March 9, 2001

Ms. Julie Cirillo
Acting Assistant Administrator
Federal Motor Carrier Safety Administration
Room 6316
400 7th Street, SW
Washington, D.C. 20590

Dear Ms. Cirillo:

The Committee for Review of the Federal Motor Carrier Safety Administration's Truck Crash Causation Study held its second meeting on January 25 and 26, 2001, at the National Research Council facilities in Washington, D.C. The enclosed meeting roster indicates the members, liaisons, guests, and TRB staff in attendance. On behalf of the committee, I want to thank the staff members of the Federal Motor Carrier Safety Administration (FMCSA) and the National Highway Traffic Safety Administration (NHTSA) for their presentations and responses to committee questions. I believe we had a very open and productive exchange of ideas.

The meeting provided the committee with an opportunity to review the progress of the pilot study, examine preliminary crash data and information for several crashes from the four pilot study data collection sites, and respond to agency questions about committee member suggestions for changes to the data collection forms. A good part of the discussion focused on the need to reduce subjectivity in the data as much as possible within project limitations. The meeting also included discussions about FMCSA and NHTSA expectations for the study. There was an exchange of views on the analysis method being used by the agency to determine critical crash events, and several other analysis methods were suggested.

The committee met in closed session to deliberate on its findings and begin the preparation of this report, which was completed through correspondence among the members. This report summarizes key discussions and provides several recommendations to FMCSA.

Study Purpose and Agency Expectations

FMCSA and NHTSA staff reviewed what they hope to achieve with the Truck Crash Causation Study (TCCS), the most comprehensive study of truck crashes ever attempted. Staff described the TCCS as an exploratory study of 1000 truck crashes aimed at collecting data on a wide range of crash factors related to the drivers, vehicles, roads, and trucking companies involved. The study data will enable the agency to develop inferences about crash circumstances and crash causes. The agencies expect the crash assessments to provide a basis for determining future countermeasure priorities, designing countermeasures, and developing measures of effectiveness for countermeasures.

Crash Event Assessment

FMCSA is basing the crash assessments on the Perchonok method of analyzing crash events as described in the FMCSA document provided at the committee's first meeting (see attachment). This method describes traffic crashes as the result of causal chains where events are linked to one another in a series of cause-effect relationships. Each effect serves as a cause for the next link in the chain. The approach calls for trained crash analysts to examine case documents to determine key crash factors, events, and reasons. These are coded according to a set of pre-determined definitions. While this diagnostic approach relies on the judgment of the crash analysts, its procedures have proven successful in other studies of motor vehicle crashes and will provide considerable information on a large number of crashes within the time and budget available. The agency plans to undertake additional analyses as described in a later section.

Several committee members and agency staff noted that there are slightly different versions of this method. In addition, the Perchonok method can result in differing conclusions about the critical precrash event and the reasons for the critical precrash events—the heart of the Perchonok method (Items 5 and 6 on the Crash Event Assessment form). Judgments on these items are critical to the Perchonok analysis (and, possibly, to other future analyses of the data) and there was considerable discussion during the meeting as to whether the judgments made in the presented cases were supported by the available data. As a result, the committee urged FMCSA to give considerable attention to ensuring both objectivity and consistency in the crash analyses.

First, the committee urged FMCSA to follow the procedures of the Perchonok version that is recognized as being the most objective approach to identifying key crash factors, i.e., the one that has been shown to result in the least bias toward any pre-determined outcome. This version should provide the crash analyst with the best tool for avoiding prejudging the circumstances or supporting a predetermined outcome. The choice should also be based on which method ensures the highest inter-rater and intra-rater consistency and reliability. The committee is not sufficiently familiar with the alternative methods to recommend the one that can best meet these goals. The choice will have to be made by FMCSA working with NHTSA staff and study consultants who are familiar with all versions. FMCSA should document its choice for future users of the analysis results and the data.

Second, the committee urged FMCSA to conduct two independent assessments of each crash case. (We note that independent here means making independent assessments of the critical precrash event and the reasons for the critical precrash event based on information in the collected data, not simply having one analyst review the assessments of another.) Subsequent to the meeting, the committee learned that FMCSA plans to undertake independent assessments of each of the 1000 cases. Crash assessments will be undertaken first by an experienced crash analyst in one of the two National Zone Centers and then by the supervisor of both zone centers. In addition, early in the study, most cases will be subjected to a third independent review by a consultant who is an experienced crash investigator. The committee strongly supports this multiple assessment approach. Continuing the dual assessment throughout the entire study will greatly increase the objectivity and consistency of the findings, and the third review in the early cases should identify the need for and facilitate any training or procedural changes needed in the assessment effort.

*Review of Pilot Cases*

Agency staff presented preliminary material on several pilot study crash cases to illustrate selected aspects of the crash event assessment process. While none of the case studies had been completed, the presentation nevertheless prompted considerable discussion and debate. Committee members expressed their concern about highly subjective interpretations of data and premature conclusions. While agency staff pointed out that the analysis of crashes would be based on several other data sources in addition to the data forms, many committee members strongly emphasized the need to ensure that any future presentations or discussions about the crash cases be limited to the recorded facts. Because the crash cases presented at the meeting were based solely on information from the data forms, many committee comments were directed at the items in the data forms (as discussed below). The committee requested that several complete pilot study crash case files be made available for committee review prior to its next meeting.

*Alternative Analysis Methods*

FMCSA staff indicated that it plans to use other analysis methods in a limited fashion following preliminary examination of the study data. The committee concurs with this decision, especially agency plans to undertake some limited exposure data analyses of specific driver- and vehicle-related factors. The committee also notes that the crash database will provide opportunities for analyses that may lead to increased insight on crash causation and risk. For example, one can hypothesize that a factor may increase the risk of certain types of crashes (e.g., poor truck brakes will result in more rear-end crashes in which the truck is the striking vehicle). One can then examine the relative risk of this factor between carefully selected subgroups in an attempt to reveal such associations (e.g., the proportion of poor brakes in trucks struck in rear-end collisions versus the proportion for trucks that are the striking vehicles in rear-end collisions). With careful planning, it may be possible to examine a number of possible "causative factors" in this manner.

In addition, the committee urges FMCSA to undertake "but-for" analyses of at least a sample of the crashes. "But-for" analysis was used in a previous crash causation study, the Indiana Tri-Level Study. The method involves a team of crash experts from several disciplines working together to identify the causal factors necessary or sufficient for the occurrence of the crash. (This could be done with the pilot study data being collected.) This method considers as many crash-related events and/or circumstances as possible and identifies those for which it can be stated "but-for the event (or circumstance), the crash would not have occurred." The committee believes this approach can provide additional insight into critical precrash events. In addition, FMCSA indicated that it will collect data on possible crash escape options or maneuvers available to the drivers involved in the crashes. These should facilitate this type of analysis. The team for such an analysis would require expertise in human factors, engineering, and trucking in addition to crash investigation. This team could be formed at a future date.

<u>Case Documentation: Data Forms and Other Information Sources</u>

*General*

Both FMCSA and the committee view the initial agency analyses of the data as the first of many such efforts because of the importance of truck safety and the landmark nature of this study. It is unlikely that such a data collection effort will be launched again for many years. (Most of the data will be collected by teams of trained investigators from NHTSA's National Automotive Safety Sampling System [NASS] project and FMCSA-funded truck safety inspectors.) The truck crash database being assembled will be important for many years to come. As a result, it is critical that the data collected be as accurate, objective, and complete as possible, and that they be documented in detail for future use by analysts who will not have the advantage of being involved in the data collection. Many committee member comments were based on the critical need for sound data and detailed documentation.

*Data Forms*

Following the first meeting, individual committee members provided written comments on the data collection and assessment forms being used in the TCCS. Agency staff provided written responses to these comments at this meeting. After some initial discussion about the comments and responses, it was clear that several issues persisted. These included the concern that some questions were not sufficiently tailored to the special circumstances of trucks and truck equipment, truck drivers, or carriers. To address this and other issues related to the forms, the committee established several task groups that met during the open session with agency staff to further discuss possible improvements in the data forms. In these discussions the committee stressed the need to reduce subjectivity in the data. The committee emphasized the need for objective, accurate, and focused crash data and information as a basis for effective assessment and determination of critical crash events. Several committee members agreed to further review selected data topics and items after the meeting and prepare additional suggestions. NASS staff indicated that they planned to complete revisions to the forms by the end of February 2001. (The committee suggested that future revisions to the data forms be identified with the revision date.)

*Other Information Sources*

Agency staff briefly reviewed other sources of information that form the full data set for each crash case. These sources include the following:

1. Crash Scene Drawings (prepared by the NASS crash investigator)
2. Narratives (prepared by the NASS crash investigator)

3. Motor Carrier Safety Assistance Program (MCSAP) vehicle inspection reports (prepared by state MCSAP inspector)
4. Police Report (prepared by the police who respond to the crash)
5. Interviews (conducted by the NASS crash investigator on site and/or later)
6. Photos (prepared by the NASS crash investigator)
7. Police Reconstruction (prepared by the police for a sample of crashes)
8. Medical Data (all or part of the medical records from the admitting hospital)
9. FMCSA Carrier Investigation Report (prepared by state FMCSA staff)

The committee plans to review completed examples of these forms at a future meeting.

*Relational Data Base*

Several committee members noted that they remained unclear as to how the various data forms relate to one another. FMCSA staff addressed this issue by briefly describing the relational database being developed for the TCCS. This database is of considerable interest to the committee and warrants further discussion at a future meeting.

*Data Availability and Data Preservation*

FMSCA has indicated that the data being collected for the TCCS will be made available to other researchers after specific personal, vehicle, company, and location references are removed. As noted above, the committee supports this plan and strongly urges FMCSA to ensure that all collected data are carefully documented and preserved so that all case information is readily available and can be easily understood by future researchers. While such documentation will involve considerable effort, it is very important for future data use.

Future Meeting Plans

The committee has scheduled its next meeting for August 20 and 21, 2001 in Washington, D.C. based on the understanding that the data collection for the full study will begin at all 24 study sites on about April 1, 2001. I invite you to join us at the meeting.

Sincerely,

Forrest Council
Chairman
Committee for Review of the Federal Motor Carrier
Safety Administration's Truck Crash Causation Study

## MEETING ATTENDANCE

### COMMITTEE MEMBERS

| | |
|---|---|
| Forrest Council, Chair | |
| Michael H. Belzer | A. James McKnight |
| John R, Billing | Raymond C. Peck |
| Kenneth L. Campbell | Lawrence A. Shepp (NAE, IOM) |
| James Dally (NAE) | Jack Stuster |
| Steven Vaughn | Anne McCartt |
| Frank R. Wilson | Hugh W. McGee |

### TRB Staff

Ann Brach
Walter Diewald
Susan Garbini

### LIAISONS AND VISITORS

Nancy Bondy, NHTSA
Stephen F. Campbell, Commercial Vehicle Safety Alliance
Joseph Carra, NHTSA
Ralph Craft, FMCSA
William Gay, Volpe National Transportation Systems Center
Donald Hendricks, Veridian Engineering, Inc.
Bob Ketenheim, FMCSA
Robert Lemieux, Volpe National Transportation Systems Center
Stephen Mavros, KLD Associates, Inc.
James Page, Veridian Engineering, Inc.
Richard Reed, Accident Research Analysis, Inc.
Jerry Scally, Volpe National Transportation Systems Center
Terry T. Shelton, FMCSA
Alan Smutny, Volpe National Transportation Systems Center
Gary Toth, NHTSA
Lynn Weidman, BTS
Robert Woodill, Accident Research Analysis, Inc.

**Attachment**

**FMCSA Statement of Approach for Coding In-depth Accident Investigation Reports**

The conceptual model for the in-depth accident database is taken from Kenneth Perchonok in *Accident Cause Analysis*. Perchonok describes traffic accidents as the product of causal chains, where events are linked to one another in a cause-effect relationship. Each effect serves as a cause for the next link in the chain.

**Crash Event Chains**

Consider a simple rear-end collision (this example is modeled on an actual fatal crash involving a heavy truck). The lead vehicle slowed to turn left into a driveway of a store's parking lot. There was no turning flare or center-left lane, so the car was slowing in the through-traffic lane. The truck driver of the following vehicle noticed some construction to his right in a mall and a sign advertising a two-for-one special at a fast food restaurant. He did not recognize that the lead vehicle was slowing until he was too close to stop safely. He braked, but couldn't stop in time and struck the lead vehicle in the rear. Cause-effect chains can be illustrated for the driver of the lead car, the driver of the following truck, and the following car itself in the table below. The arrows show the causal direction:

| Lead car driver | Following truck driver | Condition of following truck |
|---|---|---|
| | Mall construction and eye-catching signage | failure to follow program of preventive maintenance |
| | Activity attracts driver's attention | brakes worn |
| | Fails to notice slowing vehicle in time | increased stopping distance |
| | Brakes sharply | fails to stop in time |
| | Collision | |

Each cause is itself the effect of some other cause. And the cause-effect chain could be extended indefinitely for each of the three factors. But all of the factors listed above had to come together to produce this particular crash. If the truck's brakes had been in better shape, it may have stopped in time or at least not hit as hard. If the trucker had been paying more attention to the roadway ahead, he would have noticed the car in front slowing. If there had been no lead car, there would have been nothing for the distracted driver to crash into. If there had been a turn lane, the car would have been out of the line of traffic. If the lead driver hadn't decided to shop at that particular store, he wouldn't have gotten into the other driver's way. And so on. Some of the examples are trivial, but the point is that traffic accidents are complex events and many things have to be present at the same time for a crash to occur.

Thinking about traffic crashes in terms of multiple cause-effect chains has two principal advantages:

First, it corresponds with our intuitive understanding of traffic accidents as complex events, in which many factors can play a role. We are not trying to find a single "cause" of a traffic accident. To use the rear-end collision above again: What is the cause of this accident? Inattentiveness by the driver of the following vehicle? Following too closely? Insufficient braking capacity? Poor maintenance? Insufficient friction from the roadway? Roadway design not up to the increased flow of traffic because of the development of the mall? Poor driving technique since he didn't attempt to steer around the stopped vehicle? Slow reaction time? The distracting signs? Many factors *contributed* to the occurrence of the accident. Which one is the *cause*? Identifying the range of factors that contributed to the crash better captures what happened than simply listing "driver inattention" or "brakes out of adjustment" as the cause.

Second, approaching traffic crashes as the product of multiple chains of events gives us a broader perspective on crash prevention. Once you start thinking about crashes as the product of many factors, you can more easily identify a variety of different ways to prevent the crash or to lessen its severity. In the example above, a better brake maintenance program might by helped lessen the severity of the crash. A forward obstacle detection system might have alerted the driver in time. Defensive driving training might have improved the drivers response. Better roadway design might have moved turning traffic into a dedicate lane, improving traffic flow.

**The Critical Event**

Perchonok used the concept of the *critical event* to organize the coding of accidents. He defined the critical event as the event after which the collision was unavoidable. The critical event is the action or failure to act that puts the vehicles on a course so that the collision cannot be avoided given the proximity and relative velocities of the vehicles. Turning in front of oncoming traffic can be a critical event, if there wasn't time to stop or steer around the turning vehicle. Pulling out in front of a vehicle can be a critical event, if there was no time to stop. The critical event "causes" the accident in a physical sense because, given the mechanical properties of the vehicle and roadway, there was no chance to avoid the crash after the critical event occurred.

The critical event essentially gives the researcher a place to start in analyzing a traffic accident. The idea is to start with the event after which the accident was inevitable and then build the description and related factors from that point.

The *critical reason* is the reason for the critical event. It is the "cause" of which the critical event is the result. The critical reason is the failure in the vehicle, driver, or environment that explains the critical event. For example, a driver falls asleep and runs off the road. The critical event is running off the road. The critical reason is falling asleep.

While the critical reason may be conceived of as the immediate cause of the accident, a number of other factors may be important. It is easy to imagine that for any particular critical reason, a variety of factors are related, and for each of those factors, there is another set of factors. Accordingly, a wide variety of factors are considered for in-depth accident reports.

On the other hand, it is true that the chains of events could be extended indefinitely. There is no point in the chain at which, purely from logic, all factors that conceivable could be related have been covered. So, while the list of related factors is intended to be comprehensive, it covers the current understanding of risk factors for truck crashes and the range of interventions currently considered feasible.

**Sources and Variables used for the Critical Event and Critical Reason**

The proposed in-depth accident database is composed of ideas and variables taken from a variety of sources. The overall concept of accident event chains is taken from Perchonok, and following him, from a methodology described by James Fell. The actual code levels for the critical event are borrowed from the National Highway Traffic Safety Administration's General Estimates System (GES). GES includes five related variables that describe the action of the vehicle prior to the critical event; the critical event; corrective action taken; vehicle control after the corrective action, and the vehicle's path after the corrective action. The GES code levels are comprehensive. Using these variables will allow comparisons with results from GES.

Coding for the critical reason essentially follows the framework of the Indiana *Tri-Level Study of the Causes of Traffic Accidents.* The *Tri-Level Study* groups related factors into driver, vehicle, and environment. For our purposes, the most important set of factors taken from the *Tri-Level Study* are those for the driver. The four primary categories of driver critical reasons are "critical non-performance," recognition errors, decision errors, and performance errors.

Critical non-performance is a "catastrophic interruption in the driver's performance," such as blacking out, falling asleep, or a heart attack, that removes the driver from any further active participation in the accident. Recognition errors include various failures to perceive or comprehend available information in a timely fashion. Decision errors are conscious decisions on vehicle control that put the driver into a situation that he could not recover from. Some of these codes have the potential to be circular. For example, "following too closely" is another way of saying "struck lead vehicle in the rear." But here the intent is to capture situations where a steady following distance had been established prior to the critical event, but the following distance was so short that an unexpected action of the lead vehicle immediately created a critical event. The final category, performance errors, refers to inadequate skills in controlling the vehicle.

Note that the critical reason is coded for both the truck and truck driver as well as the other vehicle and other vehicle's driver.

The critical event refers only to the physical movement of the vehicles involved, not which vehicle had the right-of-way at the time of the accident. There will be cases where a vehicle is assigned the critical event, yet had the right-of-way at the time of the crash. For example, a vehicle turning left on a green arrow in front of on-coming traffic had the right-of-way, but also committed the critical event in that the turn put the vehicles on a collision course. In order to address these cases as well as to sort out an important element of traffic crashes, an additional variable has been added. The variable simply records which vehicle had the right-of-way at the time of the accident. Perchonok addresses the issue with the concept of "culpability." A driver is "culpable" if he violates the expectations of a normal driver. This is reformulated here in terms of right-of-way, which can generally be determined at the scene, either from the physical configuration of the accident and its location, or established by witnesses.

**Related Factors**

Following the critical event and critical reason variables is a long list of "related factors." These related factors capture important characteristics of the driver, vehicle, and environment. The items on the list are taken from previous studies of accident causation and they have either been shown to increase crash risk or there are good theoretical reasons to think that they may increase crash risk. The point here is to consider all parts of the crash, i.e.,, the driver, vehicle, and environment and record the presence of any of the factors.

It is important to understand that, in this section, we are recording all factors present, *regardless of whether they contributed to this specific crash or not.* In practical terms, it is often not possible to determine all factors that contributed to a particular crash. The resources required are not available or the effect of the factor itself cannot be determined after the fact. For example, fatigue can have effects far beyond just falling asleep and running off the road. It can slow perception and reaction time, or cloud judgment. In a particular accident, fatigue *may* cause a driver to misjudge his speed or slow his perception of the movements of traffic ahead, but the evidence in a particular case is often not strong enough for the investigator to identify fatigue as <u>causal</u> in the crash.

At the same time, coding factors where the connection to a particular accident might not be immediately apparent allows statistical associations to be drawn. If we comprehensively collect the incidence of a factor among drivers involved in a crash, we can measure statistically whether and how much that factor increases the risk of crash involvement. We may not know that fatigue "caused" this or that crash, but we will be able to determine that fatigue raises the risk of accidents by a certain amount.

To give another example: it is clear that poor braking can contribute to traffic crashes. Some cases are very clear, as when a truck loses all braking. But there are other cases where the brakes are just out of adjustment and diminished braking capacity may or may not have contributed. It is likely that many truck drivers are aware when their truck's brakes are not fully adjusted and compensate for the longer stopping distances. A study a few years ago by the National Transportation Safety Board showed that about 45% of the trucks on the road had misadjusted brakes at that time, yet the overwhelming majority of trucks made it to their destination safely. So, does brake adjustment affect accident risk? By collecting brake adjustment data on all trucks involved in a crash, regardless of whether braking had anything to do with the crash or the role of the truck in it, it is possible to measure the effect of brake adjustment on particular types of crashes. If trucks that are rear-ended while stopped (where their own braking capacity had nothing to do with the crash) have a lower percentage of brakes out of adjustment than trucks that are rear-ending other vehicles, that is evidence that brake out-of-adjustment increases the risk of accident involvement and we can calculate the amount of the increased risk.

**References**

Fell, J., *A Motor Accident Causal System: The Human Element*. Research and Development, Office of Statistics and Analysis, NHTSA, DOT-HS-801-214, July, 1974.

Perchonok, K., *Accident Cause Analysis*. Cornell Aeronautical Laboratories, Inc., July, 1972.

Treat, J, et al., *Tri-Level Study of the Causes of Traffic Accidents: Final Report*. Institute for Research in Public Safety, School of Public and Environmental Affairs, DOT HS-034-3-535-77-TAC, March, 1977.