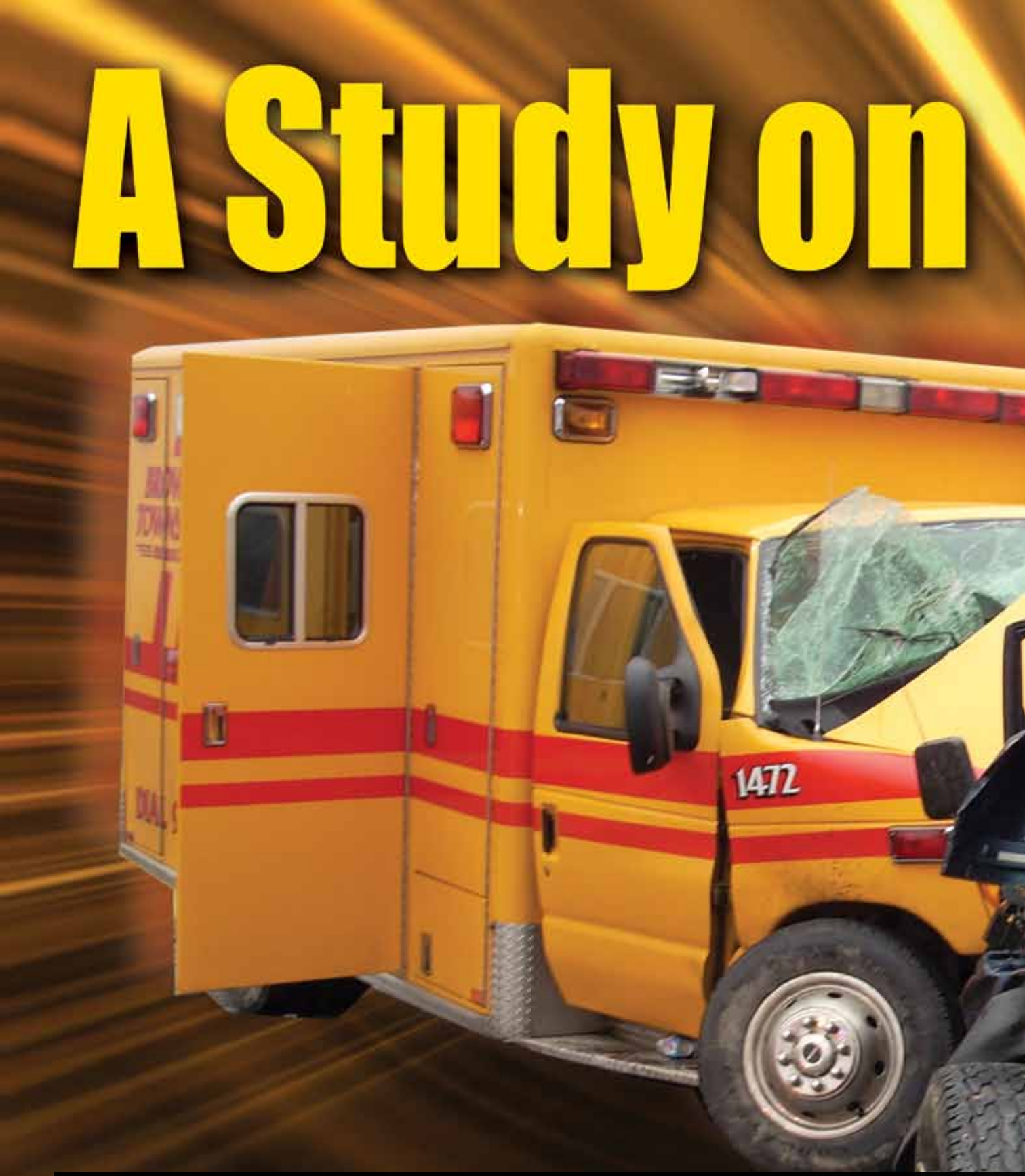
A Study on



In 2010, more than 250 U.S. ambulance crashes were reported in the news media.[1] During such crashes, EMS providers riding in the ambulance patient compartment while caring for patients are at high risk of suffering injuries. An ideal internal patient compartment layout would facilitate efficient clinical care and ensure the safety of both patients and EMTs. Such patient compartment layout should be based on needs and requirements addressed by the EMS community and ambulance manufacturing community.

This article describes the workshop, Design Requirements for Ambulance Patient Compartments, held on Feb. 29, 2012, during the EMS Today Conference & Exposition. The workshop was sponsored by the U.S. Department of Homeland Security Science and Technology (DHS S&T) Directorate and conducted by the National Institute of Standards Technology (NIST). The purpose of the workshop was to identify gaps in current practice, establish

Safety

HIGHLIGHTS FROM WORKSHOP ON AMBULANCE PATIENT COMPARTMENTS

>> BY JENNIFER MARSHALL & Y. TINA LEE

Participants in a workshop held at the EMS Today Exposition & Conference noted that keeping their employees safe from crashes like this one is important.

PHOTO: ASSOCIATED PRESS/INDIANA STATE PATROL

consensus on technical issues related to ambulance design, and review and prioritize design needs and requirements. The workshop results will eventually help identify key requirements to recommend for the next release of the National Fire Protection Association (NFPA) 1917 Standard for Automotive Ambulances.

PROJECT TASKS

Achieving a balance between EMS crew safety and patient care in the ambulance is a significant challenge for the EMS community. There are approximately 50,000 ambulances on the road every day.[1] But there are currently no standards that address performance, ergonomics or safety in ambulance patient compartments that can be used by EMS organizations when procuring ambulances.

The DHS S&T Human Factors/Behavioral Sciences Division and the First Responder Resource Group have teamed with NIST, the National Institute for Occupational Safety and Health (NIOSH), and the BMT designers

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and planners, to aid in the development of standards for the design of ambulance patient compartments.

The project, titled "Ambulance Patient Compartment Design," will develop new crash-safety design standards and improved user-interface guidance that will result in patient compartments that are safer for EMS personnel and patients, and that enable the effective delivery of patient care.

The project includes the following five major tasks:

Needs and requirements analysis: To identify needs and requirements of future patient compartment design through structured and systematic approaches.

Design concepts evaluation: To validate requirements using a set of alternative design concepts and criteria.

Final requirements identification: To identify critical and important requirements that would improve patient care and safety based on the results of the design concepts evaluation.

Industry review: To ensure that the selected requirements satisfy community needs.

Standard recommendation: To present the requirements document to the NFPA for incorporation into the next draft (2013) of the NFPA 1917 standard.

To understand ambulance design and current practices issues, the project team studied documents that included the NFPA 1917 standard, the General Services Administration (GSA) KKK-A-1822F standard, ASTM International Standard Guide for Training Emergency Medical Services Ambulance Operations, Alberta Ambulance Vehicle Standards Code, Australian/New Zealand Standard 4535 and British Standards Institution BS EN 1789.[2–8]

The project team then performed needs and requirements analysis of patient compartment design. Their approaches included practitioner interviews, ridealongs, patient care walkthroughs, focus group meetings, a Web-based survey, and a workshop. These approaches allowed the project team to gain firsthand experience with practicing EMTs and paramedics to better understand their work environment, constraints, and concerns and hence, understand the needs of those in the EMS community.

The interviews, ridealongs and patient care walkthroughs were carried out throughout the country at a variety of volunteer, state, local, private and hospital-affiliated EMS organizations.

The goal of conducting focus group meetings was to gain a broader understanding of the issues involved in ambulance safety, from a variety of stakeholder viewpoints. Three focus groups, including one manufacturers group and two groups of EMTs, were conducted in August 2011 in Las Vegas in conjunction with the 2011 EMS World EXPO. These groups identified several design challenges and suggestions for the improvement of working the environment within the patient compartments.

The findings from these focus group meetings were used as the basis for developing a nationwide ambulance survey that was conducted in December 2011. The purpose of the survey was to aid in soliciting requirements for design standards for ambulance patient compartments and to measure customer satisfaction with current design standards. This Web-based survey received more than 2,500 responses from EMS personnel across the country. As the result of these efforts, a draft version of needs and requirements for patient compartment design was generated. The aforementioned efforts culminated in the EMS Today workshop to review, add to and prioritize the needs/requirements gathered.

Figure 1: Likert Scale

Essential
Would significantly improve patient and EMS crew safety if implemented.
Would significantly improve patient care if implemented.
Conditional
Would improve patient and EMS crew safety if implemented, but not to a significant degree.
Would improve patient care if implemented, but not to a significant degree.
Low
Could improve patient and EMS crew safety to some degree if implemented, but not an important requirement at this time.
Could make patient care somewhat easier if implemented, but not an important requirement at this time.

WHY THE WORKSHOP

The purpose of the workshop was to work with practitioners and federal stakeholders to identify gaps in current practice, establish consensus on technical issues related to ambulance design, and review and prioritize design requirements. The workshop participants included practitioners, practitioner organization representatives and federal government agency representatives.

REQUIREMENTS ASSESSMENT

The workshop was structured to promote dialogue and knowledge sharing among a diverse group of practitioners and assess the collective priorities for the design requirements of patient compartments in ambulances. It used breakout sessions to initiate focused discussions. A set of needs and requirements, which was developed by the project team based on the results of previous project tasks, was provided to the participants of each breakout session. They were instructed to assess the requirements from the safety, functionality, and the combined safety and functionality points of view. The assessment used a three-point Likert scale. (See Figure 1, above left.)

TOPICS & DESIGN NEEDS

Participants were grouped into four breakout sessions in order to facilitate the discussion of technical design issues, current practices, and needs and requirements in different topical domains. The topics of these sessions included:

Seating, restraints and communication systems: This covered two domains. The seating and restraints domain concerns the extent to which the patient compartment will enable EMTs and paramedics to provide safe and effective patient care from a seated and/or restrained position in the ambulance patient compartment. The participants focused on the needs/requirements that will help achieve a critical balance between safety and effectiveness—restraints vs. seating, adjustability of seating for better access to patient and equipment, being able to interact with the patient while seated, and ergonomic seating.

The communication systems domain concerns the extent to which the patient compartment shall 1) enable efficient and effective communications between the patient compartment, the driver, and others; 2) facilitate driver awareness of activity in the patient compartment; and 3) facilitate the EMS provider's awareness of driver actions. The participants focused on ways to communicate effectively within the patient

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compartment with patients and others in the back, the driver, dispatch and hospitals.

Work environment: This domain concerns the extent to which the patient compartment will 1) enable the provider to safely and effectively perform patient care; 2) enables easy cleaning and restocking after each trip; 3) enable quick and safe ingress/egress; 4) include safety mechanisms (e.g., padding and nets) to reduce hazard risks; and 5) provide space and accessibility for storage of disposal containers. The participants focused on overall space design, accessibility of power and lighting control, as well as flooring and the height of the patient compartment.

General equipment and storage: This domain concerns the extent to which the patient compartment will 1) provide space and accessibility of storage for equipment and controls; 2) allow safe and effective use of patient care items; 3) facilitate the ability of providers to perform inventory management; and 4) allow safe and secure storage of the patient care items including equipment, supplies and medicines. The participants focused on the needs/requirements for accessibility and location of equipment/supplies.

Special equipment and storage: This topic covers the special equipment (e.g., cots and jump bags) and storage. This domain concerns the extent to which the patient compartment will 1) allow cots to safely and effectively be secured/released or loaded/unloaded; 2) allow the prehospital professional to securely restrain the patient in the cot and safely and effectively treat the patient; 3) facilitate the ability of the EMS provider to safely and effectively perform CPR; 4) provide safe and secure storage and accessibility of jump bags; and 5) allow safe and secure storage of patient's equipment/belongings. The participants focused on space around the cot, cot loading systems and jump bag locations.

WORKSHOP RESULTS

At the end of each breakout session, the group identified the essential design requirements that are most important across both safety and functionality. The groups also identified a small number of items that should not be included in the requirement list for a variety of reasons, such as measurability, policy/regulatory or out of scope. The participants recommended that some requirements be merged. The following list includes essential design issues/requirements:

PARTICIPANT COMMENTS

The workshop participants identified a number of concerns/issues during all four sessions. Several examples are listed here.

SEATING REQUIREMENTS: Participants expressed concerns about the possibility that new seat designs could infringe on space for equipment and storage. Participants did not perceive that forward-facing or rear-facing seating arrangements were functional enough to address the patient's needs. The group suggested investigating best practices and designs used in other countries. The group also suggested that the community needs to move away from legacy designs behind and be more innovative in patient compartment design.

RESTRAINT SYSTEMS: The ability to reach the patient is just as important as the ability to reach equipment. Comfort was identified as an important requirement for restraint systems, because the lack of comfort could hinder widespread use of new systems by practitioners. The group identified that existing retractable restraints do not work efficiently, and that there is a need to clarify the difference between restraint systems and seat belts. It was noted that restraint systems could differ according to specific needs; for example, an advanced restraint system would not be needed for "walking wounded," but such patients would still need to be subjected to some form of restraint.

COMMUNICATION REQUIREMENTS: Participants expressed concern about the use of non-verbal communication systems, which could cause distractions. Hands-free verbal devices were perceived as safer options. The group noted that new technologies could be readily available before the next release of NFPA 1917. Participants also perceived that means of communicating between the EMS provider, the driver and third parties (e.g., hospitals) do not need to be provided in and accessible from all EMS provider workstations.

AIR AMBULANCE DESIGN: A useful model for ambulance design would be air ambulance design (i.e., helicopter and fixed wing). Participants noted that ambulance design is often viewed from the perspective of designing the inside of a large automobile. They suggested that the patient compartment be viewed more as a cockpit.

PRIORITIZATION: The NIOSH accident trend data and no-strike zones would help prioritize implementation (i.e., procurements).

TRANSPORT CAPABILITIES: The ability to transport more than one patient should be considered as a possible requirement.

ERGONOMIC STORAGE: Equipment storage locations should take into account ergonomic issues such as weight and lifting height.

PROTECTING OUR OWN: Participants indicated that they care about their employees, and that protecting them from injury is the primary concern.

LIFT INJURIES: The leading cause of EMS injury is lifting/loading injuries. Lifting heavy equipment is also a major cause of back and muscle strain.

AGGRESSIVE/UNPREDICTABLE PATIENTS: Patients who are aggressive or move unpredictably represent a safety consideration.

A SPACE OF OUR OWN: There should be a space provided to accommodate EMS providers' belongings.

CHILD SAFETY SEATING: Participants recommended not using the adult cot equipped with child restraints, noting that a child safety seat is a better option.

LOADING OF PATIENTS: Hospitals are increasingly prohibiting EMS providers from lifting patients, due to the rate of back injury claims and patient injuries. Reducing back injury to EMS providers should be emphasized.

LACK OF DATA: Participants expressed concern that there's no available data on EMS provider injuries, or the causes, severity, etc. of those injuries.

PROTECT THE HEAD: Participants recommended EMS providers wear helmets.

INDIVIDUAL EQUIPMENT STANDARDS: There's a need to address the items carried by EMS providers, and there is a need to address requirements for individual equipment items.

TRAINING: Participants suggested there is a need to address training in the standard.

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Seating/restraint and communications systems

1. The provider is able to reach common and critical equipment/supplies from a restrained and/or seated position.
2. The provider is able to operate equipment controls from a seated and/or restrained position.
3. The provider is able to reach and treat the patient from a restrained position.
4. Communication systems support the provider's ability to continue providing safe and effective patient care. Means for communicating between the EMS provider, the driver and third parties are provided and accessible from all EMS provider workstations.
5. EMS providers in the patient compartment are able to establish communications quickly with the driver or other third party.

Work environment

1. Workspace has appropriate space for secure and safe placement and use of equipment, papers and supplies.
2. Providers are able to exit the patient compartment with a patient loaded on a transport device from the main patient loading and unloading doors and one other door.
3. Safety mechanisms (e.g., padding, nets and airbags) are included in the patient compartment to reduce the likelihood of injury to EMS providers and patients during crashes or evasive maneuvers. This priority was seen as also subsuming three additional items:
   - >> No head strike obstacles;
   - >> Pathways clear of obstacles (no portable patient care equipment); and
   - >> Doors do not intrude into workspace or provide strike risk.

General equipment and storage

1. The location of the equipment while in use in the patient compartment minimizes the likelihood of introducing additional risks to EMS provider and patient safety.
2. Placement of equipment that requires EMS provider interaction, including the monitor, allows EMS providers to complete this interaction from a restrained and/or seated position.
3. Equipment stored outside of a cabinet is secured such that it does not become a hazard to the EMS provider or patient.

Special equipment and storage

1. The cot guidance and securing mechanism allows for the cot to be secured in a safe and efficient manner.
2. The cot loading system allows for the patient to be loaded or unloaded safely with minimal risk of injury to patient or EMS provider.
3. When being used for patient care, the placement of secured jump bags allows EMS providers to quickly and safely access them.
4. Secure storage is available for patient and staff belongings.
5. Cot allows for the patient (including aggressive/violent ones) to be securely restrained without hindering the ability of the EMS provider to provide safe and effective patient care.

CONCLUSIONS & FUTURE WORK

The results of the ambulance patient compartment workshop confirmed and prioritized the needs and requirements the project team gathered from other research efforts. These results will be further reviewed, enhanced and evaluated.

The workshop participants were asked to continue sending any further needs, requirements and suggestions about future ambulance patient compartment design.

The next step is to focus on modeling potential designs for the patient compartment.[9] These designs will be based on the prioritized requirements. The selected requirements will be used to develop a set of design concepts that represent three-dimensional graphical models. Clinical-care experiments with

different designs, placement of equipment and supplies and providers will be simulated using a human modeling tool. The purpose of these simulation experiments is to validate the requirements.

With the experimental results, a final set of design requirements will be identified. The final set of requirements and the validated crash safety standards from NIOSH will be input to the next open comment period for NFPA 1917, which is tentatively scheduled for spring. JEMS

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