MILITARY BASED USER ASSESSMENTS FOR MEDICAL SIMULATION

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Abstract

Modern warfare has demanded a different kind of approach to combat readiness. Modeling and simulation have successfully reduced instructional resources, increased training and retention quality, and have allowed non-lethal experience for combat conditions and mitigated the environmental impact of live training exercises. It makes absolute sense in a time of diminishing controlled clinical exposure to combat medicine conditions that this successful application of modeling and simulation be applied to the field of combat medicine. Simulation applied to medicine should yield the same results and advantages that come from warfighting, aviation, or other military simulations, and should follow the same requirements and principles.

Under the U.S. Army's Combat Trauma Patient Simulation Program (CTPS), managed by Simulation Training and Instrumentation Command (STRICOM), and sponsored by Medical Research and Material Command (MRMC), a series of user based simulation assessments were conducted to facilitate the creation of a military medical simulation system. The user assessment methodology was not meant to produce an independent test to measure definitive first order principles. It was more correctly an attempt to survey a variety of military medical users as to their perceptions of the efficacy of using simulation within their educational domain for further development and research. The user assessments were conducted over a period of two and a half years, and are continuing as part of the CTPS program. They were conducted in the broadest range possible, in all areas of medical education and with as many domain experts as possible.

Some of the assessments were directly related to CTPS and included use of existing CTPS hardware, particularly the Human Patient Simulator. While the CTPS chosen simulator was used, assessments were made of other types of training aids, devices, and patient simulators as well.

This paper describes the results of those experiments.

Author's Biography

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Introduction

Modern warfare has demanded a different kind of approach to combat readiness. More diffuse settings, diverse combat conditions, and more unpredictable enemies have created faster operational tempos, less certainty, and greater deployability as subordinate principles of war. Quite logically, training methodologies leveraging modeling and simulation have progressed to prepare doctrine, force organization, training, and leadership for the fluid conditions of modern war. Modeling and simulation have successfully reduced instructional resources, increased training and retention quality, have allowed non-lethal experience for combat conditions and have mitigated the environmental impact of live training exercises. It also has provided an objective evaluation of individual, team, and collective skills to provide better performance prediction. It makes absolute sense that this successful application of modeling and simulation be applied to the field of combat medicine, especially in a time of diminishing controlled clinical exposure to combat medicine conditions.

Under the U.S. Army's Combat Trauma Patient Simulation Program (CTPS), managed by Simulation Training and Instrumentation Command (STRICOM), and sponsored by Medical Research and Material Command (MRMC), a series of user based simulation assessments were conducted to facilitate the creation of a military medical simulation system. This paper describes the results of those experiments.

Background

In order to develop an effective assessment methodology, the CTPS Integrated Project Team (IPT) spent a great deal of time investigating medical education. The only prejudicial attitude that the team brought was that the application of currently proven advanced simulation methodologies would enhance medical education. This is noted because in the investigation that view was not necessarily shared by others. In any case, the investigation revealed certain basic education and simulation principles for medicine that are relevant to an understanding of the investigative results.

Currently, users see approximately five categories of modeling and simulation that are in use, or which can be investigated for future use, in increasing the readiness of combat medicine treatment providers to

assist in preparing the force for conflict. These categories are as follows:

Training Aids and Devices
Medical Task Trainers, Simulators, and Simulations
Computer Based Training
Tele-medical Education
Virtual Reality

Within these generic categories of simulations, the models that support them can be physical, instructor generated, algorithmic, static, dynamic, physiologically based, protocol based or real time object oriented, or any combination of each. As the training task becomes more complex, the accuracy, fidelity, and validity of the models become more important. In most cases, the model base for any given simulation was transparent to the first level user, the student. The second level user, the instructor, was only concerned about the validity of the training event relative to his or her skill level. The third level, instructional supervisors, had grave concerns about the validity of the core models.

These categories of modeling and simulation must be applied to the current accepted teaching methods for medical education, most of which are based on the apprenticeship system of see one, do one, teach one. Standard medical teaching methods currently in use are:

Didactic Teaching
Motor Skill Training
Decision Making Preparation
Clinical Exposure and Experience
Team Training

Currently, although rapidly changing, the didactic teaching method is still the primary methodology used for military medical training, supported by training aids and devices. There are efforts to include computer based training methodologies and tele-medical education systems, as well as efforts to get more clinical trauma exposure. But in large part, the military medical community is just becoming aware of advanced simulation technologies and the application to their mission.

Training aids and devices consist of charts, diagrams, organ or anatomical models, or skeletons. Moulage and casualty cards fall in this category as well as cadavers. For anatomical training, the Visible Human Project has provided a computer based visual aid, which mitigates some of the deficiencies of using subjective charts and models or of using cadavers, which can be misleading by discoloration, inaccurate telemetry, or uncontrolled pathology. The Visible Human Project also has provided the first level of virtual reality, which is interactive computer based visualization. The didactic methodology using training aids and devices is the least efficient or effective educational model.

The primary simulations used today for motor skill training are actors, live tissue, partial task trainers, or simplistic computer based mannequins. While better than the didactic method, they have their own limitations in that they are in some cases extremely simplistic, not realistic, not objective, and instructor intensive. Augmented virtual reality has been partially used in this setting with preliminarily successful results. Most of it has been based on interactive Computer Based Training systems with some haptic interfaces for basic procedures. Surgical simulators fall in this category, but to date have had mixed response because of the limits of visual presentation and haptic interfaces along with their relatively high cost. Endoscopic surgical simulators while expensive, seem to be the most successful.

Decision-making preparation is a relatively new medical education concept. In the concept of combat medicine, it is a critical component since the decisions made are usually fast, without proper resources, and in many cases irreversible. Currently computer based instruction systems, fully instrumented physiologically based mannequins, and surgical simulations all have appeared in this context. While currently successful, the criticisms of these systems center on lack of anatomical reality, robustness, and cost. This is the area in which most users today believe that immersive virtual reality will eventually pay off.

Clinical exposure and experience is dwindling. The reasons are complex but center around better first responder and emergency room treatment, less opportunity for non-credential student personnel to even observe procedures, let alone provide treatment, and less ability to control patient pathology and load. For combat medicine in the United States there are several initiatives ongoing to provide rotations within civilian level one trauma centers. These programs are criticized because there may be a negative training transfer to combat medicine based on the disparity between the two environments. In this application, simulated rehearsal prior to clinical rotation can indeed maximize clinical experience and perhaps mitigate the environmental differences. The advanced computer based instruction systems, fully instrumented physiologically based mannequins, and surgical simulators along with virtual caves and immersive virtual reality also show great efficacy in this arena.

The Combat Trauma Patient Simulation Program

The purpose of the CTPS program is to more realistically assess the impact of battlefield casualties in order to increase medical readiness by leveraging current education and simulation technologies. It is an open architecture system that does not depend on any single methodology or technology. The system primarily consists of commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) live, virtual, and constructive simulation components. Its capabilities include simulating, replicating, and assessing battlefield injuries by type and category, monitoring the movement of casualties on the battlefield, capturing the time of patient diagnosis and treatment, and comparing interventions and outcomes at each military healthcare service delivery level. The CTPS is Department of Defense (DOD) High Level Architecture (HLA) compliant. The CTPS goals are:

To provide more realistic representations of casualty instances
To provide enhanced initial, refresher, and sustainment training for medical personnel
To provide an improved mechanism for analysis and test and evaluation of issues in casualty medical treatment
To increase readiness by having better prepared military medical personnel, ultimately decreasing the fatalities due to combat conditions.

CTPS was an ideal vehicle to conduct the user assessment.

User Assessment Methodology

The user assessment methodology was not meant to produce an independent test to measure definitive first order principles. It was more correctly an attempt to survey a variety of military medical users as to their perceptions of the efficacy of using simulation within their educational domain for further development and research. It also was designed to refine the CTPS system architecture and design to ensure that the user would have direct unfiltered access to the system designers as to the efficacy of the CTPS system.

To ensure objectivity, a multi-service Military Medical Simulation Advisory Board was formed by the Commanding General, STRICOM, to oversee both the conduct and the results of the assessments. The board established the measures of performance (MOPs) and measures of effectiveness (MOEs), reviewed the results of the assessment, and prioritized all follow-on effort. Each assessment consisted of a series of decomposed checklists developed in the first Phase enumerating both MOPs and MOEs based on an established list of documented requirements. These requirements were described in a traceability matrix to ensure continuous identification, experimental observability, and metric definition. The methodology

establish a test-model-test matrix baseline based on the draft Combat Training Center Operational Requirements Document.

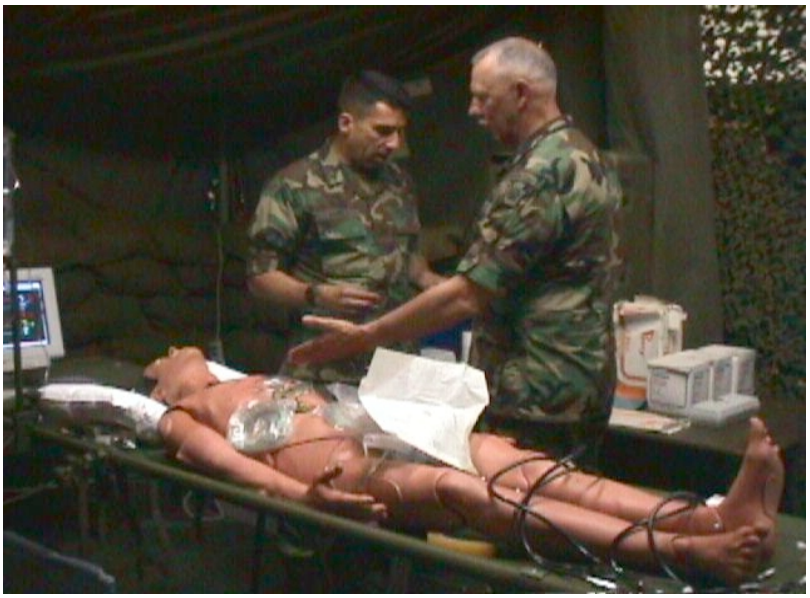
In addition, civilian medical simulation baselines allowed a double check system for the validity of the results. The assessment was in no way to interfere with the user's mission, in some cases included the use of CTPS hardware, and was done only with voluntary user sites. STRICOM in conjunction with the U.S. Army's Medical Command (MEDCOM) had overall responsibility for the user assessments.

User Assessments

The user assessments were conducted over a period of two and a half years, and are continuing as part of the CTPS program. They were conducted in the broadest range possible, in all areas of medical education and with as many domain experts as possible. The division of education and training considered was initial entry training, refresher training, and sustainment training at all levels of military medical education from level one to level three. Level one and two training is defined as combat medical personnel from battalion surgeon on down to combat medic. Level three was more specialized to include military forward surgical teams, combat support hospitals, and military hospitals. There were hybrid levels in different services, i.e. nursing, nursing anesthetists, physicians, and special operations personnel that were also assessed.

Some of the assessments were directly related to CTPS and included use of existing CTPS hardware, particularly the Human Patient Simulator (HPS). While the CTPS chosen simulator was used, assessments were made of other types of training aids, devices, and patient simulators as well. Very little assessment was made of surgical simulators, since there were few at the beginning of the assessment in actual use. Some of the assessments were done by interview only, by observational visit only, and by actual measurement of defined standards of training. In some cases, identified requirements were immediately executed on an engineering level in a test-model-test matrix. All of the evidence gathered was anecdotal in nature. Currently, there are three specific tests occurring that are scientifically based. Below is a summary of some of the conducted assessments.

CTPS Related Tests



The CTPS related tests all used the Human Patient Simulator as a basis for assessing the user's needs. In each case the user was instructed to compare the use of simulation to a defined instructional standard whether it was related to a military occupational specialty (MOS) like the U.S. Army's 91B and 91C combat medics or the Special Operations 18D medics. In addition defined standards for civilian credentialling for Basic or Advanced Cardiac Life Support, or Basic or Advanced Trauma Life Support were also evaluated. The description of these tests is detailed not to evaluate the validity of the test results, but more to demonstrate the nature and detail of the test methodology.

The first test was conducted at the United States Army National Guard's two Medical Company Training Sites (MCTS), one located at Ft. Indiantown Gap, Pennsylvania and the other at Camp Shelby, Mississippi. These two sites were chosen since 80% of the U.S. Army's medical capability is in the Reserve Components. The MCTSs conduct primarily refresher and sustainment training for medical unit personnel, both on-site and in a mobile training team configuration. They also conduct extensive Nuclear, Biological, and Chemical (NBC) training. The initial assessment was conducted for sixty days, with a follow-on assessment, which still continues. In addition, in conjunction with seven other sites, a distance learning experiment was conducted sponsored by the Army Medical Department (AMEDD) Center and School.

The results of the initial test were that the CTPS simulation system could effectively be used for refresher and sustainment training for level one and two military medicine. The areas rated excellent were patient assessment, difficult airway management, and to a limited degree, chemical casualty treatment training. The simulator in its beginning configuration could not be used for mobile or field training. This initial test resulted in a quick engineering effort under the CTPS program to produce more valid chemical scenarios, mannequin secretions, and a mobile field version of the CTPS simulator. The site was able to train on the average 150 unit medical personnel per month effectively, and to deploy the mobile version to a field exercise at Fort Pickett, Virginia in June 2000. In addition, the use of simulation in chemical agent treatment led to a specific scenario development for auto inject atropine overdose, a critical element in the treatment of Weapons of Mass Destruction (WMD) casualties. The below quote from the test report summarizes the reaction of the site personnel.

> *"CTPS allows the military healthcare providers to take advantage of the virtual reality world and the interactive age. The military has been taking advantage of this type of technology in other aspects of training for years. Now, CTPS gives the Medical Corp the same opportunity. Medical training, for the most part, has lacked realism due to the treating of an inanimate object (a manikin) and not being able to assess and treat in real time. With CTPS, these shortcomings have been improved dramatically by its real time responsive capabilities. The Human Patient Simulator is not a perfect replica of a patient, but it is the best tool the military has for training the healthcare provider for today's and tomorrow's missions."*

The MCTSs are also in the process of creating additional scenarios in an effort to create a library of standard chemical/conventional injury scenarios and suggested treatments. The scenarios create a standardized format for the healthcare providers to utilize their knowledge and skills collectively. Ultimately, this allows the fielding of the highest quality product and training for the military's healthcare providers.

The second test was conducted at the Joint Special Operations Medical Training Center (JSOMTC) located at FT Bragg, North Carolina. This site conducts all training for the 18D MOS as well as refresher training for all Special Operations

medics. The simulator was on site for approximately four months. During this time, the mannequin was utilized in conjunction with three types of training. The first was Advanced Cardiac Life Support (ACLS)/Emergency Cardiac Care (ECC), second, Advanced Trauma Life Support (ATLS) and third, to supplement anesthesia training for their medics.

In each of these situations the simulator proved to be a very good training tool. The physiology and appearance of the simulator helped bridge the gap between procedural skills and cognitive understanding of a "real life" patient's response. During the ACLS/ECC training the simulator was very useful for developing the concept of a team approach to patient care. One student would be assigned to "run" the code, the other students received directions from the "code runner" and then the roles would be rotated. Student response was positive. The following are positive and negative aspects of the HPS identified during this training.

Durability: Overall the HPS was resilient. This was particularly so in regard to the practice of airway management skills. However, Chest compression during cardiopulminary resuscitation (CPR) was not as well tolerated. Multiple events of chest compression resulted in subsequent problems with rise and fall of the chest Furthermore; the chest plate may also be adversely affected by chest compressions.

Drug Recognition: The bar code reader is an excellent means of identifying the drug given. An unusual problem arose with the bar-code reader after defibrillation. Following administering 200-360 joules, the bar-code reader ceased to function and required resetting. This problem occurred inconsistently. The questionable bar-code reader was replaced and the problem did not recur. An additional feature, which would serve as an excellent training aid, would be if a "syringe" could be designed that would appear identical to the types of drug administering devices used in the pre-hospital setting (i.e. Bristol-Ject syringes).

Arrhythmias: Adding arrhythmia's that correspond to those used in ACLS training would be beneficial. For example, adding various heart blocks (1st degree, 2nd degree Type I & II, etc.) would increase the utility of the HPS for arrhythmia recognition training.

Defibrillation/Pacing: Integrating technology that would make the simulator capable of recognizing therapeutic electricity would also add to training.

IV Arm: Including simulated veins capable of being cannulated would also enhance the overall value of the simulator

During the ATLS training, the simulator was used in a limited fashion. Again, the appearance of the simulator added to the overall experience and the student response was positive.

Airway management: The appearance of structures of the upper airway greatly enhanced understanding and led to improved intubation skills. The "Difficult Airway" options were excellent. Having the ability to alter visualization and cause intubation and ventilation to be made more difficult enhanced understanding. These options caused the student to realize and think through an actual problem with minimal instructor prompting. The ability to perform a cricothyroidotomy as a part of airway management also was beneficial.

Pneumothorax: This was the most disappointing feature for it failed to work. After the initial installation, the needle decompression option ceased to function. Perhaps this problem was also related to aggressive chest compressions during ACLS training? The simulator is one of the few simulators that have the pneumothorax capability. The inability to fully utilize this very important training tool was very disappointing.

During the anesthesia related instruction, students received approximately one hour per student training time with the simulator. The training went well. The instructors were satisfied with the training results. Again, the students gave positive feedback and expressed a desire for additional simulator related training.

Overall, the test of the CTPS simulator here at the Joint Special Operations Medical Training Center was a success. Some instructors were able to utilize the simulator for training that was beneficial to the student. Additionally, we were able to demonstrate the capabilities of the technology to other medical personnel here

on Ft. Bragg and generate additional interest. Unfortunately, having only a single simulator prohibits maximal utilization during the training of large number of students. Our goal is to continue to develop ways of integrating the HPS into training. Additionally, we are interested in attempting to develop a research project to evaluate the educational benefit of the utilization of the simulator in our medical training.

The JSOMTC test resulted in several quick engineering changes. The simulator was reengineered as to the identified problems, i.e. chest compressions, defibrillation, and tension pneumothorax functionality. In addition, the underlying hematology models were expanded as a direct result of this test and the eye functions were tied directly to human physiology. The drug recognition functions were expanded, as were the ACLS protocols. This user test continues with multiple simulators and expanded elements of the CTPS system to measure the actual effectiveness of simulation training versus traditional methodologies. Also as a side bar, JSOMTC was one of the few agencies to have on-site a surgical simulator prototype. Because of the lack of detail of the visual graphics and the fidelity of the haptics interface, the simulator prototype was deemed to require additional research.

There were a number of missions served by performing this CTPS User Test in conjunction with the United States Air Force's (USAF) Small, Portable, Expeditionary, Aeromedical Rapid Response (SPEARR) Team Test at Elmendorf Air Force Base (AFB) and King Salmon, AK. Evaluate the performance of the portable simulator in harsh and austere field conditions. Evaluate the use of the simulator in the field as a tool to assess the operational, equipment, and clinical performance issues related to a newly formed expeditionary military medical team. Evaluate the use of the simulator in the field as a training tool for expeditionary medical teams. Evaluate the use of the HPS in the field as an adjunct to live tissue and human volunteers for simulated disaster/mass casualty events. Demonstrate the overall value of the HPS to the training requirements of the USAF.

The operational and clinical scenarios for the tests at Elmendorf AFB and King Salmon were prepared by LTC Ty Putnam, from the USAF Office of the Surgeon General. Clinical scenarios on the simulator were prepared jointly by Ron Carovano, METI and Maj. Warren Dorlac, MD, a trauma surgeon at the Joint Trauma Training Center located at Ben Taub Hospital, Houston, TX. Approximately 25% of the simulator work was performed during a one-day session at Ben Taub and the remaining 75% was done in a just-in-time fashion at the field locations. Principally, the simulator was used as a supplement to live tissue (i.e., pigs) for a simulated mass casualty event. In the overall scenario, five casualties were brought in from a simulated aircraft accident for pre-hospital assessment and initial treatment, surgical intervention, and post-operative critical care. The overall exercise ran 24 hours and the simulator was used for 18 hours. The SPEARR team set up at the Camp Madbull field site, located at Elmendorf AFB, Anchorage, Alaska. The SPEARR Team equipment included a kerosene power generator and heater. For the duration of the exercise, external temperatures averaged highs in the upper 30's and lows in the lower 20's. The simulator was set-up in one corner of the tent, which was warmed to room temperature. The gases and the compressor were set-up outside of the tent.

The goal was for the SPEARR team to perform a complete PHTLS (Pre-Hospital Trauma Life Support) assessment and treatment that would drive the surgical and post-surgical critical care. To accomplish this, they made extensive use of the following features:

Airway (airway occluder, tongue swelling, laryngospasm, cricothyroidotomy, airways resistance, lung and chest wall compliance)

Breathing (chest movement, breathing patterns, breath sounds)

Circulation (heart rate, blood pressure, pulse palpation)

Level of consciousness (blinking, pupils, and voice)

Physical trauma findings (e.g., moulage for burns, open fractures, physical arterial and venous bleeding)

Simulator trauma features (e.g., chest tube insertion, and needle decompression of a tension pneumothorax)

Other monitored parameters (e.g., ECG, SpO2)

Following the pre-hospital assessment and initial treatment, the live tissue models were used for the surgical and anesthetic procedures. Post-surgery, the live tissue models were then sustained in the critical care component of the SPEARR Team. At appropriate times, clinical problems were introduced for each patient on the simulator. Each patient incurred 5 to 10 problems throughout the course of the exercise. In addition to the planned problems, numerous unanticipated events occurred resulting from improperly performed procedures or difficulties with equipment.

The results from this exercise showed that the simulator definitively added to the realism of the overall scenario. Without the simulator, the pre-hospital assessment would have been severely limited. Moreover, instantiating and managing numerous post-operative critical care scenarios would have been impossible to pull off using the live tissue models.

King Salmon Air Force Station, Alaska: Again, a mass casualty scenario was presented at King Salmon in this case, a school bus accident resulting in 10 casualties.
Because it wasn't possible to bring live tissue models to this remote location, the simulator was particularly effective. Local high school students and their parents wore moulage and acted as though they were injured. So, triage and transport was performed with these live human models and the pre-hospital assessment and treatment were performed using the simulator. The SPEARR Team evaluation team was particularly impressed with how much realism the simulator added to the exercise. A number of clinical problems were introduced with each patient. And, as previously experienced, a number of unanticipated clinical events occurred. Of note, one of the patients running on the simulator experienced a severe asthma attack, arrested, and was resuscitated.
A number of important operational and clinical problems and observations resulted directly from the use of the simulator, which otherwise would not have occurred or been recorded.

Integration of the portable oxygen concentrator and the Impact Ventilator.
The USAF is investigating if they can replace their heavy, liquid oxygen containers with lightweight, portable oxygen concentrators. In particular, they want to ensure that they can deliver adequate FiO2 to the patient, particularly in acute respiratory distress syndrome (ARDS) patients. To assess this, we created two patients: a spontaneously breathing patient on a nasal cannula and an ARDS patient on a ventilator. Although it worked splendidly for the spontaneously breathing patient, it initially appeared that the combination of ventilator and oxygen concentrator wouldn't deliver a high enough oxygen concentration. After debating why this was so, they experimented with an alternative set-up, which doubled the oxygen concentration delivered to the patient, increasing it to an acceptable level.
A second issue arose with combining these two pieces of equipment. For technical reasons using the oxygen concentrator requires a reduction in the tidal volume setting on the ventilator. Otherwise, the patient is at risk for barotrauma resulting from hyperinflation of the lungs. During one of the critical care scenarios, the surgeon noticed that the peak airway pressures were decreased. Subsequently, the patient desaturated. It turned out that output from the oxygen concentrator was disconnected by accident, thus resulting in hypoventilation.

Impact Ventilator: During one of the planned critical care scenarios, bronchospasm was instantiated to create ventilatory difficulties with a specific patient. But, these difficulties were identified late in

the development of the problem, as the patient was desaturating. The early warning signs of the developing bronchospasm, namely visible and audible high pressure alarms, were missed because the ventilator was mounted on the litter such that the display was hidden, and the ventilator alarms are muffled by the protective cover that prevents unintended adjustment of the ventilator settings. Subsequent to this problem, the SPEARR team mounted the ventilator in a better location.

Bag-valve-mask (BVM) Assembly: During one of the simulations, they completely obstructed the airway, yet the care providers were able to squeeze some oxygen into the lungs by generating extremely high airway pressures with the bag valve mask (BVM). As they discovered, the BVM's had no high-pressure pop-off valves to prevent unintended barotrauma. Again, this was a fault of their equipment that may have gone unnoticed.

General Equipment Issues: The simulator also offered a good platform for spontaneous in-service training. Though individual team members are specialists by training, the small size of the team requires that each be cross-trained in the operation of all acute care equipment. Many of the team members were not familiar with the operation of the Impact Ventilator, Propaq Monitor, Portable Oxygen Concentrator, and Portable Ultrasound. The vast majority of the just-in-time in-service training took place with the HPS.

Without the use of simulation, the user may never have encountered these issues until they were deployed. Moreover, these results will allow the USAF to fine-tune their implementation.

This test clearly demonstrated the use of the CTPS system for test and evaluation data

Other User Assessments

Several other user assessments outside of CTPS were addressed. The U.S. Navy has conducted extensive testing of medical simulation in port and on board ship through its Certified Registered Nursing Anesthetist (CRNA) program with similar results to the CTPS tests. The DoD Uniformed Services University of Health Sciences has successfully integrated simulation into its medical student and residency programs. The National Capital Area Simulation Center located at Forest Glenn, Maryland is conducting extensive surgical simulation research and is the first agency that has been granted authority to conduct ACLS training without the use of live tissue.

Conclusions

Until the final data is fused and correlated and further assessment conducted, there are five evaluative criteria that seem to consistently fall out of all these efforts.

The first is a set of simulation principles that have been well documented in all DoD simulation programs. Simulation applied to medicine yields the same results and advantages that come from warfighting, aviation, or other military simulations, and should follow the same requirements and principles. Any simulator must be fully capable of inter-operabiliy to other teaching simulators, computer based instructional tools, and both networks and web based delivery systems, and must comply with the DoD High Level Architecture. It must be modular in design to minimize full life cycle replacement and obsolescence and consist of an open system architecture that allows easy upgrade. It also in today's world should be PC based. Work station based simulators are fast becoming obsolete and unsupportable. In addition, the simulator must include appropriate tool sets to allow the user to tailor patient profiles, critical events and appropriate scenarios to their specific instructional training objectives without being held hostage to an expensive

purchase of additional effort because the software was hard coded. The simulator must be at least transportable, but preferably fully portable. Finally, life cycle support and associated costs are a major issue.

The second is an educational issue. By definition a simulator as opposed to a training aid or skill trainer must combine both cognitive and psychomotor skills in a collective task environment in real time. That is to say, it must be capable of presenting a multiplicity of situations with a high degree of fidelity in order for the student to grasp the execution of individual tasks in the context of the real world setting, he or she will actually face. Student performance must be definable, observable, and measurable so that instructors can actually evaluate performance and conduct detailed after-action reviews. The first level user has a better perspective on specific needs, but has no concept of transposing those needs into requirements or specifications. Consequently, the combination of U.S. Army Medical Command and U.S. Army Simulation, Training and Instrumentation Command fulfills both requirements with a minimum of risk.

The third is a clinical issue. The users we have dealt with all want a high fidelity full scale model of a human being that is capable of responding physiologically to both deteriorating patient conditions and interventions, that result automatically in specific outcomes. They also want both anatomical and physiological realism. Their only concern is technological complexity for their specific Program of Instruction (POI) and the current cost of such simulators. Clearly, the user wants the appropriate fidelity at the appropriate cost for their specific training objectives. For example, at AMEDD Center and School, the instructors felt that the CTPS system was too sophisticated and too expensive for use in 91B and 91C initial entry training, but thought it was excellent for the sustainment training of those two MOSs.

The fourth issue is an ease of work principle. The instructors want a user friendly system with a simplistic graphical user interface that is semi-automated to produce realistic outcomes while still allowing the instructor to override any feature at will. They are currently undermanned and overburdened with teaching and curriculum development issues, and thus are reticent to accept any new methodology, which will cause them to neglect their primary task of military medical instruction

The final issue is cost. From the assessment perspective, cost is an independent variable. Military simulation is advancing in an unconstrained environment to produce something meaningful and useful. However, by leveraging commercial-off-the-shelf and government-off-the- shelf equipment, cost is significantly reduced. As the user test assessments continue, it is the opinion of the assessment team that medical simulations are affordable as long as they are tailored to the specific learning objectives of each particular application. In addition, from initial indications of the economies of scale gained by the use of simulation, the initial simulation cost is quickly amortized.

These results are all pending additional analysis, however the major observation of the evaluation team provides real insight into the potential efficacy of the use of simulation technology in military medicine.

" The greatest benefit of advanced military medical simulation may very well be its physiological components which force military medical personnel to review basic physiological principles taking them out of rote algorithmic health care provision into mental decision tree consequence management. This principle will increase medical readiness, improve patient outcome, husband critical medical resources, and in the long run save lives on the modern battlefield."