An Analysis of the Development of Helicopter Egress Training Simulators

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Over the past century, vehicles have become an essential element within our society. Transportation is a key resource that is required to successfully work and live within the global network that has been created. Additionally, vehicles such as aircrafts and ships are now utilized not just merely for transportation, but by our military for objectives such as the protection of our coastlines and extending humanitarian aid to our allies in crisis. With the development of this reliance on vehicles comes a need for established training measures to ensure that the operators of these vehicles can maintain the highest levels of proficiency. Without this level of expertise, controlling a car, train, or airplane can become a risk-averse and even dangerous task. A recent technology has emerged to provide this integral training within a safe environment are simulators. This technology can replicate the experience of operating a vehicle, while creating an environment where the operator can make mistakes without facing the significant consequences of the mistake in a real situation. The lessons learned via mistakes and failure are essential to growth and development; simulators can assist individuals and machines in gaining these invaluable experiences without facing the detrimental consequences.

In my research, I carefully analyzed how navy helicopter crashes and their casualties over the past century have influenced the design of the navy's helicopter egress training technology and how this technology can be enhanced. Between the years of 1969 and 1972, there were seventy-eight Navy helicopter crashes at sea, and in turn sixty-three lives were lost (Tillison). The Helicopter egress trainer (HUET) program in place at the time utilized an underwater egress simulator called the Dilbert Dunker. The simulator was constructed to look like a single pilot cockpit and when released, it traveled down a pair of metal rails and then flipped nose-first as it made impact with the water. Water then proceeded to rush into the simulator, and the pilot was required to overcome disorientation and make their escape. Its objective was to teach personnel how to orient themselves under water and make a successful egress. However, the Dilbert Dunker did not roll over onto its side as a helicopter does after it impacts the water, which resulted in the simulator not serving as an effective training tool for helicopter aircrew personnel. (Taber, Handbook, 12).

To reverse this trend in fatalities due to aircraft crashes at sea, the Navy began training all flight personnel in the 9D5 Multi-Place Universal Underwater Egress Trainer (Tillison). The 9D5 HUET was introduced in 1974. It utilized a rudimentary cockpit and generic back end compartment and could accommodate up to two trainees in the front and four in the rear. It was not designed to simulate a specific helicopter; it was considered to encompass the basic structure of all U.S. Navy and Marine Corps helicopters operating at the time. This was accomplished by a universal-type exit release mechanism, which allowed a participant to pull down, pull up, or push out on the door to open it. (Taber, Handbook, 14).

In 1987, a company called Survival Systems introduced a helicopter egress simulator called the METS trainer. It was first utilized in Nova Scotia by the Canadian military and offshore oil and gas employees. It can replicate various kinds of helicopter models through the integration of different window configurations, seating, and emergency exit designs while still utilizing the fundamental framework for the simulator. The METS trainer is considered to be the current world standard for HUETs today (Taber, Handbook, 14).

Looking forward, there is one central question that the U.S. Navy needs to be considering; how can helicopter egress simulators provide a more realistic experience? This question can only be answered by analyzing the most dangerous aspects of a helicopter egress and how these circumstances can be more effectively replicated without injuring or killing their personnel.

For example, the “impact phase”, in which the helicopter actually makes contact with the water, is one of the most dangerous aspects of the crash and egress process. However, so far assessments of the potential replication of the impact phase through simulation have been negative. The losses due to injury and death of personnel seem to outweigh the potential benefits of having personnel gain experience with that aspect of the crash and egress process.

However, another dangerous aspect of the crash and egress process is the intensity of disorientation. Disorientation is already a factor that simulators and trainers increase during training by changing the lighting inside the simulator and in the pool, by changing personnel’s seat position and location inside the simulator, and by inverting the simulator once it makes impact with the water. The U.S. Navy could continue to enhance this feeling of disorientation through multiple additions and changes to the simulator and the training program.

By continuing to enhance their helicopter egress simulator training program, the U.S. Navy can more proudly and confidently claim that their sailors are ready for combat. Just this past September, five sailors lost their lives while an MH-60S helicopter was conducting routine flight operations from the aircraft carrier Abraham Lincoln. The helicopter crashed into the flight deck and then fell into the ocean (Dyer). Although casualties are inevitable when operating complex machinery in difficult circumstances, the lives of military personnel can be protected more efficiently through continued enhancements and evaluations of training practices, especially those associated with the training simulators utilized.

Additionally, it is important for the U.S. Navy to be considering how their progress impacts the public sector’s usage of helicopters. Our society views the military as the forefront of development, and in turn it is important that the technology we’re utilizing illustrates this. Additionally, helicopter’s popularity within the public sector has continued to increase. Those working in the private sector where there is a need to travel to various locations frequently are constantly searching for faster forms of transportation, specifically in areas where there are no airports. Helicopters have more enhanced landing capabilities than any other airframe, and can offer a more accessible form of transportation to both rural areas and major cities. Furthermore, in locations such as Hawaii, the use of helicopter rides have become a popular attraction for tourists.

Based on my research, I have determined that there are changes that need to be made to the design of the METS simulator, as well as changes that need to be made to the helicopter egress training program's structure. There are current characteristics in both the HUET and the training program that are enhancing the immersiveness of the egress experience. The METS simulators are designed to match the configuration of the aircraft that the personnel are flying. For example, the diagram below shows the layout of Lockheed Martin's Sikorsky S-22 helicopter, currently utilized by the U.S. Army, and the layout of one version of the METS trainer (Taber, Crash Attenuating Seats, 181).

M.J. Taber/Safety Science 57 (2013) 179–186

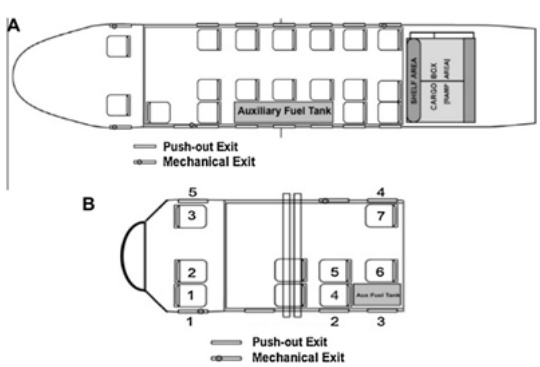

Fig. 2. Sikorsky S-92 interior (Panel A) and METS™ test configuration (Panel B).

Based on this diagram of the Sikorsky S-92's layout and the METS trainer's configuration, it can be interpreted that the simulator's seat arrangement, exit placement, and structural shape is modeled to emulate the Sikorsky S-92. Additionally, when conducting training in HUETS, military personnel are required to wear all the gear that they would wear during a typical flight that includes flight suits, helmets, harnesses, etc. (Taber, Handbook, 20*)*. As touched on earlier, the HUETS are also designed to increase the intensity of disorientation that personnel are experiencing by having variable lighting within their interiors. Furthermore, personnel will be required to practice with and without a HUEBA device in various seat positions and various seat locations within the simulator (McCabe and Taber, 290)

To continue to enhance the immersiveness of HUET training, I have concluded that there are three central aspects of the simulator and the training program that should be evaluated. These improvements will affect the emergency exit doors, the utilization of seat harnesses, and the angles at which the simulator can submerge.

First, force maps, such as the one illustrated in the diagram below, should be developed for the HUETs to be able to more effectively mimic the quantity of pressure required at various locations along the exit doors of actual helicopters (Sweeney and Taber, 548*).*

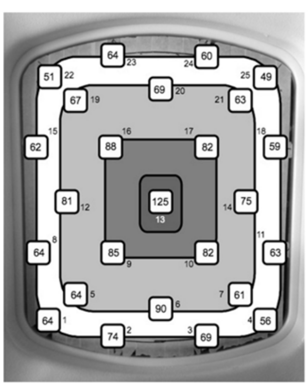

Fig. 6. S92 PFP force map (in-air). The amount of force in lbs required to open the exit is indicated for each location.

The development of emergency exit doors that can mimic the exit doors within a personnel's helicopter regarding how they respond to internal pressure, will ensure that personnel experience a realistic level of difficulty while attempting to egress. Additionally, the training program can be enhanced by instructing personnel where the most effective areas to apply force are based on these force maps. This will ensure they are developing good practices regarding egressing.

Second, the program should train personnel on how to use their seat harnesses to overcome disorientation after impact. Historically, the initial reaction for most personnel is to remove their harness as quickly as possible to avoid being trapped underwater. That being said, by instructing personnel to first orient themselves, take several breaths from their HUEBA device, and then proceed to locate their closest exit point, personnel are more likely to egress successfully. After locating this exit, personnel should proceed to remove their safety harness and swim to this exit point. By utilizing their seat harness until they locate their exit point, personnel can avoid wasting energy and time.

Lastly, egressing at various angles and at various levels of submersion, personnel will experience disorientation. Helicopters do not always completely submerge or invert. In turn, by emphasizing the need to understand the amount of rotation and submersion , their egress will be more effective.

In conclusion, the U.S. Navy should continue to enhance the immersiveness of HUETs in order to more effectively prepare their pilots and air crews for air combat. The public sector will also benefit from these developments as our society's commercial usage of helicopters continues to increase. My research enabled me to identify three key areas that the U.S. Navy should focus on enhancing. First, by developing force maps of actual helicopter exit doors, navy engineers can utilize this data to develop more realistic simulator exit doors and in turn more effectively educate personnel on the best locations and methods to apply force on exit doors for egress.

Secondly, educating personnel on the technique of utilizing their seat harnesses until they locate their exit point will ensure that they can overcome and prevent disorientation before attempting to egress. Finally, providing the capability to adjust the angle of the simulator's rotation will allow personnel to experience a greater variety of potential egress scenarios.

Works Cited

Dyer, Andrew. (Sept 5th, 2021). Navy identifies 5 San Diego sailors killed in helicopter crash off coast. Retrieved from https://www.sandiegouniontribune.com/news/military/story/2021-09-05/navy-identifies-5-san-diego-sailors-killed-in-helicopter-crash-off-coast

McCabe, John and Taber, Michael J. *Helicopter Ditching: Time of Crash and Survivability*

Sweeney, Dana H., Taber, Michael J. *Forces required to jettison a simulated S92 passenger exit Forces required to jettison a simulated S92 passenger exit: Optimal helicopter underwater egress training techniques*

Tillison, Lt. Howard. Performance in the 9D5 Multi-Place Universal Underwater Egress Trainer: Physiological and Behavioral Correlates. *Proceedings of the Human Factors Society Annual Meeting*, vol. 25, no. 1, 1981, pp. 411–415., https://doi.org/10.1177/1071181381025001108.

Taber, Michael J. *Handbook of Offshore Helicopter Transport Safety : Essentials of Underwater Egress and Survival*, Elsevier Science & Technology, 2015. *ProQuest Ebook Central*, http://ebookcentral.proquest.com/lib/uva/detail.action?docID=4012548. Created from UVA on 2022-03-17 00:03:17.

Taber, Michael J.. *Crash attenuating seats: Effects on helicopter underwater escape performance* * Saved Study in STS folder on computer

Tillison, Lt. Howard. Performance in the 9D5 Multi-Place Universal Underwater Egress Trainer: Physiological and Behavioral Correlates. *Proceedings of the Human Factors Society Annual Meeting*, vol. 25, no. 1, 1981, pp. 411–415., https://doi.org/10.1177/1071181381025001108.