

# Engineering analysis of 'safety concept' ambulances

Nadine Levick, MD, MPH, EMS Safety Foundation, New York USA Raphael Grzebieta, MEng Sci, PhD, UNSW Injury Risk Management Research Center (IRMRC)

## ABSTRACT

**Introduction:** 'Safety concept' ambulances recently appeared on the USA market, however independent automotive vehicle safety design engineering technical analysis is lacking

**Objective:** To conduct an automotive safety engineering analysis of the potential safety performance and occupant protection design of 'safety concept' ambulances.

**Methods:** The 6 study vehicles were 'safety concept' ambulances developed from 2003-2008. Potential safety performance was analyzed by a multidisciplinary automotive safety engineering and EMS team. Information on vehicle design and construction was identified, and evaluated via application of basic engineering principles of crashworthiness and available crashworthiness testing data, with a focus on countermeasure design for reducing harmful loading and potential for injury causation in crashes or sudden decelerations. Development costs were estimated. Data sources: vehicle specifications, inspections, photographs, crash tests and published crashworthiness and injury mitigation literature.

**Results:** Automotive safety technical engineering data input or impact crashworthiness testing to demonstrate vehicle safety performance by developers was not identified. Vehicles were not optimized for occupant protection based on known, existing technical data. Serious hazards were determined- including design elements proven in peer reviewed crash tests to result in non survivable G force loads on the head and neck at 25 and 30 mph tests with 80 to 100 millisecond crash pulses; head strike zone and egress hazards; use of hazardous 4 and 5 point harnessing for side facing occupants; and anchorages for restraints systems and equipment not subjected to a 25 G impact pulse. There was no demonstrated patient compartment structural crashworthiness. Estimated direct costs, up to \$350,000/per vehicle.

**Conclusion:** Ambulance design is a vehicle and automotive safety engineering issue and is a technical field of expertise outside of EMS practice. Based on peer reviewed and established automotive safety principles and data there are major deficiencies in the safety of the design of these ambulances. A >\$2 million expenditure on alleged 'safety concept' vehicle development by EMS providers and aftermarket manufacturers, outside of - and in conflict with - accepted automotive safety technical data is completely unacceptable and should not be tolerated. Automotive safety, crashworthiness and transportation safety expertise, technical data and oversight must be centrally integrated into ambulance vehicle safety development.

## BACKGROUND

Data strongly point to the hazards of ambulance transport generally and also specifically to the rear occupant compartment of the ambulance as being of high risk of serious injury and fatality in the event of a crash. There has been a recent increase in the promotion of the marketing of 'safety concept' ambulances in the USA, however there is an absence of accessible independent technical evaluation of the design and potential safety performance of these alleged 'safety concept' vehicles.

USA ambulances are built by aftermarket ambulance manufacturers, to meet the Ambulance Manufacturing Division's (AMD) own design standards. These 'standards' are essentially developed outside automotive safety and crashworthiness engineering oversight. Similarly the case for the KKK-F purchase specification developed by the General Services Administration

## OBJECTIVE

With now numerous USA "safety concept" ambulance vehicles being showcased and distributed into EMS markets, this study's objective is to evaluate the potential safety performance of the more recent 'safety concept' ambulances based on accepted human factors and occupant protection principles, and existing data.



Fig 1. Study vehicles

## METHODS

The 6 study vehicles were 'safety concept' ambulances developed from 2003-2008. Potential safety performance was analyzed by a multidisciplinary automotive safety engineering and EMS team. Information on vehicle design and construction was identified, and evaluated via application of basic engineering principles of human factors, crashworthiness and available crashworthiness testing data, with a focus on countermeasure design for reducing harmful loading and potential for injury causation in crashes or sudden decelerations. Development costs were estimated. Data sources: vehicle specifications, inspections, photographs, crash tests and published crashworthiness and injury mitigation literature.

## RESULTS

The vehicles were not optimized for safety and occupant protection based on known, existing and published technical data. Serious occupant protection hazards were determined- including head strike zone hazards; use of hazardous 4 and 5 point harnessing for side facing occupants which included design elements proven to result in non survivable G force loads on the head/neck at 25 -30 mph tests with 80 - 100 millisecond crash pulses; sideloaded patient orientation with restraint systems around the neck, anchorages for restraints systems and equipment not subjected to a 25 G impact pulse, no demonstrated patient compartment structural crashworthiness.

## RESULTS (contd)

Serious egress hazards were identified in the side loading vehicle (12ft minimum loading projection of stretcher and provider into the active roadway, and major challenges for reverse-in ambulance bay patient unloading). Automotive safety technical engineering data input or impact crashworthiness testing to demonstrate vehicle safety performance by developers was not identified. Additionally visibility and conspicuity features were not consistent with current state of the art technical information. Estimated direct and indirect costs, up to \$350,000/per vehicle.

Fig. 2. Hazardous restraint configuration and head impact zone



Fig.3a. 25 mph NIOSH crash test

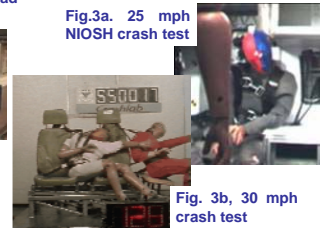


Fig. 3b, 30 mph crash test

Fig. 3a, & 3b. Demonstration tests of hazardous side facing occupant harness restraint configuration

## DISCUSSION

Whilst the science, practice and principles of automotive safety is a well advanced technical science and discipline, this study demonstrates a serious and substantive disconnect between what is known, well described and understood in the world of automotive safety technology and what appears to be occurring in the design and development of some ambulance vehicles, in the USA. There are features of ambulance design in the 6 vehicles studied that are potentially hazardous and not within the known principles and technical aspects of crashworthiness and automotive safety design. Several features identified, demonstrated predictable serious crashworthiness and occupant protection hazards.

Of increasing concern is that the USA general EMS association publications and magazines continue to publish "reviews" of these "Safety Concept" vehicles in non technical EMS industry magazines. These publications are widely broadcast and distributed, yet absent of technical automotive safety engineering or crashworthiness input. This information has been determined by the automotive safety experts (in their peer reviewed literature) to be hazardous and distanced from accepted automotive safety knowledge and practice. Even of greater concern is that as a result of these EMS industry "review" articles that EMS personnel are now making design and purchase decisions which could be placing patients and EMS personnel at predictable risk of serious injury.

## DISCUSSION

There now appears to exist a rapidly accelerating culture and purchasing pattern in the EMS industry, forged by this information dissemination in the EMS association publications and magazines. Vehicle and fleet purchase decisions appear to be based on an increasing cultural perception that is guided primarily by the EMS industry publications rather than by the information in the technical scientific literature. These EMS publications espouse a perception of safety innovation that has no credible basis in either the open automotive safety literature or worlds best practice vehicle crashworthiness standards.

Compounding this, it is difficult now for those not trained in automotive safety engineering and crashworthiness, and in the absence of relevant standards to process this situation.

However it remains that these "Safety Concept" vehicles are not vehicles that utilize state of the art occupant protection systems for the rear compartment and are not demonstrated to be crashworthy. As such, they should not be considered by fleet purchasers as model safety vehicles. Furthermore an ~\$2 million expenditure on development of these alleged 'safety concept' vehicles, outside of accepted automotive and human factors safety expertise is completely unacceptable.

## LIMITATIONS

One of the challenges of this study was the combination of the absence of any meaningful testing standard for the USA vehicles and the failure of the aftermarket manufacturers to provide technical safety performance information or data that had guided their design process.

## CONCLUSION

Ambulance design is a vehicle and automotive safety engineering issue and is a technical field of expertise outside of EMS practice. Based on peer reviewed and established automotive safety principles and data there are major deficiencies in the safety of the design of these ambulances. An ~\$2 million expenditure on alleged 'safety concept' vehicle development by EMS providers and aftermarket manufacturers, outside of - and in conflict with - accepted automotive safety technical data is completely unacceptable and should not be tolerated. Automotive safety, crashworthiness and transportation safety expertise, technical data and oversight must be centrally integrated into ambulance vehicle safety development.

## Contact:

Nadine Levick MD, MPH - nlevick@attglobal.net  
www.objectivesafety.net