



## Heavy Truck Occupant Crash Protection (A Historical Chronology – Compiled by Farrel Krall) January 2006

Significant progress has been made in recent decades in advancing the state-of-the-art of mitigating truck occupant crash injuries. This document provides a 35-year chronology of accident investigation, crash analysis, research development programs, and codification of *SAE Recommended Practices* that have contributed to these real-world improvements.

**(1966) Ernst & Ernst Truck Accident Study**<sup>1</sup>. In October 1966, one month after the U.S. Congress passed the 1966 Safety Act, truck manufactures launched the pioneering *Ernst and Ernst Truck Accident Study* under the auspices of their trade association known at that time as the *Automobile Manufacturers Association* (AMA); later renamed *Motor Vehicle Manufactures Association* (MVMA) to improve the Association's focus on large commercial vehicles. MVMA continued to sponsor specialized truck accident data studies until the organization was dissolved in 1992.<sup>2</sup> The principal objective of these studies was to determine the types and frequency of truck accidents and their consequent injuries. Exhibit No.1 provides a listing of accident studies sponsored by MVMA from 1966 through 1992.

**(1972) The Williamsburg Conference on Highway Safety Research...a technical conference to develop a plan of needed safety research.** (Nov. 29 – Dec. 1, 1972)<sup>3</sup>

The Group VII panel of truck safety experts participating in this hi-level three-day conference developed a list of priority safety research needs for large trucks. Pertinent to the topic of crashworthiness, the panel identified the subject of truck occupant crash protection as a top priority research topic needing further in-depth study.

**(1976) Motor Vehicle Safety Seminar - Sponsored by the National Motor Vehicle Safety Advisory Council** (July 12, 1976)<sup>4</sup>

The Motor Truck Manufacturers Division, Motor Vehicle Manufacturers Association of the United States, Inc. presented comprehensive comments to the NMVSAC entitled “Key Issues in Heavy Truck Safety”. Findings contained in the MVMA report were based, in part, on two independent research studies conducted by Southwest Research Institute and Calspan Corporation.

One of the 21 hypotheses identified in the NMVSAC report concerning accident involvement of tractor-trailer combinations had to do with driver survivability in off-road crashes. Based on the available studies, MVMA concluded the following:

**The data on single vehicle accidents show that occupant injuries are less severe in heavy trucks than in passenger cars. The North Carolina data show that in single vehicle crashes 79 percent of the heavy truck drivers will suffer no visible injury while only 70 percent of the passenger car drivers will be as well off.**

MVMA, on behalf of its member truck manufacturers, offered the following recommendation and commitment to improving truck safety:

**Expressing its continuing commitment to heavy truck safety, MVMA pledges full support to the National Motor Vehicle Safety Advisory Council in its efforts to improve knowledge and understanding of the key safety issues involved. MVMA cites its considerable investment in truck safety research and analysis and underscores the industry’s concern and its commitment to further study and evaluate accident causation and other safety issues. This includes the need to focus on all three elements of highway traffic safety: the vehicle, the driver and the highway itself.**

**In this regard, MVMA suggests a coordinated heavy truck safety research and information gathering program involving government, industry, the academic and scientific communities.** (The author, as chairman of the MVMA Motor Truck Research Committee, participated in the preparation and co-presentation of this report to the NMVSAC).

**(1978)** The SAE Cab Occupant Environment Committee was formed to address heavy-truck driver accommodations, including the subject of occupant crash protection. Committee membership was comprised of representatives from U.S. truck manufactures, industry suppliers, research institutions, and the US DOT. (The author is a charter member of this committee).

**1980:** The SAE Crashworthiness Subcommittee was formed for the specific purpose of addressing the subject of truck occupant crash protection. (The author is a charter member of this subcommittee).

**1982:** The SAE Crashworthiness Research Task Force was formed to monitor on-going crashworthiness developments and to formulate and provide technical monitoring of future crashworthiness research programs. (The author served on this task force through out the planning and conduct of the heavy truck crashworthiness study carried out by the Failure Analysis Associates ( FaAA) organization from 1991 thru 1996).

**(1980)** NHTSA published a Request for Proposal for the conduct of “A Study of Heavy Truck Occupant Crash Protection.” <sup>5</sup> As part of this comprehensive study, the contractor (Arvin Calspan, Contract No. DTNH22-80-C-07457) was requested to develop and perform a “pilot test program” for at least two “representative” heavy truck crash tests. In **June 1981**, the contractor published final report DOT-HS-805-935 “Heavy Truck Pilot Crash Test – Frontal Impact” and in **July 1981** Final Report DOT-HS-805-978 “Heavy Truck Pilot Crash Test Rollover.” <sup>6</sup> These two reports contain Arvin Calspan’s recommendations for Frontal Impact and Rollover test requirements.

**(1982) SAE Paper 821270 Heavy Truck Occupant Crash Protection - - A Plan for Investigating Ways to Improve It** by Clarke and Mergel of USDOT <sup>7</sup> referenced the following findings:

- It is difficult to ascertain directly from accident data files whether or not an occupant was killed because the cab crushed in around him.
- The paper notes that unrestrained occupants “fly around” inside the cab fatally striking cab interior components. Thus, 33.8 percent of the truck rollover accident occupant fatalities appear to result from lethal contact with cab interior components.
- Before listing any potential solutions to the causes of fatalities and serious injuries among heavy truck occupants it is appropriate to establish not only the types of crash environments for which protection will be sought but also an upper range of severity for which practical solutions are deemed feasible.
- Secondly, the upper level of crash severity for which solutions will be sought must be established. Attempts to clearly define accident conditions which generate unreasonably high decelerations upon the vehicle and its occupants, from those which do not, have been difficult.

**1983:** Arvin Calspan published a final report entitled “A Study of Heavy Truck Occupant Protection: Accident Data Analyses.” <sup>8</sup> The study sponsored by NHTSA included the following pertinent findings:

#### **4.2 Sources of Injury to Drivers of Articulated Vehicles (CPIR-B)**

<b><u>Source</u></b>	<b><u># of Injuries</u></b>	<b><u>%</u></b>
Steering Assembly	98	18.6
Instrument Panel	60	11.4
Windsheild	35	6.6
Surface of Side Interior	53	10.0
Sunvisors, Top Molding	32	6.1
Roof	20	3.8
Roof Side Rails	19	3.6
Window Glass	18	3.4
Console	10	1.9
Area Exterior to Vehicle	55	10.4
Other	83	15.7
Unknown	45	8.5
	528	100.0 %

As shown in the chart, the steering assembly, instrument panel, and surface of the side interior collectively account for approximately forty (40) percent of driver injuries in this NHTSA study.

## **6.2 Priorities for Countermeasure Development**

Establishing priorities for countermeasure development requires consideration of a number of factors including the significance of the problem addressed, the expected effectiveness of the approach, the amount of research and development necessary for implementation, and identification of any potential constraints (e.g., legal) to implementation. The amount of rigor with which priorities can be established depends upon the quality of the information available to define the specific problems and their solutions. The piecemeal nature of existing heavy truck accident data and the dearth of engineering data concerning possible means of increasing heavy truck occupant protection necessitate a crude prioritization of research and development strategies for initiation of work in this area.

## **6.3 Recommendations for Countermeasure Development**

Although the report does present recommendations for addressing most of the higher frequency injuries shown above in 4.2, it does not make any mention or recommendation regarding truck rollovers. The omission of rollovers from this list is consistent with and supported by the rationale discussed in 6.2 above.

**(1985/86)** Leasure and Clarke of NHTSA prepared a draft Section 217 report on Truck Occupant Protection as authorized by the Motor Carrier Safety Act of 1984 (P.L. 98-554). Leasure and Clark visited truck manufacturers, industry suppliers, and other organizations to determine existing state-of-knowledge and programs underway within the industry at large. The purpose of these visits was to determine what manufacturers knew about truck crashworthiness and to obtain their viewpoints on how best to proceed to achieve improvements in occupant crash protection.

**(1986) Truck Safety – An Agenda for the Future** (June 3-5, 1986 Annapolis, MD) <sup>9</sup>

This symposium provided a forum for public participation in the preparation of the NHTSA reports to Congress required by Sections 216 (Heavy Truck Safety) and 217 (Truck Occupant Protection) of the Motor Carrier Safety Act of 1984. The symposium yielded a written record of the views of nearly 300 participants regarding the appropriateness of the proposed NHTSA research plan for the study areas of heavy truck braking, handling, stability, crashworthiness and occupant protection.

With regard to the subject of rollover protection, there was general pier support for the following comments offered by co-author Bob Clarke:

- 1) **It is difficult to tell how many truck occupants may have been killed in cabs in which the structure was inadequate to contain and protect the occupant in a crash.**
- 2) **Based on Texas data (Figure 5 shows a 7-point scale, which is an index of 1 to 7 in terms of damage severity), you can track the amount of damage the vehicle sustained as a function of whether or not someone was killed or injured. In the case of death, 89% of the people killed in trucks were killed in accidents in which there was moderate to severe total damage. I don't know whether this is a chicken or egg proposition; that is, they were killed because the accident was so severe that the vehicle was very badly damaged or the other way around.**

**(1986) S.217 Truck Occupant Protection Report** (December 1986) <sup>10</sup>

NHTSA published the above comprehensive final technical report as authorized by the congressionally mandated Section 217 Study. This report recommended that research studies be initiated in the following four priority areas: 1) restrain systems, 2) cab structural integrity, 3) steering wheels and other interior surfaces, and 4) post-crash fires.

**(1987/88)** The SAE Crashworthiness Subcommittee developed a comprehensive crashworthiness research plan incorporating recommendations contained in the above-referenced NHTSA S217 Report on Truck Occupant Protection. This research plan formed the basis for a five-year study on heavy truck crashworthiness that was carried out by an organization known at that time as Failure Analysis Associates (FaAA). The FaAA program was co-sponsored by the USDOT and U.S. truck manufactures under the auspices of the SAE Cooperative Research Program.

**(1991)** The above-mentioned **SAE/FaAA Heavy Truck Crashworthiness Research Program** was launched in 1991 and completed in 1996. <sup>11, 12, 13, 14</sup>

**(1993)** **SAE Paper (933058) The Decade of Declining Heavy Truck Fatalities...A Tribute to the Co-operative Process.** <sup>15</sup> The accident statistics reported in this paper are based on a comprehensive in-depth analysis of the 1980-1991 TIFA File. As indicated in this report, the occupant fatality rate for heavy trucks declined sixty (60) per cent from 1980 to 1991 even though there was a significant increase in both the number of vehicle miles traveled (VMT) and the number of new USDOT registered fleets.

**(1994)** Dr. Ken Campbell's April 15, 1994 letter to the SAE Truck Crashworthiness Task Force <sup>16</sup> concluded from his analysis of NTSB & TIFA data for 1980-90 that: **These results do not provide a definitive answer to the question of the national incidence of rollover onto the roof, although they suggest that the estimate from the NTSB cases may be too high. At this point, the best recommendation would be to initiate coding of the quarter turns of roll in the TIFA Survey for 1993 that will be initiated in a month or so.**

**(1994/1995)** UMTRI conducted the **1993 TIFA Rollover Survey** <sup>17</sup> in follow-up to the above-mentioned recommendation. The following information was collected by the UMTRI survey on all fatal truck rollover crashes that occurred in the U.S. during 1993:

- Direction of roll
- Number of quarter turns of roll
- Extent of roof damage
- Occupant injuries

**(1996)** : Dr. Ken Campbell's letter of April 15, 1996 to SAE <sup>18</sup> reported **Results from the 1993 TIFA Supplemental Rollover Form Survey.** Of the 583 trucks involved in fatal accidents in 1993, 288 (49%) were rollover accidents that resulted in fatal injuries to the driver.

**(January 1998)** SAE published the following nine new cab crashworthiness test procedures encompassing results of the five-year SAE/FaAA Crashworthiness Study: <sup>19</sup> slides 44 – 51

**J-2418 Occupant Restraint Components**

**J-2419 Occupant Restraint Systems, Frontal...**

**J-2420 COE Frontal Strength, Quasi-Static...**

**J-2421 COE Frontal Strength, Dynamic...**

**J-2422 Cab Roof Strength, Quasi-Static...**

**J-2423 Cab Roof Strength, Dynamic...**

**J-2424 Free Motion Headform Impact...**

**J-2425 Steering Control Systems...**

**J-2426 Occupant Restraint Systems, Lateral...**

**(July 2000)** SAE Heavy Vehicle Rollover TOPTEC July 12-13, 2000 <sup>20</sup>

The following paper on heavy-truck crashworthiness was presented as part of this SAE TOPTEC Session:

**Truck Crashworthiness in the United States “A Historical Perspective” <sup>21</sup>**

Information regarding crashworthiness research and related activities referenced in this document can be obtained from the following source:

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**AMA/MVMA SPONSORED TRUCK ACCIDENT  
COLLECTION/ANALYSIS PROGRAMS**

(Source; MVMA Sponsored Motor Truck Research Bibliography December, 1992)

- 1) Truck Accident Study, Report of Procedures and Findings; Ernst and Ernst August 1968
- 2) Trucks in Rural Injury Producing and Property Damage Utah Accidents; Cornell Aeronautical Laboratory December 1969
- 3) Characteristics of Large-Truck Accidents as Represented in Texas Accident Data; UM-HSRI October 1975
- 4) Truck /Bus Accident Study; University of California, Institute of Safety and Systems Management December 1975
- 5) Analysis of Tractor-Trailer and Large Truck Accident Data; SWRI June 1976
- 6) Analysis of Truck, Tractor/Trailer Accident Data; Calspan June 1976
- 7) Car-Truck Fatal Accidents in Michigan and Texas; UM-HSRI October 1977
- 8) Analysis of Heavy Truck Accident Data; Calspan April 1978
- 9) Analysis of Heavy Truck Underride Accident Data; Calspan September 1978
- 10) Effects of Truck Conspicuity on Collisions: UM-HSRI August 1979
  - a) Car/Tractor-Trailer Underride Accidents; Analysis of 1977 FARS Data
  - b) Retro-reflectorization and Nighttime Truck Conspicuity; A Literature Review
  - c) Truck Conspicuity Eye Mark Study
- 11) Analysis of Truck Accident and Exposure Information, Phase I; UM-HSRI November 1979
- 12) Comparison of Michigan Fatal and Non-Fatal Car-Into-Truck Accidents; UM-HSRI November 1979
- 13) Accidents and the Nighttime Conspicuity of Trucks; UM-HSRI December 1979
- 14) A Comparative Analysis of Truck and Non-Truck Accidents in the State of Michigan; Wayne State University January 1980
- 15) Combination Vehicles: Five-Year Accident Experience; UM-HSRI July 1980
- 16) The Effect of Cab Style on the Accident Experience of Heavy Trucks; February 1981
- 17) A Comparison of Accident Characteristics and Rates for Combination Vehicles with One or Two Trailers; UM-HSRI August 1981
- 18) Occupant Survivability in Heavy-Truck Crashes: UM-HSRI November 1981
- 19) Truck-Truck Fatal Accidents; UMTRI February 1985
- 20) Road Class and Large Truck Involvements in Fatal Accidents; UMTRI January 1986
- 21) The UMTRI Large-Truck Survey Program; UMTRI July-August 1986
- 22) Road Class and Large Truck Involvements in Fatal Accidents; UMTRI May 1987

***Exhibit #1 continued***

- 23) Presentations on the Large Truck Survey Program-Proceedings of the National Truck Safety Symposium; UMTRI June 1987
- 24) Rear-End Collisions and Conspicuity; UMTRI June 1987
- 25) Heavy Truck Fuel System Integrity, Summary of First Nine Months of Operation; Texas Transportation Institute October 1987
- 26) Analysis of Accident Rates of Heavy-Duty Vehicles; UMTRI April 1988
- 27) National Truck Trip Information Survey, UMTRI Truck Study; UMTRI March 1988
- 28) Heavy Truck Fuel System Integrity Study, Summary Report; Texas Transportation Institute November 1988
- 29) Feasibility Study: Accident Rates of Existing Longer Combination Vehicles; UMTRI July 1989
- 30) Evaluation of Personal Injury Occurrences in, on, or around Medium and Heavy Trucks; Gallagher & Ross October, 1991
- 31) TIFA Annual Reports from 1980 thru 1992, UMTRI 1980-1992

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- 2) **Truck Manufacturers Pioneering Development of Accident Data Programs** Presentation by Farrel L. Krall at SAE Truck and Bus Meeting October 14, 1996  
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- 3) **The Williamsburg Conference on Highway Safety Research...a technical conference to develop a plan of needed safety research** sponsored by SAE Vehicle Research Institute November 1972; Session VII Truck, Bus and Multipurpose Vehicle Safety chaired by Farrel L. Krall  
This Document is Reference **10** in the Farrel Krall Resource Library: [www.kralltrucksafety.com](http://www.kralltrucksafety.com)
- 4) **Key Issues in Heavy Truck Safety** statement of Motor Truck Manufacturers Division, Motor Vehicle Manufacturers Association of the United States, Inc. submitted at the Motor Vehicle Safety Seminar sponsored by the National Motor Vehicle Safety Advisory Council July 12, 1976 (presented by Peter Griskivich MVMA and Farrel L. Krall International Harvester Company)  
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- 5) **A Study of Heavy Truck Occupant Crash Protection** Request for Proposal May 22, 1980  
Department of Transportation, National Highway Traffic Safety Administration, Office of Contracts and Procurement
- 6) 1) **Heavy Truck Pilot Crash Test -Frontal Impact**, R. Rice and N. Shoemaker, U.S. Department of Transportation Report No. DOT-HS-805-935, June 1981; 2) **Heavy Truck Pilot Crash Test – Rollover** R. Rice, U.S. Department of Transportation Report No. HS-805-978, July 1981
- 7) **Heavy Truck Occupant Crash Protection – A Plan for Investigation Ways to Improve It** SAE Paper 821270 Robert M. Clarke USDOT National Highway Traffic Safety Administration and Joseph Mergel U.S. DOT Transportation Systems Center SAE Truck & Bus Meeting November 8-11, 1982
- 8) **A Study of Heavy Truck Occupant Protection Accident Data Analyses** DOT HS-806-426 Thomas A. Ranney Calspan Field Services, Inc. April 1983
- 9) **Truck Safety - An Agenda for the Future** P-181 SAE Symposium Annapolis, MD June 1986 (Sponsored by SAE in cooperation with NHTSA)
- 10) **Section 217 Truck Occupant Protection** USDOT HS-807-081 R.M. Clarke and W.A. Leasure Jr. USDOT National Highway Traffic Safety Administration December 1986
- 11) **Heavy Truck Crashworthiness-Phase I; Statistical Analysis, Accident Reconstruction, and Occupant Dynamics Simulation** SAE CRP-9 Failure Analysis Associates, Inc. March 1995
- 12) **Heavy Truck Crashworthiness-Phase II; 180 Degree Dynamic Rollover and Static Roof Crush Simulation** SAE CRP-12 Failure Analysis Associates, Inc. September 1996

- 13) **Heavy Truck Crashworthiness-Phase III; Restraint System Test Procedure Development, Cab Interior Component Test Development, and Cab Structural Test Procedure Development**  
SAE CRP-13 Failure Analysis Associates, Inc. April 1997
- 14) **Heavy Truck Rollover Crashworthiness; Testing Methods and Development of Recommended Practices** SAE 2000-01-0467 Exponent Failure Analysis Associates, Inc. Stephen M. Werner and Robert E. Larson
- 15) **The Decade of Declining Heavy Truck Fatalities...a tribute to the co-operative process**  
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- 17) **1993 TIFA Rollover Survey** Center for National Truck Statistics University of Michigan Transportation Research Institute, Kenneth L. Campbell Principal Investigator
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- 19) **Legislative Impact on the Design and Operational Safety of Large Trucks in the United States**  
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