of behavior required)
    3: Acceptable (generally meets criteria)
    2: Marginal (generally does not meet criteria)
    1: Unacceptable (significantly below criteria required for successful job performance).

Occasionally, an applicant's response will give no clear-cut indication as to his potential performance in a specified area. When this occurs, rate 0.

There will sometimes be indications that the person behaves differently under different conditions. Do not hesitate to give a range, for instance, 4-2 (which means that on some occasions they are more than acceptable, while on other occasions they may be less than acceptable).

Finally, when an applicant's performance falls slightly above or below a particular number, do not hesitate to use a + or a - sign to suggest the direction in which you are leaning.

Regardless of your hiring decision, make the structured interview form a part of the applicant file.

STRUCTURED INTERVIEW FORM

Categories:

I. Company Background

II. Basic Driver-Applicant Information

III. Understanding the Job

IV. Safety

V. Interpersonal

VI. Stability/Tolerance

VII. Reliability

VIII. Composite Sheet

I. COMPANY BACKGROUND

Our company was founded in _____________. We operate in _____ states. We are a ____ (include brief description of your company and its history). We have ___________ locations and operate _____________ power units.

Our company philosophy is ____. We attempt to hire drivers who ____.

When you join our company, you can expect ____________________________________. We have _____________ drivers. The average length of time on the road is ____________________. You can expect to be home_____________________________.

Include information on:

- Pay Scales & Systems
- Incentive Programs
- Award Programs
- Equipment Types & Assignment
- Dispatch System

II. BASIC DRIVER-APPLICANT INFORMATION

Name: ____
Age: ________

Current
Address:____

Current Place of Employment:
____

____

Why Does He/She Want to
Leave?____

____

____

Education
Level:____

When Did He/She Take Their First Job?_______________________________________

Average Stay with a Company:____

Expectations of This Job:____

____

____

____

Questions on Previous Employers Besides the Latest One.

____

____

____

Questions on Violations & Accidents Listed on the Application.

____

____

____

Questions on Previous Employer Responses.

____

____

____

Questions on Licenses & Experience.

Any other questions that arise as a result of information obtained during previous steps in the hiring process.

III. UNDERSTANDING THE JOB

1. What do you like best about your job as a driver? Give me examples.

   Like Best Why

2. What do you like least about your job as a driver? Give me examples.

   Like Least Why

3. What are your standards of success in your job? What have you done to meet these standards?

   Standard Action Result

4. In your current or most recent position, how do (did) you define "doing a good job?" Are (were) you doing a good job? How do (did) you know? Give us examples.

   Definition Action Result

5. What do you think it takes to be a top-notch driver? How do you match up?

   Standard Result

6. What makes the job of driving difficult for people? What makes it difficult for you?

   Definition Result

Notes:

IV. SAFETY

1. Everyone has had to bend rules, at times, to get a job done. Share some examples of when you had to do this.

   Situation | Action | Result

2. Give some examples of safety requirements that were part of your job at ____________. How did you honor these requirements?

   Requirement | How Honored

3. Give me an example of when you recognized and corrected an unsafe situation.

   Situation | Action | Result

4. What kinds of accidents or near accidents have you had? (Probe for a cause.)

   Accident | Cause | Result

5. What is the difference between a safe driver and an unsafe driver?

   Difference | Result

6. In most cases, which factor contributes most to accidents (e.g., road conditions; traffic; other drivers; weather; visibility; you, the driver)?

   Factor | Result

Notes:

V. INTERPERSONAL

1. How much customer interaction do (did) you have on your job? What are the pros and cons of dealing with customers?

   Amount of Interaction   Result

2. Sooner or later, we have to deal with a customer who makes unreasonable demands. Think of a time when you had to handle unreasonable requests. What did you do?

   Situation   Action   Result

3. Have you ever had to go the "extra mile" to satisfy a customer? Give me an example.

   Situation   Action   Result

4. Contrast times when you have been effective in handling customer complaints and times when you have not. What did you do differently in these situations?

   Effective   Ineffective   Difference

5. Give me an example of when you recognized and corrected an unsafe situation.

   Situation   Action   Result

6. What is the key to dealing successfully with others?

   Key   Result

Notes:

____

____

____

____

____

VI. STABILITY/TOLERANCE

1. Everyone loses his or her temper once in a while. Tell me about the time when you last lost your temper. What led up to it and what was the result?

   Situation   Result

2. What kinds of pressure do you feel on the job? Tell me about them. Have you dealt with them?

   Pressure When, How Coped? Effect

3. What are the highest pressure situations you have been under in recent years? How did you cope?

   Situation Result

4. How do you deal with someone who is obviously trying to give you a hard time?
   Situation Result

5. By hiring an employee, our company is making a financial investment. Why should we invest in you, ______________________ ?
   (name)
   Answer

6. How does someone really get under your skin?

   Situation Result

Notes:

____

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____

VII. RELIABILITY

1. Our bosses are not always completely satisfied with the way we do things. Can you give me some examples of when this happened to you?

   Project Action Result

2. What personal sacrifices do (did) you make to do your job effectively?

   Situation Sacrifice (Why?) Result

3. What are some valid reasons for not living up to a commitment?

   Reasons Result

4. In doing a job, sometimes we have to make a trade-off between quality and quantity.

How do you decide?

How

Notes:

VIII. COMPOSITE SHEET

UNDERSTANDING THE JOB

Has a distorted or inaccurate view of the driving job. May have glorified view - sees the good, but not the bad.	Has a fairly well balanced perspective. Understands what the job entails for the most part.	Knows what the job entails, clear picture of what it's all about and what he/she needs to do to succeed.

1 2 3 4 5

Notes:

SAFETY

Seems unaware of safety issues. Willing to let some safety issues slide (e.g., pre-trip). Doesn't take ownership of safety problems--points to others, believes he/she can't make a difference.	Aware of some, but not all crucial issues. Does most of the important things. Believes he/she is partially responsible.	Recognizes extreme importance of safety. Follows regs and SOPs to the "T". Believes he/she is totally responsible for safety problems.

1 2 3 4 5

Notes:

INTERPERSONAL

Rude, offensive, argumentative. “It's not my job” and does the minimum needed to get by.

Hot and cold. Works O.K. with some, has trouble with others. Will help out at times when convenient and when he/she feels like it.

Cordial, respectful, co-operative. Eager and willing to help others in need of assistance.

1 2 3 4 5

Notes:

____

____

STABILITY/TOLERANCE

Impulsive, flies off the handle. Argumentative. Rigid. Has difficulty dealing with shifting priorities. Unwilling to put up with difficulties or inconveniences.

Can react when “hot button” is pushed. Likes consistency. Will tolerate only so much, then will put his/her foot down.

Restrained, steady, calm, relaxed. Flexible, will go with the program. Will tolerate inconveniences when required.

1 2 3 4 5

Notes:

____

____

RELIABILITY

Careless with respect to commitments, casual about his/her responsibilities. Unreliable. Cannot be counted on for much of anything.

Keeps commitments some - times - depends on circumstances, but will usually come through. Will not really push himself when he/she should.

Responsible - takes commitment seriously. Will go out of his/her way to get the job done. Can be counted on to come through for the company.

1 2 3 4 5

Notes:

____

____

APPENDIX F-4

MINIMUM DRIVER ELIGIBILITY CRITERIA

(Contributed by Jim York, Zurich Services Corporation)

Background

In an effort to ensure that the most competent and safe drivers are employed at Any Company USA, the following eligibility requirements must be met by each prospective/current employee seeking/holding a position as a driver of a commercial motor vehicle.

Minimum Age: 21

Language: Must be able to speak and write the English language.

Required License: Must possess a valid driver's license with the applicable endorsements to operate the vehicle within the department to which applicant has applied for employment.

Experience: Must demonstrate a minimum of two years total experience, with at least one year "in-type" (similar to prospective position).

MVR Quality: No more than one conviction for moving violations within the previous 12 months. No more than two convictions for moving violations within the previous 24 months. No more than three convictions for moving violations in the previous 36 months.

Accident History: No more than one ***preventable accident*** in the previous 12 months and no more than two ***preventable accidents*** in the previous 36 months. No more than one ***major preventable accident*** within the previous 36 months.

Disqualifying Offenses: No applicant may have been convicted for any of the disqualifying offenses defined at 49 CFR Part 383.51 and 383.53 of the Federal Motor Carrier Regulations.

Criminal History: The review committee must review any applicant with a prior criminal history.

Physical Qualifications: Each applicant must meet the requirements defined at 49 CFR Part 391.41 of the Federal Motor Carrier Safety Regulations.

Definitions

Moving Violation: A conviction, that occurred in a commercial or non-commercial motor vehicle for any of the following offenses:

Speeding: less than 15 mph over the posted speed limit
Failure to obey traffic control device
Improper passing
Improper turn
Failure to yield right of way

Preventable Accident: An accident, as ruled by the review committee, where the driver failed to do everything that reasonably could have been done to avoid the incident

Major Preventable Accident: A preventable accident arising from a lane change, rear end collision, or intersection incident, which resulted in a fatality, injury requiring treatment away from the scene, or disabling damage (tow away) to any vehicle(s).

Disqualifying Offense: Any of the drug or alcohol or serious traffic violations, committed in a commercial or non-commercial motor vehicle, which are defined at 49 CFR Part 383.51 of the Federal Motor Carrier Safety Regulations. Generally, those violations include:

- **Drug or alcohol violations**
    1. Driving while under the influence of alcohol as prescribed by state law.
    2. Driving while under the influence of a controlled substance
    3. Refusing to take a drug or alcohol test

- **Serious traffic violations**
    1. Speeding for any speed equal to or greater than 15 mph over the posted speed limit
    2. Reckless driving as defined by State or local laws
    3. Improper or erratic lane changes
    4. Following too closely

Disqualification provisions

Drivers convicted for the ***first Drug or Alcohol violation within the previous five year***s are disqualified for driving for a period of one year.

Drivers convicted for the ***second serious traffic violation within a the previous 36 month period*** are disqualified for driving for a 60 day period.

APPENDIX F-5

DRIVER SAFETY RECORD

(Contributed by Jim York, Zurich Services Corporation)

Driver Name:								Terminal Name:																
Safety Incident	Incident Date and Performance Step																							
	Calendar Year: 2004												Calendar Year: 2005											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Preventable Accident																								
Major Preventable Accident																								
Moving Violation																								
DOT Violation																								
Spill/Contamination																								
Other:																								

Notes to Terminal/Branch Managers:

1. Use this form to track the safety record of each employee during a 24 month period.
2. Enter the date and "Step Number" in the appropriate year/month box. For example, you were notified that driver John Doe's violation record indicated a speeding (Moving) violation, which occurred on June 25, 2004. This was his first moving violation within a 24 month period. This incident would be entered in the ***"Moving Violation"*** row as ***25/1 in the June, 2004*** grid box.

DEFINITIONS

Preventable Accident:	An accident, as ruled by the review committee, where the driver failed to do everything that reasonably could have been done to avoid the incident
Major Preventable Accident:	A preventable accident arising from a lane change, rear end collision, or intersection incident, which resulted in a fatality, injury requiring treatment away from the scene, or disabling damage (tow away) to any vehicle(s)
Moving Violation	Violations noted in driving record. Examples include: speeding, failure to obey traffic warning device/sign, following too closely, unsafe lane change, & etc.
DOT Violations	Other violations of the Federal Motor Carrier Safety Regulations. Examples include: log violation (false logs, over hours, no/missing logs)

APPENDIX F-6

PERFORMANCE COACHING JOB AID

(Contributed by Jim York, Zurich Services Corporation)

Name:		Employee ID:		Position:	
Date Hired:		Location			

Incident Review

Record the issue or opportunity regarding a specific safety incident noted in the driver's safety performance record.
Please provide details and dates:

____

____

____

____

Intervention Step

Please indicate the appropriate intervention step:

- ☐ Verbal (Step One)
- ☐ Written (Step Two)
- ☐ Decision Making Day (Step Three)
- ☐ Termination (Step Four)

Intervention and Action Plan

Part One: Employee

Employee's action plan to resolve the noted safety issue (to be filled out by the employee). Specifically, the plan must state what you, the employee, intend to do differently, to prevent future occurrences.

____

____

____

____

Part Two: Supervisor

Supervisor's action plan to resolve the noted safety issue (to be filled out by the supervisor). Specifically, the plan must state what you, the manager, intend to provide for the employee (e.g., training, information, etc.).

____

____

____

____

Certification

Employee	Date	Supervisor	Date

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation