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The Honorable Philip R. Recht
Deputy Administrator
NATIONAL HIGHWAY TRAFFIC
SAFETY ADMINISTRATION
400 Seventh Street, S. W., Room 5220
Washington, DC 20590

Dear Mr. Recht:

Re: **Settlement Agreement**
Section B. Fire Safety Research

Enclosed is a publication authored by Joseph P. Lavelle, Douglas W. Kononen, and James R. Nelander of General Motors Corporation entitled "Field Data Improvements for Fire Safety Research." It relates to B. 1 Analysis of Motor Vehicle Accident Data.

This publication will be included in the conference proceedings of the 16th International Technical Conference on the Enhanced Safety of Vehicles held in Windsor, Ontario, June 2 - 4, 1998.

Sincerely,

David A. Collins
Attorney

Enclosure

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FIELD DATA IMPROVEMENTS FOR FIRE SAFETY RESEARCH

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Paper Number 98-S6-W-45

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ABSTRACT

As part of the March 7, 1995 Settlement Agreement between General Motors and the U.S. Department of Transportation, General Motors sponsored analyses of various field collision data files maintained by Federal and State highway safety organizations. These analyses were performed to: 1) evaluate possible causes and effects of vehicle fire events; 2) assess the adequacy of existing databases for studying these events; and 3) recommend possible enhancements to these data files to assist safety researchers in studies of motor vehicle fires.

Results of this GM-sponsored research indicate that existing data sources contain insufficient information to enable researchers to satisfactorily understand the causes of vehicle fires. This paper describes some major deficiencies in current field accident databases (with respect to information about the causes and consequences of vehicle fires) and recommends enhancements to these databases which might provide researchers with better, more comprehensive information about the causes and effects of vehicle fires.

BACKGROUND

Researchers studying crash-related vehicle fires seek answers to the following types of questions:

1. How do vehicle type, vehicle age, driver age and gender, crash mode, and crash severity affect the likelihood of post-collision vehicle fire?
2. What are the sequential crash-related events associated with the fire?
3. What is the extent of vehicle damage associated with the fire?
4. If leakage occurs, what is the fuel and what is the source of the leak?
5. What is the source of ignition?
6. What are the injury (trauma/bum) consequences of the crash?

Typically, initial approaches to answering these types of questions involve analyzing vehicle fire-related data contained in various Federal and State traffic safety databases. This paper summarizes results obtained from GM sponsored analyses of various field collision data files maintained by Federal and State highway safety organizations.

Fatal Analysis Reporting System (FARS)

The Fatal Analysis Reporting System (FARS), maintained by the National Highway Traffic Safety Administration (NHTSA) has often been used as a starting point in efforts to gain an understanding of crash-related vehicle fires. FARS represents a census of motor vehicle crashes on public roads in the United States that result in at least one fatality within thirty days of the crash. Even though FARS' broad coverage of fatal crashes makes it a logical data source to begin quantifying the most extreme injury consequences of vehicle fire, there are limitations that make FARS a less than reliable source of data on fatal vehicle fires.

Some of the limitations of FARS for studying fire incidents are apparent from a cursory review of the variables that are coded in the FARS files. For instance, FARS provides no opportunity to code presence or absence of fuel leakage, let alone what the source of such fuel leakage might be. There is also no indication in FARS as to possible ignition source for the fire nor is there any indication of the origin of the fire (e.g. engine compartment, passenger compartment, fuel tank area, etc.).

Moving beyond questions about the vehicle to those dealing with the occupants of the vehicle, other difficulties are encountered. FARS only codes the most basic information about a person's injury severity. The coding for a person's overall injury severity is derived from police level injury scales (K-fatal injury, A-incapacitating injury, B-non-incapacitating evident injury, C-possible injury, O-no injury). Other than providing only a rough measure of a person's overall injury severity, FARS provides no information on a person's injuries -- their type (e.g. laceration, fracture, bum, etc.), the part of the person's body involved (e.g. face, heart, left leg, etc.), or the contacts with objects associated with the injury (e.g. contact exterior to the vehicle, A-pillar, etc.). Even the cause of death is not contained in the FARS files.

To account for some of the limitations of FARS, researchers have used indirect methods to bound estimates dealing with fire related fatality. Tessmer relied on the FARS variable Most Harmful Event (MHE) to make projections about the number of people who had died as a result of vehicle fire (Tessmer 1994). The author recognized that not every occupant fatality in a vehicle which experiences a fire can be reasonably thought to have his/her death directly caused by the fire, as opposed to impact-induced trauma. To derive a lower bound, it was assumed that for vehicles with an occupant fatality and "fire or explosion" coded as the MHE, at least one occupant died as a result of the fire. To get an upper bound, it was assumed that all occupant fatalities in vehicles with fire died as a result of fire, with the exception of one occupant fatality in each vehicle with fire and a MHE coded as other than "fire or explosion". Bounding projections, using such an indirect approach, is perhaps the best one can do to overcome the lack of specificity in the FARS fire coding. However, evaluation

of the FARS database calls into question the meaningfulness of these bounds, due to the inconsistency in the application of the coding from state to state.

State Accident Files

As part of their police reported crash databases, several states have data on the presence of vehicle fire either as an explicit variable or as a possible code value to variables dealing with harmful events associated with the crash. The degree of detail (never too great) and the way in which the fire data is presented vary from state to state.

National Automotive Sampling System (NASS) General Estimates System (GES)

The National Highway Traffic Safety Administration's National Automotive Sampling System's General Estimates System (NASS-GES), as its name implies, aims to serve as a resource for making general estimates about traffic crashes nationally. It relies on extracting common pieces of data from the reports of selected police agencies nationwide. NASS-GES' general outlook and underlying data sources prevent it from having very great detail in any one area, fire events being no exception.

National Automotive Sampling System (NASS) Crashworthiness Data System (CDS)

The National Highway Traffic Safety Administration's National Automotive Sampling System's Crashworthiness Data System (NASS-CDS) contains a relatively rich set of variables providing relevant data on crash-involved vehicles and occupants. The primary problem with NASS-CDS is not the lack of detail but rather the relatively low number of reports received annually. A NHTSA study of vehicle fires noted that "there are very few vehicles in the NASS database that had a fire, most likely less than 50 per year." (Tessmer 1994) This relatively small sample size results from the low frequency of fires in towaway crashes combined with a smaller number of cases selected compared with FARS.

National Fire Protection Association (NFPA) Survey Data

The National Fire Protection Association (NFPA) conducts yearly surveys of a random sample of U.S. fire departments to make national projections of fire occurrence. This survey does not capture any detailed information about vehicle fire incidents. NFPA estimates of vehicle fire and of fatalities in vehicle fires are based on a sample survey of fire departments and are subject to sampling error of approximately 10%.

National Fire Incident Reporting System (NFIRS)

The Federal Emergency Management Administration's (FEMA) U.S. Fire Administration established the National Fire Incident Reporting System (NFIRS) for the collection of fire incident and fire casualty data in the U.S. NFIRS was designed as a tool for fire departments to report and maintain computerized records of fires in a uniform manner. This system provides data that allows analysts to detect local, state, and national trends. However, the system is voluntary; not every U.S. fire department contributes to the system. Data from NFIRS must be combined with information from other sources (e.g., NFPA sample survey data) to produce national estimates of fire trends. NFIRS offers codes for injuries and fatalities in noncollision motor vehicle fires by vehicle make and model. In addition, the amount of direct property damage is estimated. Fire incidents can be detailed by area of fire origin, type of material first ignited, and form of heat of ignition.

RESULTS OF DATABASE EVALUATIONS

Research sponsored by General Motors as part of the March 7, 1995 Settlement Agreement between General Motors and the U. S. Department of Transportation examined the reliability of FARS data for fire research (Griffin 1997 & 1998). Some of the conclusions of this research include:

- A large amount of variation exists among the states in the coding of the presence of fire. Without getting beyond even the most basic level of data dealing with vehicle fire -- its presence or absence -- there is some reason to believe that the data input to FARS is not consistent nationwide.
- A large amount of variation exists among the states in the coding of "fire or explosion" as the most harmful event (MHE) for vehicles coded as having experienced a fire. Because of this variability in MHE coding, it is unlikely that the states are estimating the same phenomenon.
- Results of crosschecking coded injuries from the Multiple Cause of Death (MCOD) files with fire coding from FARS found:
  - Occupants with bum type injuries in vehicles not having fire coding and
  - Vehicles with "fire or explosion" coded as the MHE having none of their fatal occupants with bum type injuries.
- An evaluation of police reports underlying the FARS data illustrated the difficulty in properly pigeon-holing complex events such as vehicle fatalities, especially those associated with fire.

Additional research sponsored by General Motors as part of the same Settlement Agreement evaluated the strengths and weaknesses of a variety of state and federal data related to motor vehicle fire (Ray 1996). The principal findings of this study include:

- State-level databases vary widely in the accuracy and completeness with which they capture information about fire accidents.
- All databases reviewed lack adequate coded information for researchers to understand the cause of fire and to differentiate significant factors in a fire accident (e.g., engine fire versus fuel fire).
- The NASS-CDS provides detailed information on traffic accidents in which fire occurred. However, the small size of the database, coupled with the low rate of vehicle fire accidents, limits the usefulness of these data for the study of the causes of vehicle fire.

- The General Estimates System (GES) of NASS is a representative sample of all U.S. police-reported traffic accidents, containing information gleaned from police reports. This database is useful for an overview of vehicle fires and as a check on the consistency of the state databases.
- Because of limitations associated with each database examined, it is recommended that separate analyses should be performed for each database and the information be combined via statistical meta-analysis techniques.

Table 1 summarizes some of strengths and weaknesses of the databases evaluated by the two GM-sponsored data evaluation studies. Comments regarding database strengths and weaknesses refer to the adequacy of these different data sources for comprehensive vehicle fire research studies.

Table 1.
Summary of Databases Evaluated

Database	Strengths	Weaknesses
FARS	Census of all fatal accidents; information on many driver and environmental variables; contains limited information on presence or absence of fire.	Restricted to highest severity (fatal) accidents; cannot identify causes of fire; difficult to evaluate contribution of environmental and operator factors that result in severe crashes and vehicle design characteristics that may contribute to likelihood of fire.
State Data	Contains information on fatal and nonfatal accidents involving fire.	Accuracy and completeness of fire accident information varies widely; frequency of fire incidents may be significantly misrepresented.
NASS-GES	A sample of police-reported crashes; contains limited information on presence or absence of fire, which can serve as check on state data.	Relatively small sample size and infrequency of collision fire limit usefulness of these data for studying collision-related fire.
NASS-CDS	Contains detailed information on fire-related traffic accidents.	Small sample size and infrequency of collision fire limit usefulness of these data for studying collision-related fire.
NFPA Survey Data	Random sample of U.S. tire departments provides general picture of vehicle fire incidents.	Does not capture any detailed information about vehicle fire incidents. Survey sampling error is approximately 10%.
NFIRS	Provides vehicle fire-related data to enable analysts to detect local, state, and national trends. Fire incidents can be detailed by estimated area of fire origin, type of material first ignited and form of heat of ignition.	Voluntary; not every fire department in the U.S. contributes data to the system. Definition of vehicle fire fatalities differs from FARS.

RECOMMENDATIONS

Looking over the relative strengths and weaknesses of existing databases, it is clear that none has all the attributes that one would desire in an ideal database for studying vehicle fires. Among these attributes would be the presence of consistent, accurate, and sufficient data to make reasonable inferences about vehicle performance and occupant injury.

The infrequency of vehicle fires in NASS-CDS greatly limits its utility as a data source for fire research. NASS-GES suffers from the same problem, but to a lesser degree. FARS has proven to be a valuable resource for research efforts seeking to gain an understanding of fatal vehicle crashes on a national basis. However, FARS has some significant shortcomings as a resource for vehicle fire research.

One of FARS' great strengths is its comprehensive coverage of fatal crashes, which should allow good national assessments to be made about the frequency of fires in fatal crashes, but the inconsistency found among states in coding of tire-related variables keep FARS from achieving its potential in this area. Recognizing that underlying police reports form the basis of FARS, a step in the right direction would be for NHTSA to expand its efforts in promoting common data definitions and coding formats among the states to include fire-related variables, such as extent and source of fire. Even though it is difficult to promote even minimum standards for common data elements, the importance of fire safety research should support the need to add data elements related to fire to the array of essential data elements that should be common from state to state.

Short of a major redesign of the FARS program, a way of obtaining some injury data on occupants killed in

crashes would be to link data on the reported cause of death from the National Center for Health Statistics' Multiple Cause of Death (MCOD) files to corresponding records in the FARS files. Linking these databases would not provide the last word on fatalities in crashes associated with fire, but it would present the possibility of gaining a better classification of these events.

The approaches suggested for FARS have some relevance to state data, as well. If states were persuaded to add common crash-related fire variables to their data systems, in addition to enhancing the utility of FARS, these enhanced state databases could serve as consistent and reliable sources of data for those fire-related crashes that are not captured by the FARS database. Going beyond mere consistency, the reliability of coded fire-related data would be further improved by implementation of field investigation programs (conducted by trained vehicle fire investigators using a standard incident investigation protocol). The importance of involving trained fire investigators in the process should not be understated given the difficulty of unraveling the chain of events in vehicle fires.

The direction that NHTSA has taken in their CODES program, shows potential for augmenting existing state crash databases, especially in the area of injury consequences. Undoubtedly, the lessons that NHTSA and their state partners have learned in piloting this process will be fed back into the process to improve the utility of the resulting linked databases. Building on what has been learned, if this linking approach could be extended to tie police-reported crash events to the reports of trained fire investigators in a representative set of states, researchers would begin to have the tools they need to get a more useful understanding of crash-related vehicle fires and their consequences.

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