Accident Data Needs for Truck Safety Issues

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ABSTRACT

Debates about changes in federal truck size and weight limits have emphasized safety as a major issue, and in all cases it has been found that adequate information concerning the safety implications of the proposed changes has been lacking. Although size and weight issues have recently dominated FHWA's concerns about truck safety, there are many questions and issues related to large truck safety on the highway that are still unresolved. In this paper are discussed preliminary findings that lead up to a study plan of data needs necessary to address large truck safety issues in a systematic manner. First, the critical truck safety issues that need to be resolved so that FHWA and the states can make better informed decisions about truck operation restrictions or modifications to the highway system are identified. Next, data elements required to analyze these issues are identified. The ability of existing data bases to provide these elements is discussed as are alternate methods for collecting nonavailable data.

To resolve an issue, test a hypothesis, or merely go on a problem-searching expedition, data to analyze are needed. These data must be of the right kind and in sufficient quantity to permit statistically valid analyses.

It is also true, or at least it should be, that data are collected for a specific purpose. That is, the data are, or are anticipated to be, used to develop statistics that are analyzed to present trends, identify problems, develop relationships, and perform evaluations.

In summary, data requirements are dictated by current or anticipated issues that need to be resolved. More specific to the theme of this symposium, truck data needs are, in part, a function of truck safety issues. This should be an obvious point, but it is one that is too often overlooked in data collection systems.

In this paper are presented what this author believes are the minimum truck data that are required for addressing key truck safety issues, particularly those relevant to the highway community. The paper is focused on accident and exposure data required for truck accident studies. It is recognized that there are other truck issues and, therefore, data elements that are important to the highway community. These are not discussed here.

TRUCK SAFETY ISSUES

The first step in identifying truck safety data needs is to define what the truck safety issues are or are likely to be. More specifically, what are the truck safety issues that can be addressed through traditional accident analyses?

To identify these issues, representatives of the various operating offices of the FHWA (e.g., Office of Traffic Operations, Office of Highway Planning) were interviewed. Additional input came from the literature (i.e., what issues were being raised and evaluated by others). Finally, a panel of researchers experienced in truck accident studies offered their opinions regarding truck safety issues.

These activities resulted in the identification of 66 issues. However, many of these were interrelated and some were not resolvable through traditional accident analyses. A list of those issues that are considered to be the highest priority truck safety issues follows.

- What is the safety record of various truck types and what variables influence their safety?
- What is the relationship of gross weight to truck safety?
- What is the relationship of truck length (or trailer length) to truck safety?
- What is the relationship of the type of highway to truck type?
- Where do truck accidents occur on various highway types and does this vary by truck type?
- How is truck safety affected by critical geometric elements such as lane width, shoulder width, degree of curvature, grade, and so forth?
- What is the relationship of traffic volume (and truck volume) to truck safety?
- In what type of accidents are different types of trucks involved?
- Are restrictions of trucks by lane or time of day effective safety measures?
- What is the incidence of drivers under the influence of alcohol, drugs, or fatigue in truck accidents?
- Are various types of barrier systems (e.g., guardrail, concrete safety shape, impact attenuators) effective in reducing truck accident severity?

The order of listing in no way signifies the order of priority. It should be emphasized that these issues are, for the most part, highway oriented and therefore within the interests of FHWA and, presumably, state highway departments. No doubt there are other valid issues that are of high priority to other organizations and agencies.

Also, except for a few specific ones, these issues tend to be global issues for which more specific subissues could be formulated. Indeed, the first issue could be considered an "umbrella" issue for nearly all of the others listed. This is so because in order to determine what variables affect truck accident rates, consideration must be given to various characteristics of the truck, the driver, the highway, and the environment.

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GENERAL DATA REQUIREMENTS

After what were believed to be the critical safety issues related to truck safety were identified, the next effort was to identify the data elements that would be needed.

In any evaluation of highway safety using accident rates as a measure, there are two types of data. The first, of course, is the accident data themselves. Depending on the issue, various data on the accident may be required. These may range from a simple count of accidents involving a certain vehicle type to a specific aspect of the accident (e.g., when it occurred, type of accident, actions before the accident, driver condition).

Accident measures are typically expressed as accident rates (i.e., accidents per mile of highway or more commonly accidents per vehicle miles traveled). The denominator that provides the rate calculation is typically expressed as the exposure value. Hence, the second principal type of data is the exposure of the vehicles.

Exposure data are important because they are crucial to calculating the actual likelihood of an accident. To be meaningful, the exposure data must be related to the variable (issue) being evaluated. For example, if an accident rate for double-trailer trucks with a van trailer configuration is being sought, then the volume of these trucks over the study section is needed as well as the number of accidents.

With regard to the first issue listed previously (i.e., what is the safety record of various truck types and what variables influence their safety?), if a researcher were asked what factors are likely to influence truck accident rates, he would likely identify quite a few. This is what was done by a panel of five experts in the field of accident research.

The following subsections give the factors, hence the types of data, that it was thought necessary to consider in addressing this basic issue. The factors are grouped into truck factors, driver factors, highway factors, traffic factors, and environmental condition factors. Collectively there are 27 factors, not including possible subcategories.

Truck Factor Data Elements

1. Type
2. Number of axles
   - Tractor
   - Trailer
3. Trailer type
4. Cab type
5. Cargo type
6. Width
7. Length
   - Overall
   - Tractor
   - Trailer or trailers
8. Weight
   - Gross
   - Net cargo
9. Trip type
10. Carrier type
11. Condition of vehicle equipment

Driver Factor Data Elements

1. Age
2. Driving experience
   - Trucks in general
   - Particular truck
3. Hours of service
4. Driving record
5. Driver training

Highway Factor Data Elements

1. Highway type
   - Function
   - Access control
   - Number of lanes
   - Divided or undivided
   - Design speed
2. Geometric elements
   - Curve
   - Grade
   - Passing or no-passing zone
   - Interchange
   - Intersection
   - Work zone
   - Lane width
   - Shoulder width
3. Location
   - Urban or rural
   - State

Traffic Factor Data Elements

1. Volume
   - Average daily traffic
   - Hourly traffic
2. Level of service
3. Truck volume
4. Percentage of trucks
5. Speed

Environmental Factor Data Elements

1. Temporal
   - Season
   - Time of day
2. Pavement conditions
3. Light conditions
4. Visibility conditions

If it is truly believed that all of these factors affect truck accident rates, albeit to varying levels of significance, then, to be statistically accurate, an experimental design that would ensure that there is enough of a sample (in this case accidents and exposure) to establish a reliable estimate of each specific cell accident rate, should be developed. Clearly, the sample size requirements would be quite large and probably unattainable within reasonable periods of time and with available resources.

Consequently, to reduce the data collection task to a manageable level, some judgments must be made about those variables of primary interest and those that can be accepted a priori as insignificant or simply ignored. For example, what if it were true that trucks with cab-over-engine tractors experienced a higher injury rate than cab-behind-engine tractors? What if it were also true that double-trailer trucks had a much greater percentage of cab-over-engine tractors than single-trailer trucks? Then, assuming all other factors were accounted for, if doubles had a higher accident rate than singles, it could be attributed, at least in part, to the tractor type rather than to the trailer configuration. This would have been indeterminable if the cab type had not been included as a data element and considered in the analysis.

It is these possible relationships that argue for more rather than fewer factors being included in the experimental design and, hence, data elements. Still, resources and time are limited, so consideration must be given to reducing the number of factors (variables) and strata within a factor.

A list of factors was developed that should be considered a minimum. These factors and the strata assigned for the factors (variables) dictate the data elements. In the next few sections these factors are discussed in more detail.

SPECIFIC DATA ELEMENTS

Truck Type

One of the most critical issues is the ability to differentiate the safety of various truck types. Types of trucks can be described in many ways depending on the specific issue at hand. Indeed, a truck could be classified according to its

- Number of axles,
- Number of trailers,
- Trailer type,
- Tractor (cab) type,
- Weight, and
- Length and width.

Here, truck type is considered to be the general description of the truck as determined by the configuration of the power unit (tractor) and the cargo unit or units. It is therefore the lowest order or, expressed another way, the least specific classification of trucks. Under this assumption the following truck types are of concern for safety issues.

1A. Single-unit truck--all trucks with the cargo unit and tractor on a single frame having two or more axles with at least six tires (2-0 and 3-A).

1B. Single-unit truck with trailer--a single-unit truck pulling any type of trailer (2-1, 2-2, 2-3, 3-2, 3-3).

2. Tractor-semitrailer (semi)--a truck combination consisting of a tractor with two or more axles and a semitrailer with one or more axles (2S-1, 2S-2, 3S-1, 3S-2).

3. Tractor-semi plus full trailer (double)--a truck combination consisting of a tractor with two or more axles, a semitrailer with one or more axles, and a full trailer with one or more axles (2S1-2, 2S2-2, 3S1-2, 3S2-2).

or

3A. Turnpike double--three-axle tractor and two two-axle semitrailers each 40 to 45 ft long coupled by a two-axle dolly.

3B. Rocky-Mountain double--a three-axle tractor, a two-axle 40- to 45-ft semitrailer, a one-axle dolly, and a second 27- to 28-ft single-axle semitrailer.

3C. Twin-trailer truck--a double trailer truck with a two- or three-axle tractor and two single-axle semitrailers, each usually 27 or 28 ft long, coupled by a single-axle dolly.

4. Tractor-semi plus full plus full trailer (triple)--a truck combination consisting of a two- or three-axle tractor, a semitrailer with one or more axles, and two full trailers with one or more axles each.

Note that this classification scheme yields four, five, six, or seven truck types, depending on the level of detail.

The smallest strata would allow distinction of four truck types:

1. Single-unit truck (straight),
2. Tractor-semitrailer (single),
3. Tractor-semitrailer-full trailer (double), and
4. Tractor-semitrailer-full trailer-full trailer (triple).

The largest strata classification would distinguish between single-unit trucks with and without a trailer and also would establish three separate types of doubles: the so-called turnpike double, the Rocky-Mountain double, and the twin-trailer double. These three types of doubles are different enough in terms of their configuration and operation that they should be evaluated separately.

The obvious truck characteristic missing from this classification is the number of axles. This is so because it was believed that the number of axles does not significantly affect safety. If this premise is accepted, there is no reason to be able to distinguish the number of axles in either the accident or the exposure data.

For accident data, the truck classifications recommended can only be discerned from the Bureau of Motor Carrier Safety (BMCS), Fatal Accident Reporting Systems (FARS), and National Accident Sampling System (NASS) data bases. Only five states currently have an accident report form that can distinguish between a single- and double-trailer truck type. Consequently, to determine truck type in accident involvement will require a special data collection effort.

On the exposure side, truck classifications are established on the basis of the number of axles and trailers, so it is possible to distinguish among straight trucks, and single- and double-trailer combinations. However, the different types of doubles (i.e., western versus Rocky Mountain versus twin trailer) cannot be distinguished by current traffic counting systems.

Truck Length

The relationship of truck length to truck safety still remains an unresolved key issue. On the basis of safety, just how long can trailers or the total tractor-trailer or trailers combination be allowed to be? There are valid arguments for evaluating both trailer length and overall length, but it is believed that overall length is the more relevant highway safety issue. The only exception to this statement is, perhaps, the specific issue of turning trucks and offtracking. Longer trailers and more specifically longer wheelbases are more critical than is overall length.

Assuming that overall length is accepted as the key variable, it must be possible to distinguish, as a minimum, total truck length in both the accident and the exposure data. For accident data, overall truck length is available from the BMCS and the NASS data base. However, none of the states currently records either overall truck length or trailer length on their police accident report form.

For exposure, truck length is not generally available from truck classification or weight surveys. Hence, this requires a special data collection effort. The technology for identifying vehicle length is still developing and therefore not yet being used to any significant degree.

Truck Weight

Maximum allowable gross and axle weight is certainly an issue related to pavement and bridge structure performance. Weight is also a critical safety issue. Hence, it is a necessary data element for a comprehensive analysis of truck safety.

Gross weight of trucks involved in accidents is available from both the BMCS data and the NASS data base. The problem with the BMCS weight data is that they are self-reported and therefore susceptible to underreporting for overweight trucks. None of the states reports gross weight on police accident report forms.

Gross weight exposure data are available from truck weigh stations for some classes of roads. However, the weights obtained from these are often not representative of the lower and overweight stratum because drivers of overweight trucks, aware that the weigh scales are open, bypass them by using alternate routes. Also, trucks are sometimes allowed to pass by the scales if it is observed that they are empty.

The technology for portable and weigh-in-motion devices is improving, which should make it more feasible to collect reliable weight data for a variety of highway types.

Trailer Type

The relative safety of trucks with different trailer (cargo) types was not identified as a high-priority issue. Still it is a required data element for the following reason. There are numerous types of trailer configurations for both straight trucks and tractor-semitrailer combinations. However, for double- and triple-trailer combinations, there are relatively few trailer types, primarily limited to enclosed vans, with some tankers, bulk commodity, and automobile trailers. An analysis of singles versus double-trailer combinations would be more reliable if similar trailer combinations were compared. This would ensure that any effect due to trailer type is controlled.

To do this it is necessary to identify trailer type in the accident and exposure data collection system. There are numerous trailer types, so to minimize the classification strata, the following classification scheme is suggested.

1. Van--cargo is completely hidden from view; cargo unit has solid top, sides, front, and rear.
2. Tank, liquid carrier--may have different configurations but contains a liquid substance.
3. Platform--flat cargo-carrying unit with no sides or top structure.
4. Bulk commodity--loose or semiloose solids carrier (e.g., agricultural products, cement) has sides but no hard top.
5. All other cargo body types.

Essentially four distinct trailer types are established with all others grouped in a fifth class.

For accident data, trailer type is available from the BMCS data but the classifications are not the same as suggested here. This is true of the NASS data base as well. Cargo or trailer type are not identified on any state accident reporting system.

For exposure data, there are no currently available trailer type classification counts. Unfortunately, this is one truck characteristic that cannot be recorded automatically and requires manual observation.

Type of Operator

A factor that is believed to be related to truck safety is operator type. By this is meant the classification of the truck driver by employment status. It has been hypothesized that owner-operators are overinvolved in truck accidents compared with employees of either common or private fleet operators. If this is true, this factor should be considered in the design of any analysis of accident rates by truck type.

There are basically two classes of operators: (a) owner-operators who own the tractor and possibly the trailer and (b) employed drivers who are hired to operate rigs owned by someone else. This is one of the more difficult data items to acquire. It is not available from BMCS, FARS, or NASS and none of the states records this on the police accident report form. Consequently, it has to be obtained from supplemental investigations, such as a mail or phone survey as was done by the University of Michigan's Transportation Research Institute.

Exposure data for this variable are likewise not readily available and are not being collected in any data collection system. These data, too, will require supplemental surveys conducted on the road at weigh stations, truck stops, rest areas, and other places.

Driver Age

The age of the driver has been found to correlate with accidents in general, and this appears to carry over to truck drivers as well. Older, more experienced truck drivers have a better accident rate than young, inexperienced drivers. If this is true, age may be an influencing variable in the issue of the relative safety of singles versus doubles because it has been claimed that drivers of double-trailer trucks are generally the older and more experienced drivers. If so, age should be considered in the analysis.

The age of the driver is an easily obtainable data element for the accident data component. It is available from the police accident report. However, obtaining truck-type mileage by driver age will require special field surveys.

Highway Type

From the perspective of the highway engineering community, a key issue is to be able to identify the relationship of truck safety to highway type. It has long been recognized that accident rates vary by highway type as well as other influencing variables, so it can be expected that trucks experience different accident rates on different highway types, and, perhaps, this difference varies among the truck types.

There currently is no formal "highway type" classification. Highways can be classified by any number of factors including

1. Function,
2. Access control,
3. Number of lanes
4. Divided or undivided,
5. Lane or pavement width, and
6. Design speed.

To develop a highway type classification system, the percentage of mileage and vehicle miles traveled for highways defined by the first four of the factors noted previously was determined. From that analysis the following highway types were established.

Urban

1. Interstates and other freeways and expressways, more than two lanes, divided, full access control.
2. Interstates and other freeways and expressways, more than two lanes, divided, partial access control.
3. Other principal arterials, two lanes, undivided, no access control.
4. Other principal arterials, more than two lanes, divided, no access control.
5. Other principal arterials, more than two lanes, undivided, no access control.
6. Minor arterials, two lanes, undivided, no access control.
7. Minor arterials, more than two lanes, divided, no access control.
8. Minor arterials, more than two lanes, undivided, no access control.
9. Collectors, two lanes, undivided, no access control.

Rural

1. Interstates, more than two lanes, divided, full access control.
2. Other principal arterials, two lanes, undivided, no access control.
3. Other principal arterials, more than two lanes, divided, full access control.
4. Other principal arterials, more than two lanes, divided, partial access control.
5. Other principal arterials, more than two lanes, divided, no access control.
6. Minor arterials, two lanes, undivided, no access control.
7. Minor arterials, more than two lanes, divided, no access control.
8. Major collectors, two lanes, undivided, no access control.
9. Minor collectors, two lanes, undivided, no access control.

This classification yields nine types of urban highways and nine types of rural highways.

SUMMARY

It is believed that the key variables that influence truck safety include

- Truck type,
- Truck length,
- Truck trailer type,
- Truck weight,
- Driver type,
- Driver age, and
- Highway type.

These variables should dictate the experimental design and sampling requirements, and both accident and exposure data, as a minimum, have to be obtained for these variables.

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