Safety and Operational Innovation: Integrating Global Best Practice and Interdisciplinary Technical Expertise into Ambulance Design

Levick NR, Fitzgerald C, Swartz J, Lukianov G, Rolfsen R, Cooper A and the Innovation Consortium of the EMS Safety Foundation

Abstract

Introduction:
Ambulance design has fundamentally not changed in 50 years. Historically and to date in the USA, ambulance design is the domain of health care providers and input from technical science of automotive safety and operational ergonomics expertise has been limited at best.

Methods:
In this study an interdisciplinary team integrating technical expertise from automotive engineering, operational ergonomics and human factors, clinical EMS and patient transport, epidemiology and ambulance manufacturing was assembled. Identification and analysis of ambulance design from 6 countries was conducted over 24 months, with hands-on inspection of 179 different ambulance vehicle types and configurations. The strengths and weaknesses of each design was assessed based on technical principles of human biomechanical tolerances and vehicle dynamics. The optimal features were integrated into the design of two ambulance fleets, the first in Dallas Texas, USA and the second in Oslo, Norway.

Results:
The vehicles developed were built into an OEM van that had met stringent global safety and operational performance testing, and that had electronic stability control. Interior design was configured around range of reach and operational task analysis, with rotatable forward and rear facing seating and no squad bench. Head impact hazards were reduced with creative use of portable equipment go-bags which minimized need for extensive cabinetry. Positioning of heavy equipment was low in exterior compartments to minimize back injury. Overall cost was less than the standard current ambulance vehicle in each service.

Limitations:
These fleets were developed by innovative EMS and medical transport services and ambulance manufacturers. There are substantive cultural obstacles relating to conceptual change that do exist in many services that would need to be addressed for broad based dissemination.

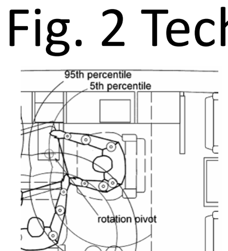
Conclusion:
Ambulance design is a complex integration of the technical realms of a number of diverse disciplines. Integrating those fields and global best practice can be achieved to develop and implement enhanced ambulance design that is both operationally and cost effective.

Introduction:

Ambulance design has not fundamentally changed in 50 years (Fig. 1), despite great strides in automotive safety and occupant protection over that time. Historically and to date in the USA, ambulance design is the domain of health care providers, and input from technical science of automotive safety and operational ergonomics expertise has been limited at best. The majority of the >80,000 ambulance vehicles in the USA are an "aftermarket box fitted to a chassis, built by an aftermarket retrofitter without input of injury data or accepted independent occupant protection or crashworthiness science - even though there is clear evidence in the scientific literature that current ambulance design practices have both occupant protection and ergonomic design hazards that are predictable and unacceptable (Fig. 2).

Fig. 1
Ambulance vehicles 1960 & 2011

Fig. 2 Technical data



Methods:

This study was conducted under the umbrella of the EMS Safety Foundation, a global interdisciplinary innovation, collaboration, and knowledge transfer platform. In this study an interdisciplinary team integrating technical expertise from automotive engineering, operational ergonomics and human factors, clinical EMS and patient transport, epidemiology and ambulance manufacturing was assembled. Identification and analysis of ambulance design from 6 countries was conducted over 24 months from May 2009- May 2011, with hands on inspection of 179 different ambulance vehicle types and configurations. Participation in 3 successive large international EMS Congresses of ~20,000 delegates - Rettmobil, in Fulda, Germany, 2009-2011 - facilitated detailed access to the 179 vehicles (Fig. 3). Additional analytical interdisciplinary interactive workshops across this spectrum of disciplines were held in Washington DC, USA, and Fulda, Germany (Fig. 4). The strengths and weaknesses of each design were assessed based on technical data and principles of human biomechanical tolerances, vehicle dynamics, crashworthiness (Fig. 5b), human factors analysis and ergonomics (Fig. 5a). The optimal features were integrated into the design of two ambulance fleets, the first in Dallas, Texas, USA (Fig. 6) and the second in Oslo, Norway (Fig. 7). Subsequent to vehicle design and development, a further operational hands-on interdisciplinary workshop was held with each vehicle model, respectively in Dallas, Texas, USA and, for the Norwegian vehicle, Fulda, Germany to which it was transported.

Fig. 4 – Interdisciplinary Workshops and Podcasts

Fig. 3 – Rettmobil Delegations 2009-2011

Fig. 6 – Fleet X Dallas, Texas USA

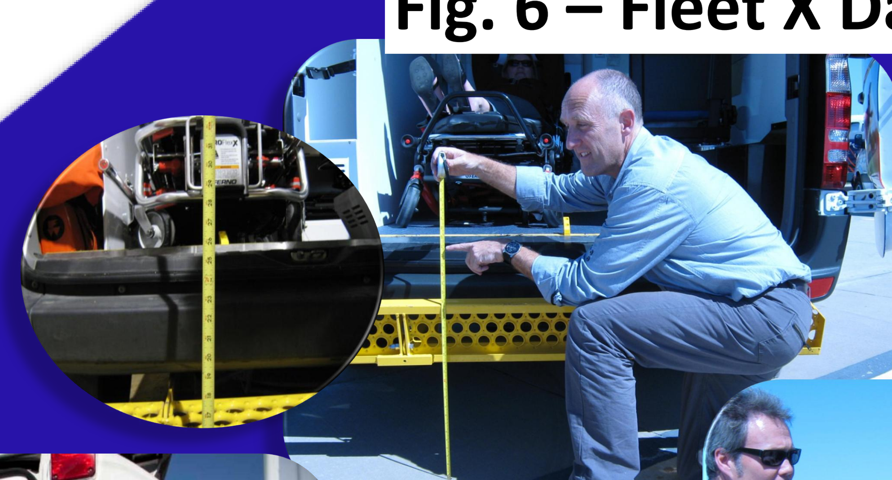


Fig. 7 – Fleet Y Oslo, Norway

Fig. 5a – Task Analysis measurements

Fig. 5b – Occupant Safety performance

Results:

The vehicles developed, Fleet X in Dallas Texas (Fig. 6) and Fleet Y in Oslo, Norway (Fig. 7) were all built into an OEM van type and model that had undergone stringent global safety and crashworthiness testing to meet automotive safety standards for occupant protection and destructive crashworthiness safety performance as a vehicle (Fig 5b)., and subsequently after the ambulance retrofit Fleet Y models have undergone additional operational performance impact testing to meet the CEN standards. These vehicles also had electronic stability control, as well as high fuel efficiency. Interior design was configured around occupant protection priorities, a spectrum of range of reach and operational task analysis (Fig 5a), with rotatable forward and rear facing seating and no squad bench. Head impact hazards were reduced with creative use of portable equipment go-bags which minimized need for extensive cabinetry. Loading height was 27 inches, to minimize any potential back strain during patient loading and unloading. Heavy equipment was positioned low in exterior compartments to also minimize potential back injury when lifting. Overall vehicle cost was less than for the standard current ambulance vehicle designs previously used in each service, in purchase price alone – not considering the overall cost savings in increased fuel efficiency.

Limitations:

These fleets were developed by innovative EMS and medical transport services and ambulance manufacturers. There are substantive cultural obstacles relating to conceptual change that do exist in many services that would need to be addressed for broad based dissemination.

Conclusion:

Ambulance design is a complex integration of the technical realms of a number of diverse disciplines. Integrating those fields and global best practice can be achieved to develop and implement enhanced ambulance design that is both operationally and cost effective.

Contact: Nadine Levick MD, MPH
email - nlevick@EMSSafetyFoundation.org
cell - +1 917 992 2979