Severe Trauma Stress Inoculation Training for Combat Medics using High Fidelity Simulation

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ABSTRACT

Severe trauma injuries create major challenges for military medical personnel treating casualties at the point of injury. Many trained medical personnel are not psychologically prepared to face severe wartime traumatic injuries. The U.S. Army Research Laboratory, Human Research and Engineering Directorate, Simulation and Training Technology Center (ARL-HRED STTC) under the severe trauma initiative developed innovative technologies to realistically simulate the look, feel and smell of severe trauma to prepare medics, combat lifesavers and Soldiers to deal with the injuries encountered on the battlefield. The Multiple Amputation Trauma Trainer (MATT®) developed under this initiative is a high-fidelity Improvised Explosive Device (IED) blast injury simulator with state-of-the-art special effects, sensing and animatronics technologies to support hemorrhage control training. This simulator introduced movement for the first time, increasing realism and immersion to support stress inoculation training. Further development led to a high-fidelity Hemostatic Agent Trainer to support learning how to address non-extremity wounds and stem the flow of blood in such an injury. A prototype upper body trainer was also developed, including a face capable of simulating expressions in response to pain, as well as support for a variety of medical procedure training including needle decompression and airway management. This paper will discuss in detail how training requirements and the student's need to master a variety of procedural skills impacted the design of the MATT®. It will also look at the criteria used to develop the overall design and identify specific capabilities. In addition, it will discuss how subject matter expertise was utilized to develop requirements, metrics and processes used to evaluate the overall benefits of the program. Finally, it will discuss results from usability evaluations and lessons learned from the development and implementation of this project.

ABOUT THE AUTHORS

Dr. Teresita Sotomayor is a chief engineer and subject matter expert in the area of severe trauma simulation at the U.S. Army Research Laboratory (ARL), Human Research and Engineering Directorate (HRED), Simulation and Training Technology Center (STTC). Her expertise in user-centric design and technology effectiveness evaluations has been instrumental in the development and transition of modeling and simulation solutions in support of medical training. She is a graduate of the University of Puerto Rico (Mayaguez Campus) with a degree in Industrial Engineering. She holds a Master of Science degree in Operations Research Stochastic Simulation from The George Washington University and a Doctorate in Modeling and Simulation from the University of Central Florida. She is a member of the Army Acquisition Corps since 2003 and has over 24 years of experience in the modeling, simulation, and training domain.

Mr. Mark Mazzeo is an Engineering Technician for Medical Simulation Technologies with the U. S. Army Research Laboratory (ARL), Human Research and Engineering Directorate (HRED), Simulation and Training Technology Center (STTC). As an intern, he takes an active role in the management of current efforts by accompanying engineers out in the field, assisting with documentation, data collection and analysis, and experimental design. He prepares and reviews contractual documents, performs technology demonstrations and maintains laboratory equipment, and explores new areas of research within the field of Medical Modeling and Simulation through literature reviews. Mr. Mazzeo is currently pursuing a B.S. in Industrial Engineering from the University of Central Florida.

Mr. Alex Hill is a Research Engineer for KGS. Recent projects include: development of algorithms to identify automobiles by their RF signature for SOCOM and development of a medical training simulator for military Medics responding to IED victims. He has led the development of several related medical training simulation projects including incorporating a packable wound for hemostatic agent training; animatronics for facial pain expressions; and improved sensors and communication systems for current medical training simulators. He has prior experience in software development for DoD projects including onboard training software for the C-130 Avionics Modernization Program; development of a carry on trainer for the C-17; integration of defensive electronic warfare systems on C-130, F-16, and A-10 aircraft; development of geolocation algorithms; and development of algorithms to reduce data storage requirements for onboard threat data. Alex Hill received a bachelor's degree in Applied Mathematics from the Georgia Institute of Technology and a MBA from Kennesaw State University.

Mr. Matthew Hackett is a Science and Technology Manager at the U.S. Army Research Laboratory (ARL), Human Research and Engineering Directorate (HRED), Simulation and Training Technology Center (STTC). Mr. Hackett oversees multiple medical simulation research endeavors. His expertise includes computer and biomedical engineering, experimental design, human computer interaction, and medical simulation. Mr. Hackett has transitioned multiple technologies and authored numerous papers and presentations within the medical simulation field. His previous professional background was serving as a computer engineering intern at the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI), giving him a solid background in acquisition. He holds a B.S. in Computer Engineering, an M.S. in Biomedical Engineering, and an M.S. in Modeling and Simulation.

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INTRODUCTION

The primary mission of military medical personnel on the battlefield is to treat the wounded and save lives. The Army combat medic, also known as 68W, is responsible for providing the first line of medical care to casualties at the point of injury. Army medics must assess a situation in a timely manner, and decide on an appropriate course of action in order to save lives under combat conditions. They have to act within the "Platinum Ten Minutes," when the decisions that they make and the treatments applied directly impact the survivability of the casualty. Severe trauma to extremities produces major challenges to front line medics because many are not mentally, psychologically, or technically prepared to treat such emotionally disturbing wounds. Soldiers treating such wounds must be trained in a realistically accurate combat environment to ensure they have the necessary skills to effectively treat traumatic extremity injuries, prevent the wounded from going into shock, and flawlessly execute medical tasks while confronted with extremely disturbing injuries.

The ultimate goal of severe trauma simulation is to immerse students into realistic scenario-driven events in order to teach procedures relating to the combat medic's initial arrival on the scene, triage, treatment and evacuation of the casualty. The severe trauma simulations currently used for initial skills and sustainment training lack the necessary realism to immerse combat medics during training. New technologies are needed to provide medics with greater opportunities to develop and test their decision-making and technical medical skills. To address these requirements, the U.S. Army Research Laboratory, Human Research and Engineering Directorate, Simulation and Training Technology Center (ARL-HRED STTC) executed a three-year Army Technology Objective (ATO) titled Severe Trauma Simulations. The objective of the ATO was to increase realism and immersion during combat medic and combat lifesaver training. The focus was on simulations to support Tactical Combat Casualty Care (TC3) which is the care provided at the point of injury.

The Initial Multiple Amputation Trauma Trainer (MATT®) was the result of a Small Business Innovative Research (SBIR) Phase II program that supported the Severe Trauma Simulation ATO. This program introduced animatronics and special effects technologies incorporating extremity movement for the first time. Movement is a key indicator of life and draws medical personnel to provide immediate care. During the first effort the team focused on extremity hemorrhage control since this is the number one preventable cause of death on the battlefield.

The medical community embraced the concept and after successfully securing funds from a Joint Consortium the team continued the research on animatronics and sensing capabilities. The follow-on effort expanded the capabilities to include a non-extremity hemorrhage wound in the inguinal area, simulating a rupture of the femoral artery. These kinds of wounds cannot be treated with the application of a tourniquet. The protocol calls for the application of hemostatic agents to accelerate coagulation and stop the bleeding. Additional research increased the realism of the upper torso, added blast-related poly-trauma and expanded the animatronics capabilities to support a new area of research, pain response (Bieri, Reeve, Champion, & Addicoat, 1990; Botvinick et al., 2005; Craig, 1992; Deyo, Prkachin, & Mercer, 2004; Hill & Craig, 2002; LeResche & Dworkin, 1994; Prkachin, 1992; Prkachin & Craig, 1995).

When utilizing a tool for training, it is important to evaluate the usability of the system to support training objectives. The system needs to be designed such that it is intuitive, effective, and subjectively acceptable to users (Nielsen, 1993). Involving the user early in the development cycle can reduce system redesign costs, enhance user satisfaction, and decrease training and technical support. A usability study was conducted to assess the system in supporting training for non-extremity hemorrhage control, airway management and the treatment of a tension pneumothorax. This paper discusses how training requirements and the student's need to master a variety of procedural skills impacted the design of the MATT® upper torso. In addition, it discusses how subject matter expertise was utilized to develop requirements, metrics and processes used to evaluate the overall benefits of the program. Finally, it provides results from usability evaluations and lessons learned from the development and implementation of this project.

BACKGROUND

The Department of Combat Medic Training (DCMT) at the U.S. Army Medical Department (AMEDD) Center and School serves as the proponent for the 68W Health Care Specialist and the Army Emergency Medical Service (EMS). DCMT provides the Army with highly motivated and disciplined 68W, Health Care Specialists (Combat Medics) who are National Registry Emergency Medical Technician-Basic (EMT-B) certified (CALL, 2006; AMMEDD, 2013).

Pre-hospital care continues to play a vital role in battlefield medicine (Parsons, 2006). Newly assigned combat medics begin their careers in a 16-week, 68W10 Healthcare Specialist Course at AMEDD. The instructors use a variety of educational strategies to effectively prepare medics for treating the injured and saving lives at the point of injury. Medics train by participating in field exercises with an emphasis on mass casualties and patient evacuation. Classroom instruction provides Soldiers with basic knowledge and skills; however, current classroom and field instruction lack the ability to provide all Soldiers with an opportunity to test their skills in multiple training scenarios relevant to the current operating environment. Improvements in TC3 training can have a direct impact on mission accomplishment by reducing the number of battlefield deaths. The goal is to improve medical care at the point of injury. If a casualty survives long enough to reach a care facility, his or her chance of survival increases (TC3 Guidelines, 2013).

The primary vehicles to develop lifesaving skills and maintain a medic's readiness are the initial training conducted at DCMT and sustainment training provided by the Program Executive Office for Simulation Training and Instrumentation (PEO STRI) Medical Simulation Training Centers (MSTCs). In both settings, trainers are focused on providing the necessary tools to enhance the Soldier's training experience and success in TC3. The application of TC3 principles has proven highly effective and is a major reason why combat deaths in recent conflicts (Operation Iraqi Freedom and Operation Enduring Freedom) are lower than in any other conflict in the history of the United States. Even though the "died by wounds" rate is historically low, Soldiers continue to die from the three main preventable causes of death: hemorrhage, tension pneumothorax, and airway compromise.

In a combat environment, casualties will generally fall into three categories:

- Casualties who will die regardless of any medical intervention.
- Casualties who will live regardless of any medical intervention.
- Casualties who will die if they do not receive timely and appropriate medical intervention.

TC3 addresses the casualties who will die if they do not receive timely and appropriate medical intervention. It is structured so that the correct intervention is performed at the correct time in order to treat the casualty, prevent additional casualties, and complete the mission.

According to statistics provided by DCMT, the department provides initial training to approximately 7000 Soldiers a year (AMMEDD, 2013). The MSTC program provides sustainment training and pre-deployment training to approximately 123,000 Soldiers a year at 18 locations across the US and overseas. In order to support their mission, the STTC, develops highly realistic and rugged solutions to better train combat medics.

Higher echelons of care need to understand the realities that Combat Lifesavers and Combat Medics face at the point of injury. This is why several programs have been developed to introduce TC3 principles to military medical providers (Physician Assistants (PA), nurses, and doctors).

The Tactical Combat Medical Care (TCMC) course, part of the Department of Medical Science at Fort Sam Houston, provides the PA, Physician, Nurse Practitioner and senior medical Non-Commissioned Officer (NCO) a practical working knowledge of how to deal with the injured patient in a combat environment. The course is based on known trauma resuscitation methods, lessons learned from past and current combat environments and from newly developed technology. Training consists of didactic lecture and hands-on practical training (TCMC, 2013).

The Defense Medical Readiness Training Institute (DMRTI) is a tri-service organization that offers resident and non-resident joint medical readiness training courses as well as professional medical programs for over 4,000 students per year in the following areas: trauma care, burn care, disaster preparedness, humanitarian assistance, and CBRNE preparation/response (DMRTI, 2013).

Even though training provides combat lifesavers, combat medics, and military medical providers with the necessary skills to treat the injured, it lacks the realism to prepare them for the reality of war. The most observable damages sustained by Warfighters over the past several decades are often marked not by physical harm, but rather psychological harm. Severe trauma at the point of injury creates major challenges to first responders, as they are not prepared mentally to treat the kind of injuries they will encounter on the battlefield. A substantial rise in the rates of Post-Traumatic Stress Disorder (PTSD) has been reported among young military personnel after deployment (Hourani et al., 2011). Stress Inoculation Training (SIT), where military personnel are repeatedly exposed to the realities and stressors of a battlefield environment before witnessing them firsthand, prepares personnel emotionally, physically, and psychologically for the real battlefield, mitigating the incidences of PTSD in the long run. The results from numerous experiments over the past fifteen years confirm that SIT is an effective tool for reducing the effects of and evading the onset of clinical PTSD among first responders (Wiederhold, 2008).

Hourani et al. (2011) emphasized the need to find a preventive solution to the increase in PTSD and discussed the effectiveness of a newly developed training strategy referred to as PRESIT (Pre-Deployment Stress Inoculation Training). In a pilot study in which participants were immersed in a Multimedia Stressor Environment (MSE) simulating a battlefield, objective biological indicators such as heart rate were used to measure stress, while qualitative measures were used to monitor levels of engagement. Results showed that PRESIT was well received by experiment participants, including program instructors, officers, and Soldiers; qualitative feedback indicated that the hands-on, group-oriented format of the stress inoculation training was preferred significantly more than lecture. Also, quantitative biofeedback showed that the training successfully triggered stress responses among participants, indicating that the pre-deployment stress inoculation training may be useful in building stress resilience among military personnel.

Stress inoculation, also referred to as desensitization, is needed during training to reduce the emotional reaction or shock the medic experiences in response to blast trauma at the point of injury in operational environments. Such reactions may cause the medic to hesitate or otherwise interfere with his/her performance in saving lives through prompt and effective medical response. An inexperienced medic’s natural response, when facing these traumatic injuries for the first time is a reluctance to treat the casualty. The negative effect on performance associated with dealing with such disturbing wounds can directly impact the survivability of the injured.

The field of medical simulation has grown tremendously over the past several years, with many higher fidelity products being developed to either augment or replace the more simplistic products of the past. The Army has been near the forefront of the development of realistic trauma simulators that are used to train combat medics across the globe. STTC developed the MATT® system which greatly increased the realism of combat medicine, particularly through the incorporation of movement. Since lack of movement is currently a disadvantage of human patient simulators regarding realistic human behavior, incorporating animatronics technology allowed for bridging the existing gap in training. Additionally, the MATT® program incorporates the necessary elements to support reductions in emotional reactions to traumatic injuries by providing the stimuli necessary for desensitization or emotional inoculation. The system provides the “look and feel” of such injuries by providing the highly realistic visual, auditory, and haptic (touch) stimuli necessary to elicit stress through repeated exposure. The research and development of the system focused on realistic training, including anatomy and physiology at the appropriate fidelity to train Soldiers to treat the three preventable causes of death.

Military Requirements

The goal of employing the MATT® simulation is to immerse students into realistic and high fidelity training scenarios for medics to practice initial triage, treatment and evacuation of the casualty. The MATT® system bleeds, moves like an injured Soldier, and provides realistic tourniquet training in rugged field environments. The system design incorporates reusable and extremely tough materials that not only increase realism and immersion during training, but allows Soldiers to practice extensively in the field. Further efforts by the STTC increased the fidelity of the unit by including a packable hemostatic wound in an area not amenable to tourniquet application. The latest effort developed an upper torso which further increased realism and added potential training points, provided in the list below. The Full Fidelity Upper Prototype (FFUP) simulates the upper half of the body, including the arms, neck, and head. The FFUP prototype incorporates high fidelity features in the upper body that provide the following functionalities:

1. Facial animatronics capable of simulating visual responses to pain.
2. Realistic range of motion.
3. Rugged, replaceable, reusable skin for increased maintainability.
4. Noticeable pulse points throughout the structure, synchronized with heart sounds and arterial spurts.
5. Training capability for a full range of medical procedures targeted at treating preventable causes of battlefield deaths, including hemorrhage control for packable wounds, intraosseous (I/O) infusion, intubation, Needle Chest Decompression (NCD), cricothyroidotomy, and intravenous line/saline lock placement.

In addition to bleeding, the upper torso also breathes, has a heartbeat, can move its eyes and eyelids, can contort its facial muscles to display pain, and can provide detailed feedback to the user as to the state of the casualty and the progress of the simulation. These features are manipulated to offer specific scenarios to better replicate a real trauma situation. Each scenario associated with the aforementioned procedures is designed to provide a hands-on capability to support the training of TC3. It is hypothesized that by incorporating these capabilities into the system Soldiers will have more realistic and immersive life saving skills training.

TECHNICAL APPROACH

The development of the MATT® system followed a systems engineering approach (Figure 1), which consisted of several phases, to include: Requirements Analysis (Phase I), Technology Gap Analysis (Phase II), System Design (Phase III), Prototype Development (Phase IV), User Evaluations (Phase V), and Prototype Refinements (Phase VI).

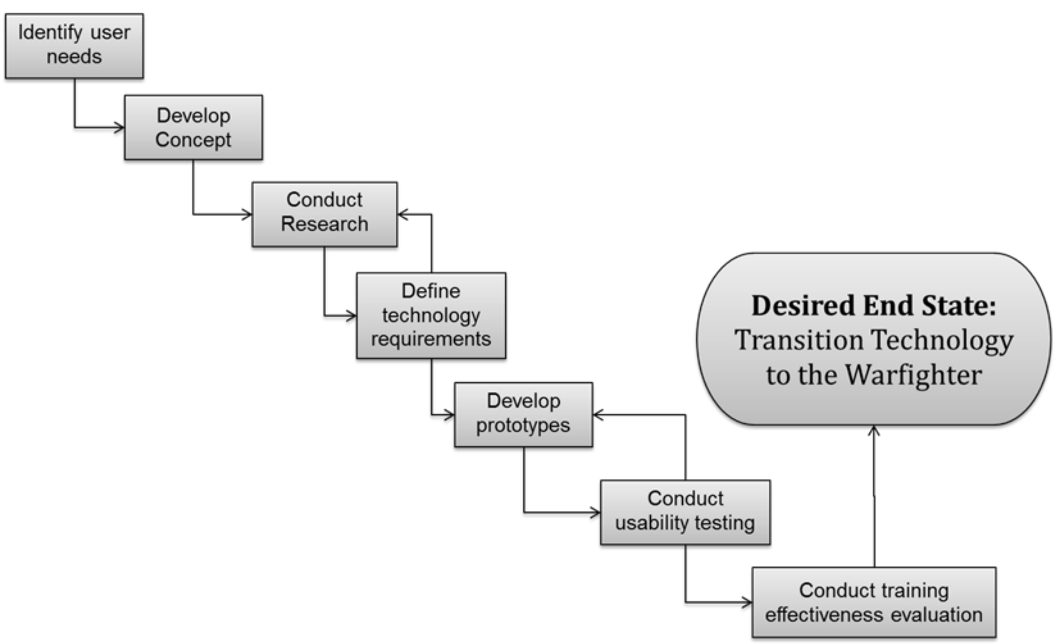

Figure 1. Systems Engineering Approach

Phase I: Requirements Analysis

During development of the MATT® system the team performed a comprehensive requirements analysis. To support phase I, a meeting was conducted with representatives from DCMT, PEO STRI MSTCs and instructors from the Tactical Combat Medical Course (TCMC). The purpose of the meeting was to identify current gaps in training and to prioritize capabilities to support the different program of instructions. DCMT provides initial training to combat medics based on the civilian EMT model. Once the medics pass the National Registry EMT exam, they receive instruction on TC3 principles, which provides them with the necessary medical skills to sustain the force, survive the battlefield and accomplish the mission. The mission of the MSTC program is to conduct sustainment and enhanced medical training for Combat Medics and Combat Lifesavers in support of Unified Land Operations. The program of instruction provides standardized medical training to both medical and non-medical personnel in a classroom environment and under simulated battlefield conditions.

TCMC, on the other hand, provides the Physician Assistant, Physician, Nurse Practitioner and senior medical NCO with a practical working knowledge of how to deal with the injured patient in a combat environment. The course is based on known trauma resuscitation methods, and lessons learned from past and current combat environments. During the requirements definition process it was important to include representatives from the different organizations to identify the capabilities that could support their mission.

Phase II: Technology Gap Analysis

During phase II the team conducted a gap analysis of all current technologies needed for the prototype system and compared it against the finalized requirements identified during phase I in order to identify technology shortfalls.

This phase also included the development of new technologies absent after leveraging innovations, designs and prototypes developed under the initial MATT® program. At the end of this task, a Technology Development Report documented the state of the technologies developed or identified for use in the upper torso.

Technology shortfalls identified and addressed during development included the following:

- Microcontroller-based control system for monitoring sensors and automating the actions of the animatronics system
- Robust animatronics design for the breathing mechanism
- Robust animatronics design for eye related movements
- Sensors to monitor various actions performed by users and the system
- Attachment points for arms, head, and neck that enable realistic movement, and provide realism and ruggedness

Phase III: System Design

The overall design for the system was developed to address all requirements identified during phase I (Requirements Analysis) using all technologies identified and/or developed during phase II (Technology Development). Where possible, the team leveraged the designs developed under the initial MATT® tourniquet simulator effort. Wherever possible, the team used computer aided design software to facilitate construction and to capture the design for future use. This was particularly critical for locating components, determining movement clearances and designing wiring harnesses. The design was guided by standard anthropomorphic measurements from Soldiers and Marines, which include weight, dimensions and reach.

Phase IV: Prototype Development

A prototype was developed from the design created in phase III (System Design). The prototype design included tasks such as mold creation, skin pouring, bleeding subsystem development, electronics development, installation, unit testing and system testing.

Mold creation and casting required the selection of an appropriate human model for a life cast. The human selected was in the mid-range of anthropometric parameters for Soldiers and Marines. A life cast was constructed and a positive made from it, which a sculptor used to finalize the final casting model. From this positive, a mold was created to manufacture the silicone skin. This positive was scanned using laser mensuration (a process in which lasers are used to digitize three dimensional models) to determine the exact dimensions required for the core design. Separate molds were developed for each of three variant head designs (normal, maxillofacial wound, and animatronics for pain response) and variant arm design (Normal, IV arm).

The sculptor required pictorial examples of wounds, which were obtained and provided from a variety of sources. Required anatomical landmarks such as ribs and bones were carefully designed into both the skin and the core to provide the necessary look-and-feel to maximize the training realism. Attachment points for the core to the head, arms and lower body were developed from the laser mensuration. Then internal attachment points for electrical, bleeding, power and control subsystem components were designed. This was performed in parallel with the final development of the plumbing system and the simulated-blood flow tubes and wiring harnesses. Once complete the location of the batteries and prime power were identified and finalized.

Finally, each of the TC3 training features was positioned in the upper torso and the animatronics designs were finalized. Unit engineering tests of all components were performed to ensure they met required ruggedness and reliability targets, followed by tests of all sub-assemblies and fit tests prior to assembly. After assembly, extensive system testing was performed to identify potential problem areas. The prototype was also evaluated in terms of its ease of field maintenance and repair. Any required modifications to the design and construction due to this testing was performed on the prototype before it was delivered for user evaluations.

Phase V: User Evaluations

Initial usability studies were performed at DCMT and at the Fort Riley MSTC on a noninterference basis with pre-deployment and other training. Test users included subject matter experts and trainers. Additional evaluations will be conducted later in the year at TCMC. A user evaluation is scheduled to be conducted at the end of the summer with trainees at the Fort Riley MSTC to better understand the impact of increasing fidelity during training. User evaluations will include data collection and subsequent analysis through performance measures, questionnaires, focus groups and individual interviews. Quantitative, as well as, qualitative metrics will be collected including the following:

- Time to engage (time to begin treatment after simulation begins)
- Time to complete a specific procedure
- Task Performance via checklist
- Reaction to the training capability (self reported)
- Self efficacy – perceived skill competency (self reported)

Phase VI: Prototype Refinements

Concurrent with, and based upon user evaluations, the prototype was refined to improve realism, ruggedness and manufacturability to better meet user requirements. These refinements were continuous both in the field and in the laboratory. Since the system was field programmable, adjustments to software were performed without deconstructing the prototype. These refinements occurred as necessary, prior to the delivery of the prototype to the STTC.

Prototype refinement activities have been identified in four specific areas:

- Skin and core mold refinements to adjust for part task simulators
- Animatronics adjustments
- Microcontroller software system upgrades, adjustments and sensor calibrations
- Engineering testing of refinements

RESULTS OF USABILITY EVALUATIONS

A good measure of a system's usability includes an assessment of how effective it is at allowing its users to meet training objectives (Nielsen, 1993). Conducting a study to assess usability during the design phases of the system helps steer development to focus on considerations for the end users. Exposing users to development phases allowed for more rapid identification and resolution of problems related to usability. Benefits of this approach included savings in time and money associated with redesigns and technical support, and increased user satisfaction.

Study I – Initial prototype evaluation

An Upper MATT® early prototype evaluation was carried out in March 2013 at DCMT (Fort Sam Houston) as well as in April 2013 at the Fort Riley MSTC (Kansas). There were two reasons for these evaluations: the first was to let users provide feedback regarding system functionality, and the second was to determine whether the training system could be included into the program of instruction. Twenty-three subject matter experts, including trainers for the Combat Medic and Combat Lifesaver programs of instruction, participated in a hands-on evaluation of the simulator system, exploring and assessing its features. Users were given as much time as possible to perform each procedure and to evaluate the capabilities of the system. Data was collected via questionnaires and focus group discussions.

Study II – Secondary prototype evaluation

A secondary prototype evaluation was carried out in June 2013 at the Tactical Combat Medical Care (TCMC) center (Fort Sam Houston) and DMRTI (Lackland Air Force Base). The focus of this evaluation was to gather feedback from military medical providers regarding the capabilities of the prototype. Four physician assistants and five physicians assessed the features of the high fidelity prototype. Again, users were given the opportunity to perform procedures and provide feedback via observations, questionnaires, and focus group discussions.

After thorough inspection, users were given three separate questionnaires totaling 41 usability questions. Participants were asked to evaluate their experience with the Upper MATT® by responding to statements about procedural tasks that can be performed using the system. Participants answered the questions by selecting options on a scale from 1 (strongly disagree) to 7 (strongly agree), with higher scores signifying a better experience. The questionnaires developed as part of this effort included questions regarding four different constructs: Realism, Anatomical Accuracy, Physiological Accuracy, and Meets Training Objectives. These constructs were selected because the system must be able to meet the training objectives identified by subject matter experts. Anatomical and physiological accuracy are crucial in enhancing realism and immersion during scenario-based training. A summary of the calculated mean responses obtained from the students and instructors on the initial prototype is provided in Table 1.

Table 1. Summary of Results (Mean Responses)

	Combat Medics		**Physicians Assistants**	**Physicians**
Factor	**DCMT (FT Sam Houston)**	**MSTC (FT Riley)**	**TCMC (FT Sam Houston)**	**DMRTI (Lackland AFB)**
Realism	**5.27**	**5.2**	**5.5**	**4.67**
Anatomical Accuracy	**5.34**	**5.26**	**5.53**	**5.63**
Physiological Accuracy	**5.32**	**5.18**	**5.13**	**5.5**
Meets Training Objectives	**5.73**	**5.63**	**6.24**	**5.73**

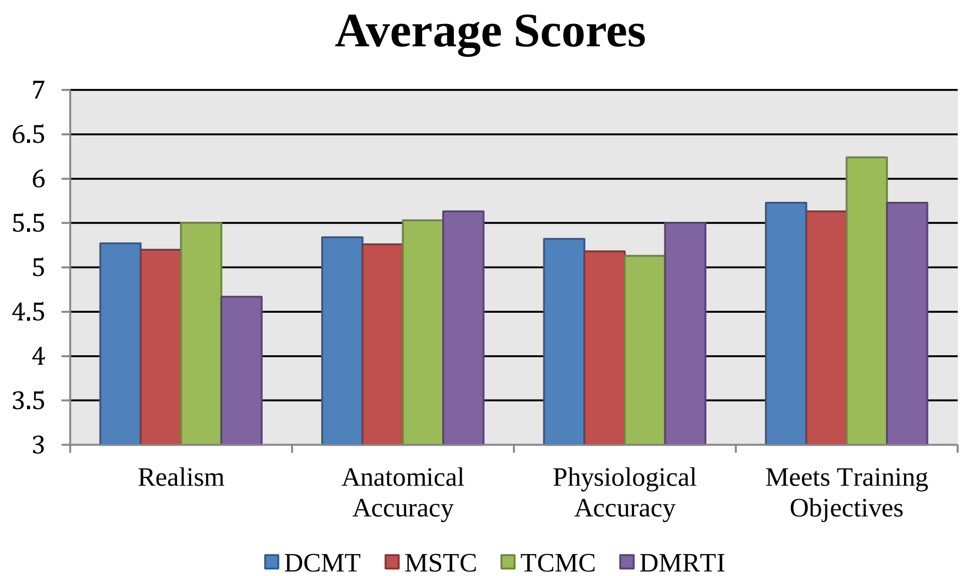

Figure 2. Average Scores per Group

To complement the questionnaires, users also had the opportunity to voice their opinions about the prototype Upper MATT®'s features in focus group discussions. Below is a list of significant findings obtained through both the questionnaires and these focus groups:

- The users acknowledged that the Upper MATT® system might be beneficial to the current training program for Combat Medics and Combat Lifesavers.
- Overall, the users felt that the system was very usable, and was not difficult to use.
- At all locations, users responded most positively to questions regarding the system's ability to meet training objectives.
- The highest scores were observed in the category of "Meets Training Objectives" for all four groups
- The category with the most varied responses among the four groups was "Realism". It is important to note that the response provided by the physician at DMRTI was much lower than the other groups because of a single question assessing the realism of the simulator's tongue, which received a score of one (strongly disagree). Leaving out this score, the average score rises from 4.67 to 6.5.
- The highest scores for "Anatomical Accuracy" and "Physiological Accuracy" were observed by physicians.
- The physician assistants also rated "Anatomical Accuracy" higher than the rest of the groups.
- Both Combat Lifesavers and Combat Medics were in agreement in their assessments for all categories.

LESSONS LEARNED

A more comprehensive evaluation was gained by drawing expertise from an assortment of users who would use the upper MATT® in different ways. Users who participated in the system evaluation included both Combat Medics and Combat Lifesavers. Combat medics are required to train for several months in order to learn the procedures and interventions necessary to perform their duties, and must recertify every year. Their understanding of medical procedures is much deeper than that of Combat Lifesavers, who are only required to know the methods behind Tactical Combat Casualty Care. The ruggedness and extensive functionality of the Upper MATT® may be beneficial for use in scenario-based training designed to support both programs of instruction.

Additional benefits were gained by evaluating the prototype simulator early in its development. Conducting the usability assessments in the early stages of development allowed potential issues to be identified and reconciled and solutions to be incorporated into the design of the prototype. This approach mitigated significant negative impacts to the project in terms of scheduling and cost avoidance.

Also, through the usability evaluation, additional requirements surfaced through extensive interviews with the users. Many of these requirements had not been accounted for in the original design, including several which would have rendered the Upper MATT® unusable or significantly less useful were they not to be included in the design of the system. Such crucial information obtained directly from the users will serve as core criterion for further research and development moving forward. Examples include anatomical landmark adjustments to aid in proper insertion of a chest tube, as well as eliminating confusion as to which procedure is appropriate, as in the case of the non-extremity wound near the axilla.

A major feature of the Upper MATT® is the ability to express emotional responses to pain through an animatronics face. Unfortunately, this feature was not evaluated extensively because knowing how to assess pain through facial expressions is not a priority in the program of instruction for Combat Medics or Combat Lifesavers.

FUTURE RESEARCH

Further research and development will focus on the incorporation of solutions in response to additional feedback brought to attention by the users. Among the technological gaps identified through the user assessments is an integrated system with After Action Review (AAR) functionality. Providing a more robust performance assessment capability would liberate instructors from having to remember and provide feedback on an individual trainee's performance. Additional research is needed to incorporate the new requirements that surfaced during user evaluations. Future evaluations must also include an assessment of the simulator's pain mapping features with users from higher echelons of care (nurses, physicians, and physician assistants). Additionally, a training effectiveness evaluation should be conducted to assess the effectiveness of the system with respect to user reaction, knowledge acquisition, and transfer of skills (Kirkpatrick, 1959).

CONCLUSION

Severe trauma at the point of injury creates major challenges to first responders as they are not prepared mentally to treat the kind of injuries they will encounter on the battlefield. They need to overcome the reluctance to treat and the potential for negative performance impact associated with treating such disturbing wounds. The research that the STTC is conducting under the severe trauma initiative is trying to provide realistic training focusing on anatomical and physiological accuracy as well as providing the right fidelity to support the training of first responders in treating the three preventable causes of death. In addition, the Army is currently pursuing reusable and rugged solutions.

Medical simulation technologies lack realism and do not accurately represent the reality of trauma encountered on the battlefield. Except for MATT®, most human patient simulators lack natural human movement, which is a key indicator of life that draws first responders to provide immediate care at the point of injury. The same applies for ruggedness and accurate representation of blast-related poly-trauma. The research has been focusing in developing advances in material technologies and animatronics to overcome the current barriers.

The initial prototype developed under this effort consists of a higher fidelity upper torso that has more realistic anatomy and higher fidelity physiology with natural human movement and pain response to support TC3. The team leveraged the work that was done under the initial lower torso MATT® program in order to provide a more realistic training capability. During the requirements analysis phase the team reached out to representatives from DCMT, TCMC, and PEO STRI MSTCs.

Results from the prototype evaluations conducted at DCMT and the Fort Riley MSTC indicate that the system is relatively easy to use and could provide some benefit to the current program of instruction. Usability areas explored included realism, anatomical accuracy, physiological accuracy and benefit to training in meeting training objectives. The team is currently incorporating feedback from the usability evaluation and a user test with trainees is planned using the final upper MATT® simulation training system during the last quarter FY13. The intent of the user evaluation is to collect quantitative and qualitative metrics to better understand the impact of increasing fidelity during training.

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