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The Need for an Improved Rotorcraft Restraint System

Limitations of existing troop seat restraint systems and opportunities for increased usage

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1. Identification and Significance of the Problem

A safety restraint may be a highly-advanced, cutting edge solution, but if the occupant chooses not to use it, then this technology becomes irrelevant. As an example, a study of the general public in 2003 sponsored by the National Highway Traffic Safety Administration (NHTSA) concluded that although 95% of those interviewed agreed that seat restraints saved lives, 22% used them sporadically or not at all (1). Usage of seat restraints is therefore a key consideration when designing any restraint system and understanding the circumstances which discourage their use should be thoroughly understood.

Occupants may forgo restraint systems for reasons relating to *comfort*, *convenience* and *perception of safety*. These concerns may be addressed through different disciplines such as education, policy, enforcement, and also through optimal design. In this proposal we focus on design and how it may be used to minimize occupants' concerns and maximize usage rates. Many comfort issues are related to belt positioning and rubbing (2). For instance, a belt that crosses a 95th percentile male's chest may cross the neck of a 50th percentile female. It is therefore important to have a thorough understanding of who your occupants are and ensure that restraints are designed to accommodate them. For example, it may be advantageous to allow for adjustment of belt exit points, or perhaps wrap the belt edges with padding or fabric. Research into new, high-strength, elastic fabric may also be warranted such as Honeywell's Securus ™ fabric which has energy absorbing properties (3). This fabric has the potential to distribute inertial loads over a longer period of time when compared to traditional belts, similar to how an airbag absorbs energy. Other comfort considerations involve belts rubbing against pre-existing injuries of the neck, chest, and stomach where the belt is in constant contact (4).

Another major seat belt usage concern, especially in the area of rotorcraft where 4 and 5 point harnesses are used, is related to convenience. Belts often have a mind of their own, tangling with one another or seemingly hiding under the seat pan or behind the seat back as shown in Figure 1. This is especially true in the case of a 5 point harness, where many individual belt straps must be joined to a central hub-type buckle. For a soldier or civilian who does not use these types of harnesses on a daily basis, donning this type of restraint system can be a daunting or even embarrassing task. Now imagine an emergency or combat scenario. Stress levels are elevated and immediate survival is in the forefront of your mind. In this situation, strapping into a safety harness is likely to be very low on your list of priorities.

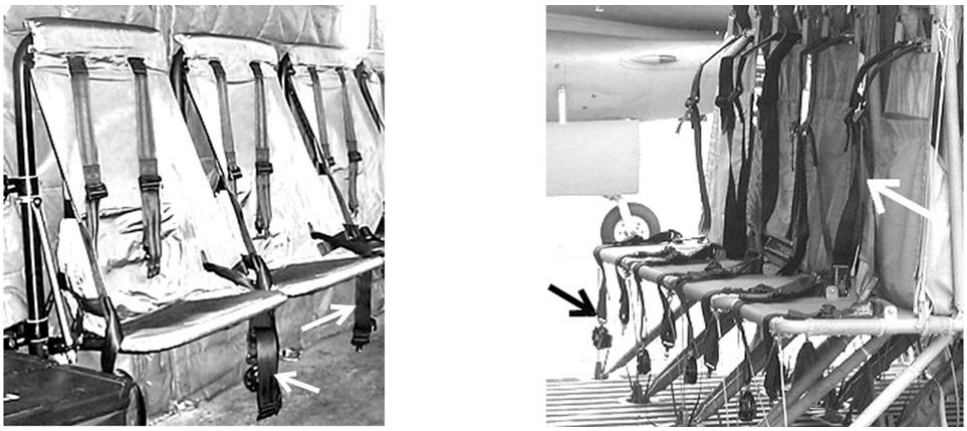

Figure 1: Side Facing and Forward Facing Seats Noting Unorganized Belts

Fairly recent surveys performed by the National Occupant Protection Use Survey (NOPUS) have suggested that since 1994 civilian usage of seat belts at the national level has increased from 58% to 86% in 2012 (5). Other studies have shown that within certain groups and ages, seat belt usage is as high as 95%. However, these results are for a broad range of drivers, across many ages, regions, and professions. As will be explained, the importance of surveying for seat belt usage within a particular group of interest is critical. For some, it is a matter of convenience. Take for instance police officers and firefighters. In data collected for the National Fire Data Center, since 1984, 27% of motor vehicle collision fatalities involving firefighters were due to ejections. Among those ejected, only 21% were reportedly wearing seatbelts (6). In a similar profession, data collected by NHTSA between 1980 and 2008 suggested that among police officers killed in passenger vehicle crashes, only 45% were wearing their seat belts (7).
One characteristic that firefighters and police officers have in common with soldiers is gear (Figure 2). Civilian users of restraint systems typically have little to no gear, so donning of a harness or simple 3-point safety belt is a much simpler process. The belt easily slides across the shoulder, chest, and lap without any restrictions. In a survey conducted of the fire department of Watertown, New York, firefighters were asked to cite reasons for not wearing seat belts (8). Of those surveyed, 33% felt that seatbelts just get in the way and 66% thought that they were too restricting with gear on. In a similar study, 341 police officers in the southeastern United States were asked the number of times a seat belt got caught in their equipment during an average shift. Among those interviewed, 34% responded with 1-2 times per shift, 31% said 3-5 times per shift, and 22% said 6-9 times per shift. Only 13% of those who responded said that the belts never got caught in equipment. Although the seatbelts worn by police and firefighters are typically 3-point systems as opposed to 4 and 5 point systems, the survey results are compelling evidence that wearing of equipment is a consideration of convenience that may contribute to seat restraint non-use.

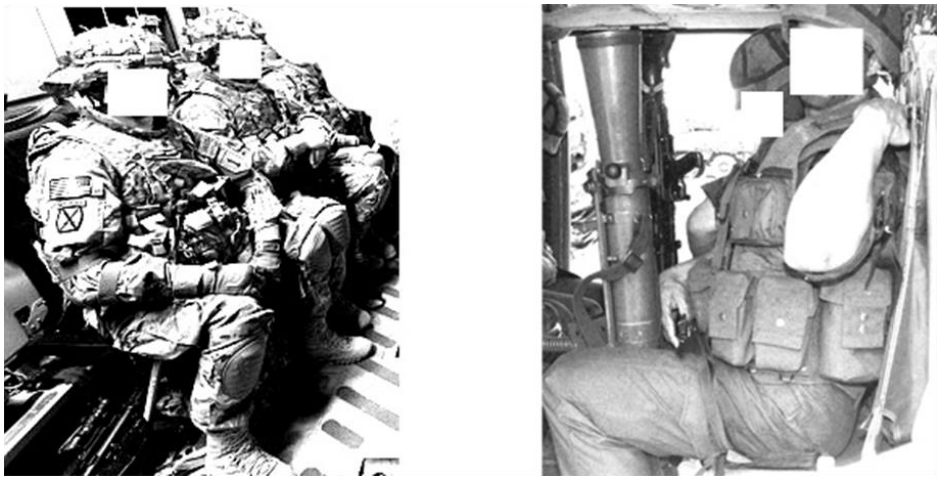

Figure 2: Soldiers Seated with Gear On – Side and Forward Faced Positions

A third reason some may choose not to use a restraint system is related to the perception of safety. While on duty, not only may a soldier be considering his or her own life, but also the lives of people they are protecting. If a soldier has a lack of confidence in the restraint system technology, then he or she may be less likely to use it. For instance, all safety systems should be simple. Buckle mechanisms should be easy to locate and intuitively released, making egress from a safety restraint system and seat quick in all conditions. In a study of commercial truckers, drivers were asked what discourages them from wearing a seat belt. Twenty-six percent feared being trapped inside the vehicle (9). According to the same survey, less than 50% of the drivers interviewed wore safety belts. These fears occasionally are realized in the armed forces, for instance, in the case of a rotorcraft performing an emergency landing or crashing into a body of water. Intensifying the situation, the aircraft may also be on its side or in a pitched position. With seconds to escape, the safety restraint system must perform flawlessly, quickly releasing and in no way hindering an escape. In other circumstances, a soldier must have the confidence that they can perform their job, which may include saving someone's life. In studies previously referred to, both police officers and firefighters had concerns that seat belts would slow their response times. Like those in public service, whether or not military personnel choose to use a restraint system may be correlated to their perception of the system's ease of ingress and egress.

1.1 Characteristics of an Ideal Restraint System for Rotorcraft

Addressing the preceding concerns, an ideal restraint system will contain many features to address comfort, convenience and safety. Specifically, it is the goal of the SBIR solicitation that the technology is innovative, advanced, and quick to use. These are the fundamentals that should be adhered to when developing a new restraint system. Like all products however, there will be a balance between ideal performance and production cost. In this proposal, it is also a goal to integrate the system into existing forward, aft, and side facing troop seat architectures. Moreover, these criteria shall be sustained even during adverse conditions such as in night time use, combat and non-combat situations. Below is our opinion and proposal of ideal safety restraint features:

Table 1: Summary of Ideal Safety Restraint Features and Performance Requirements

Comfort	Convenience	Safety
Allows adequate maneuverability	Restraints are unable to twist	Absorbs inertial energy
Adjusts to all body types	Large, quick release buckle and one-handed buckling/releasing	Occupant is fully constrained in all degrees of freedom
No belt to skin contact	Restraints are positioned and retained in a near-net position	Prevents submarining (slipping under the lap belt)
System does not over tighten	Easy to don with equipment on	Acceptable belt impact pressures
No high pressure points	Intuitive donning achievable without special training	

In summary, it should be the goal to develop an innovative seat restraint system that will address the deficiencies of the current technology primarily in the area of comfort and convenience. The technology will adhere to the ideal safety restraint features of table 1, taking military personnel and their gear into consideration. Moreover the restraint system will be easily integrated or retrofitted into existing seat architectures.

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