COMBAT & CASUALTY CARE

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EVOLVING MASS CASUALTY COMBAT MEDEVAC

The challenges of future large-scale combat operations mean mass medical evacuations may very well become the norm.

By MG Patrick Sargent

Features

COMMANDER'S CORNER

BALANCING MEDICAL FORCE READINESS WITH FUTURE MODERNIZATION

COL Sean O'Neil

Commander
U.S. Army Research Institute of Environmental Medicine

LEADERSHIP PERSPECTIVE

MATURING CAPABILITY FOR ENABLED CARE

COL Jerome Buller

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U.S. Army Institute of Surgical Research

Departments

Cover: Soldiers simulate patient evacuation after prolonged field care scenarios at Joint Base San Antonio-Camp Bullis during advanced combat medic training with the Army Medical Department's Health Readiness Center of Excellence. The exercise enables Soldiers to familiarize with current Tactical Combat Casualty Care (TCCC) standards in preparation for real-time combat casualty response. (HRCoE)

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INSIGHTS

The Summer 2019 issue of *Combat & Casualty Care* sheds light on the criticality of medical evacuation or MEDEVAC. As distances between point of injury and facility-level care increase, challenges in addressing trauma more fully during the "golden hour" have also increased. In the face of this reality, advances in MEDEVAC response are providing a level of care that increasingly results in positive outcomes.

With force modernization well underway across the DoD, advances in combat medicine are an important element of current and future readiness. In an exclusive interview from the U.S. Army's Health Readiness Center of Excellence (HRCoE), MG Patrick Sargent, HRCoE Commander, discusses challenges relating to ways MEDEVAC capabilities will need to support Large-Scale Combat Operations (LSCO) in the Future Operational Environment (FOE). With a focus on Multi-Domain Operations (MDO) as a battle concept for future force maneuver, MEDEVAC support capable of answering the casualty call will be a primary pillar of mission preparation. From an aeromedical evacuation vantage, Air Force Air Mobility Command is at the tip of the air MEDEVAC spear with the deployment of the Aeromedical Evacuation System (AES). As airframe speeds, ranges, and capacities have increased, casualty response is now more efficient with assets that the AES brings to the fight.

The U.S. Army Research Institute of Environmental Medicine (USARIEM), Ft. Detrick, under the command of COL Sean O'Neil, is working on capabilities in wearable technology, targeted fitness, and precision data capture, all at the core of building warfighters of the future. Personnel at the U.S. Army Institute of Surgical Research, Ft. Sam Houston, led by COL Jerome Buller, are mirroring these concepts from a field trauma perspective, developing surgical techniques that bring facility-level, point-of-injury care to the critically-wounded. From a health standpoint, none of this added capability means much if a Soldier or Marine wearing it is not healthy enough to endure the rigors of combat. As such, the Defense Health Agency (DHA), in cooperation with the Department of Veterans Affairs, is continuing to oversee the roll out of the MHS GENESIS electronic health record for faster, more-timely patient-doctor communication and better management of chronic, complex, and time-sensitive medical conditions.

Don't miss a perspective on trends in modeling and simulation training center (MSTC) standardization and *C&CC*'s first-ever International Spotlight on advances in tactical combat casualty care readiness across Africa.

Your comments and suggestions are welcome. Thanks for the continued readership!

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EVOLVING MASS CASUALTY COMBAT MEDEVAC

As the U.S. Army grapples with the challenges of Large-Scale Combat Operations in the Future Operational Environment, so will the Army's medical evacuation, or MEDEVAC, force.

By MG Patrick D. Sargent, Commander, Health Readiness Center of Excellence

Spc. Thomas Appelhanz, C Company, 6th Battalion, 101st Combat Aviation Brigade flight medic checks to ensure IV fluid is flowing properly to a wounded Afghan National Army Soldier during a patient transfer mission at Forward Operating Base Tagab, Kapisa province, Afghanistan. (U.S. Army photo by Sgt. Duncan Brennan)

It is almost a truism to say that we, as an Army, will be challenged in unique ways by armed conflict in the Future Operational Environment, or FOE. We are told that all domains—land, air, maritime, space, and cyber—will be contested and congested. Anti-access and area denial, or A2AD, strategies will deny us the land, air, and maritime superiority that we have come to expect. Large-scale combat operations, or LSCO, particularly against peer, near-peer adversaries, will present problem sets that we have not encountered in the contingency operations of the past two decades. Fundamentally, we expect LSCO to be more dangerous and difficult for the MEDEVAC force to operate--but it will not be impossible. We will not be able to evacuate in LSCO as we have in the contingency operations of the past two decades.

MG Patrick Sargent

To operate effectively, we must have a well-grounded understanding of the dynamics of LSCO, a sound grasp of the inherent risks, and take a clear-eyed approach to how to operate effectively on these future battlefields. To be successful, the MEDEVAC force must adapt itself to the new environment.

Perhaps the most critical adaptation required is one of mind-set. Over the last two decades—and for all the right reasons—we optimized the employment of the MEDEVAC force for the unique circumstances of the contingency operations to which the Army has been committed, particularly those in Iraq and Afghanistan. While the results have been superb in terms of lives saved, there have been unintended consequences. We have become habituated to a risk calculus that

accepts relatively little risk in operations. We have become so reliant on our dominance of air and ground lines of communication that there are those who believe we cannot operate without it. We have become so accustomed to relying almost exclusively on our air ambulances that many have forgotten that Army MEDEVAC has both an air and a ground component. We have also become accustomed to relatively static operational environments to the point where many have forgotten how to plan, coordinate, and execute in dynamic environments where the situation is changing rapidly at the tactical, operational, and strategic levels. To be successful in the future, we must overcome the thinking we have cultivated over the last two decades and expand our mind-set to match the demands and dynamics of LSCO in the FOE.

U.S. Army soldiers and Afghan forces medically evacuate an insurgent, wounded after attacking coalition forces, to an American base to receive further medical treatment during Operation Mountain Fire in Nuristan province, Afghanistan. The U.S. soldiers are assigned to the 10th Mountain Division's 1st Battalion, 32nd Infantry Regiment. (U.S. Army photo by Sgt. Matthew C. Moeller)

Facing Greater Lethality of Conflict

It is not hard to accept that LSCO in the FOE, particularly against a peer, near-peer adversary, will present much more lethal environments than the contingencies of the past two decades. What we cannot accept is that this increased lethality will preclude our ability to conduct MEDEVAC. There are those who believe that, because the levels of risk to medical evacuation assets (air and ground) will be far greater than what we consider acceptable risk in our current contingency operations, we will cease to conduct medical evacuation operations. What they fail to understand is that these future battlefields will be more dangerous for the entire force, not just for the MEDEVAC force. Clearly, as articulated in the Multi-Domain Operations (MDO) and Echelons Above Brigade, or EAB, concepts, the rest of the force intends to operate on these more lethal battlefields. The MEDEVAC force cannot—and will not—stand aside as the rest of the force goes into harm's way. We must understand that the threshold for what constitutes acceptable risk on the LSCO battlefield will be significantly different than what we use today.

As we look to potential LSCO conflicts in the FOE, there is a tendency by some to consider only the capabilities potential adversaries may bring to the fight. They assess the unopposed impact that these potential adversaries could have on the battlefield—and draw a number of flawed conclusions. They fail to acknowledge that the U.S. military—and our allies and partners—will bring significant opposition to these battlefields. An assessment of the opposed impact of potential adversary capabilities provides a much different picture. It acknowledges the challenges for U.S. forces—which will

Soldiers evacuate a wounded comrade. (Staff Sgt. Alfred Johnson)

be considerable—but also highlights the opportunities. The MDO and EAB concepts, among others, provide the vision of how to create and leverage opportunities to penetrate and disintegrate adversary A2AD capabilities and exploit the resultant opportunities for movement and maneuver. In addition, the Army's modernization strategy promises to establish and/or restore critical capabilities in the Force that will, at least, restore a degree of initial domain parity—enabling a degree of freedom of action from the outset of a contingency. So, while operations in LSCO in the FOE against a peer/near-peer adversary will be difficult, they will not be impossible.

Evolving Tactics of Combat Casualty Care

The scope, scale, and tempo of medical casualties during LSCO in the FOE will present distinct challenges to the MEDEVAC force—but will also make MEDEVAC an imperative. Failing to evacuate will put both the medical mission and the operational mission in jeopardy. Failing to evacuate will jeopardize the medical mission by risking culmination of forward medical treatment facilities through overwhelming the capacity of the medical providers and equipment or through consumption of medical supplies on hand faster than they can be replenished. Failing to evacuate will jeopardize the operational mission through the drain on combat power required to secure/protect the accumulating casualties and through the drag effect these accumulated casualties will have on movement and maneuver. In short, not evacuating in LSCO will not be an option. The scope, scale, and tempo of medical casualties in LSCO will require the full commitment of the MEDEVAC force—air and ground. Adversary lethality and reach will require MEDEVAC assets to be arrayed through the entire breadth and depth of a theater of operations in anticipation of casualties. The scheme of evacuation must carefully position air and ground ambulance assets for best effect—and dynamically reposition them throughout the course of an operation to anticipate casualty flows, weight critical efforts, and react to evacuation contingencies.

In general, air ambulances will focus on the evacuation of the most critically sick or wounded (where speed is of the essence and platform stability is essential); on rapid clearing of casualty backlogs on the battlefield and patient backlogs at treatment facilities when windows of opportunity enabling access are limited and evacuation velocity is key; and on providing commanders a capability to react rapidly to evacuation contingencies across the breadth and depth of a theater of operations. The speed and reach of our air ambulances make them highly flexible evacuation assets. It is anticipated that ground ambulances will move the bulk of the MEDEVAC workload, moving the lion's share of priority and routine category patients and moving Urgent/Urgent-Surgical category patients when air ambulances cannot reasonably reach them. While the slower speed and shorter reach of ground ambulances make them less flexible assets than the air ambulance fleet, their greater proliferation through the force significantly offsets this lack of flexibility. Despite the evacuation capacity that MEDEVAC assets bring to the Force, there will likely be times when this capacity is exceeded—either in a specific locality or broadly across a theater of operations.

Accordingly, operational commanders must plan to complement MEDEVAC assets with casualty evacuation, or CASEVAC, assets. This should include: dedicating assets to assist in evacuation when there is a high likelihood that MEDEVAC capacity will be exceeded; designating assets to be prepared to assist in evacuation to enable rapid transition to an evacuation contingency; and conditioning the Force to provide lift of opportunity when absolutely required with least the impact to their primary mission/task.

One of the primary challenges to the MEDEVAC force in LSCO will be battlefield access—the ability to get to casualties/patients in order to evacuate them. In LSCO, we must expect our adversaries to have the ability to interdict both air and ground lines of communication, or LOCs, thereby impeding the battlefield access of our MEDEVAC assets. However, an adversary's ability to interdict our use of air and ground LOCs will not be uniform across the breadth and depth of a theater of operations, nor will it be uniform over time. An adversary's ability to interdict air and ground LOCs will be greatest where he can mass effects. Simplistically, an adversary's ability to mass effects will diminish with distance from the physical location of his assets. While the reality will be a bit more complex, in general, we can expect the greatest interdiction of LOCs in the vicinity of brigade combat teams in contact and to diminish, in terms of effects or duration of effects, through the depths of the division and corps support and consolidation areas and the theater's joint security area. We can also expect an adversary's ability to interdict LOCs in the operational area to be greatest at, or near, the outset of a campaign and to be diminished over time, assuming a degree of success by U.S. forces, as U.S. forces penetrate and disintegrate an adversary's A2AD capabilities and then exploit the resultant windows of opportunity for movement and maneuver. The key throughout is that we constantly press to get our MEDEVAC assets as close as prudently possible to the casualty/patient needing evacuation. We cannot afford to cede any advantage to the enemy that he has not actually taken from us.

What this means is that the MEDEVAC force will have the battlefield access it requires to acquire and evacuate casualties/patients over much of a theater of operations. In these areas, achieving the 1-hour evacuation standard for urgent and urgent-surgical casualties should be well within the realm of the doable. Based on the reach and lethal capabilities of potential adversaries, we should expect significant numbers of wounded throughout the depth of the theater of operations. Even flying or driving ambulances to points of injury, or POI, will be possible in some cases; although nowhere near as prevalent as today. Where units are in contact with enemy formations, however, our ability to achieve the 1-hour evacuation standard will likely be challenged. Air ambulances will likely be precluded from regularly operating in these areas until U.S. operations to penetrate and disintegrate A2AD capabilities begin to have effect. It is unlikely that ground ambulances will be precluded from these areas but will find themselves slowed in the evacuation sequence. At the earliest prudent opportunity, the most critical patients will be transferred to air ambulances to speed them through the rest of the evacuation sequence. Wherever evacuation is delayed beyond the standards, our prolonged field care concepts and capabilities will be used to mitigate the risk to the sick and wounded—buying time until evacuation can be conducted.

Balancing Evacuation Force Deployment

The scope, scale, and tempo of medical casualties in LSCO will place a premium on effective and efficient employment of the MEDEVAC force. This will require establishing the right balance in the MEDEVAC force structure between assets assigned at tactical unit level—to serve the typical needs of those formations and those assigned at operational and theater-strategic command levels—to provide higher-level commanders the ability to weight critical efforts and react to contingencies. It will also require a mission command structure that can achieve unity of effort/purpose in highly dynamic situations from assets that are arrayed through the breadth and depth of a theater of operations and under both medical and non-medical command. This begins with the theater medical command-deployment support, or MEDCOM-DS, —and the evacuation planners in the Theater Patient Movement Cell (TPMC)—providing top-down guidance and direction—for the overarching scheme of MEDEVAC within the theater and reaches down through medical brigade support and multi-functional medical battalions and through corps, division, and brigade headquarters for bottom-up refinement. These elements must be able to dynamically plan, coordinate, and execute MEDEVAC operations that are integrated into and synchronized with schemes of maneuver and continually adapting to the demands of rapidly changing operational environments.

Not evacuating our sick and wounded in LSCO is not an option. Failing to evacuate may cause us to lose today's battle—as the backlog of casualties/patients cause a cascade of medical and operational culmination on the battlefield. Failing to evacuate often enough—with its potential impact on Soldier morale and national will—may cause us to lose the next battle, the next campaign, the next contingency operation. While the evacuation of the sick and wounded will be difficult in LSCO in the FOE—it will not be impossible. To be successful in MEDEVAC in LSCO, we must adapt to the projected operational environment. While we must certainly adapt the MEDEVAC force structure and our mission command processes, the most critical adaptation is one of mindset. Without a mindset that grasps the dynamics of LSCO, that understands the challenges and sees the opportunities, and that refuses to cede any advantage to an adversary that the adversary has not actually taken away—we cannot be successful. Cultivating and inculcating such a mindset must be a high-priority effort throughout the medical force. ▪

Editor's Note

MG Sargent has been the commander of the Health Readiness Center of Excellence since June 2018. He is a combat tested aeromedical evacuation pilot with over 30 years of service in Army Medicine. Effective September 15, 2019, the HRCoE will be redesignated as the U.S. Army Medical Center of Excellence, or MEDCoE. The name change will help solidify the full realignment of the MEDCoE to the U.S. Army Training and Doctrine Command effective October 2019.

BALANCING MEDICAL FORCE READINESS WITH FUTURE MODERNIZATION

COL Sean S. O'Neil currently serves as Commander, U.S. Army Research Institute of Environmental Medicine.

COL O'Neil is a 1995 Distinguished Military Graduate from the University of Massachusetts at Amherst, where he earned a Bachelor of Science degree in Resource Economics. He also holds a Master of Business Administration from Bentley University, a Master of Science in National Security Studies from the U.S. Naval War College and a doctorate from George Mason University Schar School of Policy and Government.

His previous assignments include: Treatment Platoon Leader and Executive Officer, Charlie Company, 115th Forward Support Company, and Executive Officer, HHC Division Support Command, 1st Cavalry Division, Fort Hood, Texas; Division Medical Materiel Officer, Stabilization Forces, Bosnia; Chief of Logistics, U.S. Army Research Institute of Environmental Medicine (USARIEM), Natick, Massachusetts; Deputy S-4, 62nd Medical Brigade and Commander, 520th Area Support Medical Company, Fort Lewis, Washington with deployment in support of Operation Iraqi Freedom in Kuwait; Special Assistant to the Chief of the Medical Service Corps; Deputy Director for Medical Logistics Systems, Office of the Surgeon General (OTSG), Falls Church, Virginia; Medical Liaison to the 401st Army Field Support Brigade (AFSB) to oversee the retrograde of medical materiel from Operation Iraqi Freedom; Medical Logistics Operations Officer at Headquarters Department of the Army G-4, Pentagon; Deputy Commander for Support, U.S. Army Medical Materiel Agency (USAMMA), Fort Detrick, Maryland; Joint Product Manager (JPM) for CBRNE Analytics and Response Systems, Aberdeen Proving Ground, Maryland. He also previously served as the Deputy Medical Acquisition Consultant to the Army Surgeon General.

COL O'Neil's military training and education include the U.S. Army Medical Department Basic and Advanced Courses, the Medical Logistics Management Course, the Command and General Staff College, and Senior Service College from the U.S. Navy War College. He is a member of the Defense Acquisition Corps, is Level III certified in Program Management and Level II certified in Life Cycle Logistics.

COL O'Neil's awards and decorations include: the Defense Meritorious Service Medal, Army Meritorious Service Medal (silver oak leaf cluster); Army Commendation Medal (oak leaf cluster); Army Achievement Medal (three oak leaf clusters); Joint Meritorious Unit Achievement Medal; National Defense Service Medal; Armed Forces Expeditionary Medal; Global War on Terrorism Expeditionary Medal; Global War on Terrorism Service Medal; NATO Medal; Army Service Ribbon; Expert Field Medical Badge; Parachutist Badge and the Army Staff Identification Badge. He was awarded the Order of Military Medical Merit, the Order of the Green Dragon, and the "9A" proficiency designator.

COL Sean O'Neil

Commander
U.S. Army Research
Institute of Environmental Medicine

C&CC had the opportunity to speak with COL Sean O'Neil, Commander, U.S. Army Research Institute of Environmental Medicine (USARIEM), regarding the concept of "modernization", a key pillar of DoD's multi-pronged effort to support and strengthen lethality and resiliency on the future battlefield. As a subordinate command of the U.S. Army Medical Research and Development Command (USAMRDC), USARIEM's current goals and ongoing work are to ensure that future medical capability supports this evolution.

C&CC: What is USARIEM's role in supporting Army modernization from an individual Soldier's perspective?

COL O'Neil: At USARIEM, the term 'modernization' isn't simply a catchphrase or some random, throwaway slogan. Rather, modernization is our core purpose. In basic terms, it represents our efforts to stay on the far-forward edge of science and technology so that our Warfighters may continue to succeed against any adversary in any environment.

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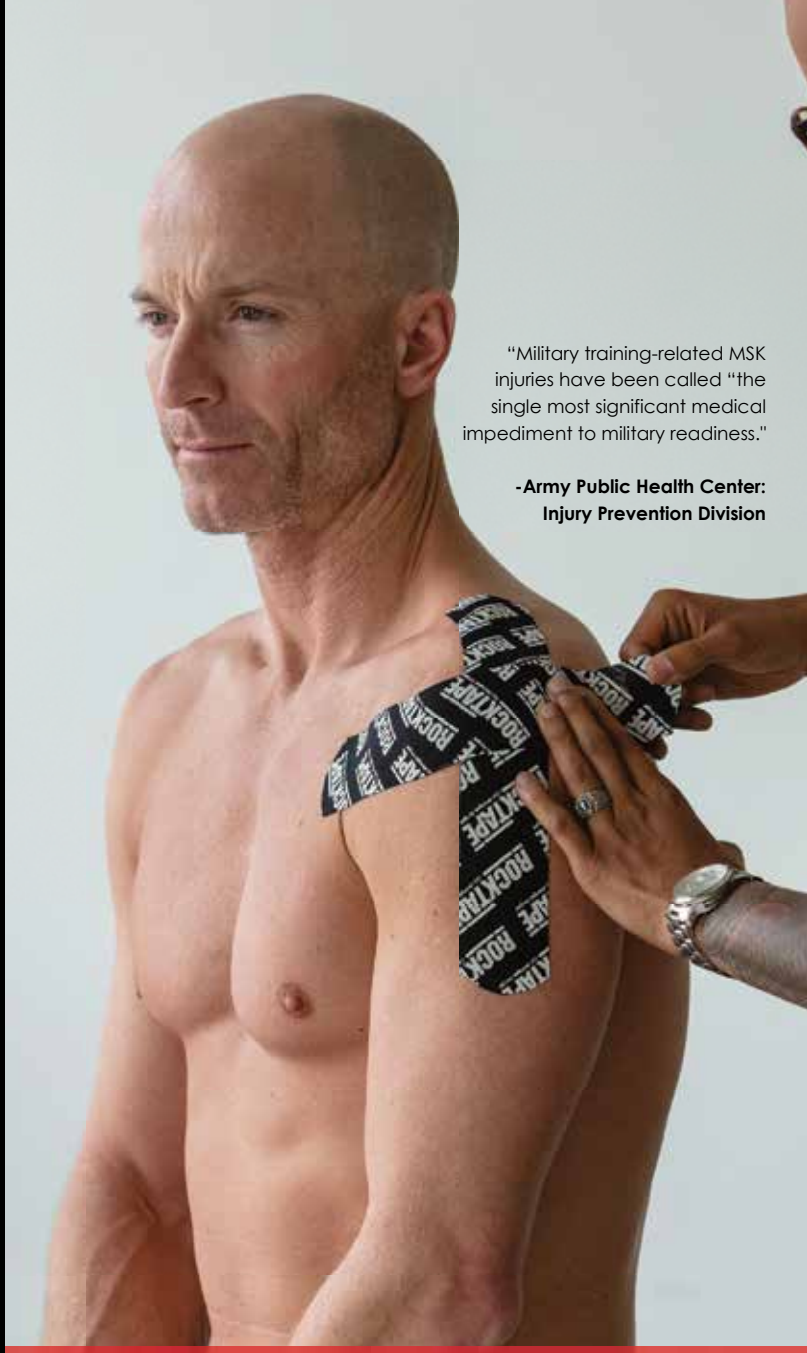

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To do this, USARIEM approaches the modernization of human performance by developing solutions that both optimize and enhance the ability of our military members to execute essential tasks in a given environment. Simply put, we want our Warfighters to enter –and sustain– operations at peak levels of cognitive, physical, and emotional potential in order to defeat adversaries on the battlefield. Much like an Olympic athlete who enters competition at the top of their game, our Warfighters must enter the fight at the height of readiness. Yet unlike many athletes, our Warfighters must also have the ability to persevere in stressful and rapidly changing situations; as well make the right decisions, maintain morale, recover from setbacks, and ultimately win the day. Additionally, Warfighters don't know when the "competition" or "game day" will occur, a reality which requires them to maintain a more constant state of readiness. Further, Warfighters can't predict when the "competition" (or mission) might end; hence opportunities for recovery are unpredictable and may not occur with regular frequency. This only highlights the need for research in the area of "reset" – which is, indeed, an area of research we are exploring.

New Army doctrine describes "maximizing human potential" as a tenet of Multi-Domain Operations (MDO) – otherwise known as the Army's operational concept for the battlefield of the future. To that end, USARIEM's research informs the Army of how best to build and sustain human performance within its formations through the selection, training, and health of its leaders and Soldiers. Indeed, while every Soldier is different in their physiology, biology, and genomic make-up, the good news is that the state of science today allows us to understand the Warfighter in ways that were not previously possible. For example, data reveals that missions requiring significant aerobic activity may require tailored nutritional products containing higher levels of carbohydrates prior to the mission and, also, particular forms of protein following the mission for recovery. Ultimately, we see a future in which we can personalize these issues so that each Soldier knows his or her own body and understands how to prepare, train, feed, and hydrate for every environment.

C&CC: Can you discuss some of USARIEM's efforts to promote physiological monitoring and wearable technology?

COL O'Neil: The work we're doing with wearable technologies – specifically physiological monitors– is directly aligned to support MDO efforts. Our biomedical sensors are able to monitor the status of the human body in order to help provide commanders with critical understanding of the readiness and abilities of their Soldiers. Further, they help inform decisions about the tempo and intensity of operations, and also assist units in sustaining and regenerating combat power.

In that same vein, leaders within close-combat formations – think infantry and special operators– tell us that they want to, in short, be able to predict the performance of their respective teams. During operations, they want actionable, real-time predictions of a Warfighter's risk for reduced physical and cognitive performance due to fatigue, environmental threats, and psychological factors, among other determinants. Physiological status monitors, in the form of wearables, can provide Soldiers, leaders, and medical personnel with all of these capabilities.

Currently, we are leveraging wearable technologies during training and operations for high-risk environments. We are working with the 75th Ranger Regiment and the Fort Benning Heat Center to identify Soldiers at highest risk of heat stroke by capturing real-time physiological data during 12-mile ruck marches and five-mile runs. Additionally, we are actively partnered with the Army Center for Initial Military Training, the U.S. Marine Corps, and the Army National Guard Civil Support Teams to deliver prototype systems that were developed in collaboration with the MIT Lincoln Laboratory. These organizations are using these devices to reduce the risk of heat injuries; and in return, we capture data which enables us to refine the algorithms and decision aids that will be transitioned to Programs of Record.

C&CC: What is USARIEM's role in supporting the Hyperfit Female Warfighter effort?

COL O'Neil: The Hyperfit Female Warfighter project is extremely exciting for our team, and one that has garnered a lot of attention from both senior leaders and the military community as a whole. Policy changes in the past five years have expanded opportunities for females to attend training courses previously unavailable to them; with female Soldiers graduating from Ranger School, Special Forces Assessment and Selection, Infantry Officer Course, and others. As a result, we now have a unique population of female Army Soldiers and Marines who have proven themselves as extraordinary performers; people we've come to identify as 'hyperfit'. And yet we want to know more about their traits; we want to explore the characteristics of females who have successfully graduated from these courses. This will help us better understand the patterns of physical, mental, and

USARIEM researchers record a Soldier's body composition as part of the ARIEM Reduction in Musculoskeletal Injury, or ARMI, study. This study is part of USARIEM's largescale effort to understand which factors most affect injury risk. (USARIEM photo by Matt Bartlett)

metabolic success which can then be applied as more females take on these roles within our military.

Ultimately, this research will enable us to compare the performance of hyper fit military females to similarly-aged and similarly-sized female and male data sets. We can then assess current biomedical markers of health to determine if any unique identifiers exist (e.g. bone composition, etc.) for these hyper fit Soldiers as compared to others. In the end, the results of this research will provide tools to identify female Soldiers who will likely succeed in physically-demanding training. From there, we also hope to learn about how we can intervene in the future through nutrition, physical training, or even mental hardiness training programs to assist those who aim to attend these elite courses.

In mid-July, the 'Hyperfit' study gained approval to initiate data collection. Within hours, the study team began recruitment of eligible Army females and received interest from potential participants. These Soldiers are pioneering leaders, and are extremely excited to contribute to this scientific endeavor. Data collection is slated to begin in late summer, and will continue for six-to-eight months.

C&CC: How is USARIEM working to promote cross-sector collaboration in support of Soldier readiness?

COL O'Neil: At USARIEM, we encourage collegial and cooperative working environments both within and across our research divisions. It is quite common for cross-division teams to form in the conception phase of the research and to continue during the construction and execution of the research projects. We find that this kind of teaming enables us to address military problems more robustly and more efficiently than when it is absent. Moreover, it fosters intra-divisional and institutional esprit de corps.

Further, we collaborate externally with industry and academic partners –as well as other government agencies– in order to bring diversity-of-thought to the problems we are trying to address. For example, our research efforts to better understand the health and performance contributions of a healthy gut microbiome include partners from other Army laboratories; as well as the Navy and the Air Force. Moreover, this particular research team is actively partnering with staff from the Pennington Biomedical Research Center and the John Hopkins University Applied Physics Laboratory, and is further utilizing commercial industry agreements. By leveraging the subject matter expertise available in other Department of Defense research laboratories, academia, and industry, we are able to address military problems and build better solutions in a more robust and comprehensive manner. We have more than 40 formal agreements with external partners for ongoing work.

Our most important partnerships, however, are with our customers – the Warfighters themselves. We like to say that we 'bring the lab to the field'. Indeed, we conduct many of our research projects at camps, posts, and stations across the world. A great example of this is our current study aimed at reducing musculoskeletal injury in trainees at initial military training. We are collecting bone and muscle data from 4,000 Army trainees and following them for the first two years of their careers. The goal is to identify potential modifiable risk factors and mechanisms of injury that can be targeted for intervention. We want to provide evidence-based recommendations to military leaders to reduce musculoskeletal injuries without reducing training standards. To do this, we are physically in the field at places like Fort Jackson working with Army trainees and at Fort Stewart working with infantry Soldiers. In summary, we both work and operate where required in order to secure the data we need to make a difference in the health, life, and safety of the Warfighter.

> *"Combat & Casualty Care has been a strategic publication for us given it is heavily distributed at the SOMA Conference and is also distributed at many other Military events. Sonia Bagherian is a long time industry colleague and is well connected in the Military community. Last year we did a feature that overviewed Masimo's business in this publication, which was well received and provided good exposure."*
>
> **~ Mark Helbing ~**
> *Masimo*

MHS GENESIS: A NEW SYSTEM OF HEALTH CARE DELIVERY

The U.S. Department of Defense has launched an enterprise solution that will standardize clinical and business practices, and provide for a patient-centric system focusing on quality, safety and patient outcomes that put readiness first.

By Col. Thomas J. Cantilina, USAF MHS Chief Health Informatics Officer, Deputy MHS EHR Functional Champion

U.S. Navy Vice Adm. Raquel C. Bono, left, director of the Defense Health Agency and U.S. Air Force Maj. Gen. Lee E. Payne, right, Assistant Director for Combat Support, Defense Health Agency, speak with Lt. Col. Joseph Sky, center, 60th Medical Group chief of cardiology, at David Grant USAF Medical Center at Travis Air Force Base, California. Bono and Payne's visit focused on the rollout of the MHS GENESIS, the Department of Defense's new electronic health record which the 60th Medical Group will use exclusively beginning in September 2019. (U.S. Air Force photo by Heide Couch)

MHS GENESIS has been called many things. Most people are accustomed to referring to it as merely the newest electronic health record for the Military Health System. But it's so much more than that. We like to refer to MHS GENESIS as a system of healthcare delivery.

The program operates under the principle of "Configuration not Customization." Its predecessor/legacy system, the Armed Forces Health Longitudinal Technology Application, or AHLTA, and others could be changed through customization. What's worse, since there are 101 CHCS servers and 63 ESSENTRIS servers, these changes were not always in alignment resulting in disjointed practices, miscommunication, and little synergy among facilities. MHS GENESIS ensures decisions are based on what is best for the Military Health System as a whole – not a single individual area – but at the same time balancing that with the needs of our medical care providers, to have access to robust information about patients.

For the medical provider, MHS GENESIS has several advantages over our legacy systems. It results in faster and better management of chronic, complex, and time-sensitive conditions; provides automated, real-time clinical decision support for physicians and care providers; increases patient engagement capabilities allowing patients to

U.S. Air Force Maj. Maria Vazquez, 86th Aeromedical Evacuation Squadron medical crew director, analyzes mission data on her laptop on a C-130J Super Hercules aircraft. The 86th AES conducts readiness missions regularly to test preparedness and keep their skills up. (U.S. Air Force photo by Airman 1st Class Milton Hamilton)

communicate directly with providers; and even reduces overall maintenance costs. For the patient, MHS GENESIS results in higher quality, safer and more reliable care. Physicians and other providers have a much easier time recalling and transferring vital medical information between various departments, labs, and pharmacies – resulting in better coordination and fewer errors.

Interoperable for Ease of Integration

MHS GENESIS and the new electronic record system under development by the Department of Veterans Affairs are the same instance of the Millennium software developed by the Cerner Corporation thus are interoperable by default. DoD and VA already share more data and information between one another than any other two Federal agencies in the United States. This new system enables information to be passed conveniently and easily, helping ensure a warm handoff of service members into the VA system of care at the conclusion of their service. In addition, DoD and VA health information technology leaders are working together on a daily basis to better synergize and align their efforts.

Better Care through Enhanced Interaction

MHS GENESIS enhances the provider-patient relationship. There are several ways this is accomplished. Through program implementation, the Military Health System raises the quality of healthcare delivered to our patients. First and foremost, the system improves patient safety, through the ability to share medical information across hospitals and clinics, the VA and civilian healthcare organizations. This is instrumental in improving patient safety issues and allows for increased flexibility in care.

Second, improving patient quality of care. This means by utilizing tools that enhance clinical decision making and improve reporting mechanisms, patients can receive faster and more accurate diagnoses of their issues.

Third, increased provider-patient interaction time. This means consolidating patient information into one electronic health record streamlines the process for recording patient information, allowing providers more face-to-face time with patients – something both sides appreciate.

Lastly, it unifies clinical and business operations, enabling stronger lines of communication between clinical and business staff, providing seamless transitions during the full spectrum of patient care.

Phased Deployment on Schedule

MHS GENESIS is launching in "waves" designated by DoD leadership. The system is currently operational in military medical facilities in the Pacific Northwest, including Madigan Army Medical Center at Joint Base Lewis-McChord; Naval Hospital Bremerton; Naval Health Clinic Oak Harbor; and the 92nd Medical Group, Fairchild Air Force Base, all in Washington State. In September 2019, MHS GENESIS will become operational at our next wave of military medical facilities. In September 2019, the effort will become operational at our next wave of military medical facilities. These are Travis Air Force Base; Naval Air Station Lemoore; and the Army Health Clinic at the Monterey Presidio, all in California; and, Mountain Home Air Force Base, Idaho. It is expected that full operating capability at all military treatment facilities will be achieved by 2022.

Not only does MHS GENESIS as a commercial system have a regular upgrade schedule implementing thousands of improvements, a sustainment and improvement process integrating end user system evaluations and recommendations to improve the system creating a much fuller, complete health record making 10-20 changes per week has been developed. During sustainment operations, end user staff are empowered to provide suggestions and recommendations as a joint Military Health System approach to merging service and personal equities into an improved joint electronic health record.

The Department has also embarked on a large and complex IT transformation with the deployment of MHS GENESIS. We continue to see improved efficiencies at our initial fielding sites since the optimization period, and as a result, providers are better able to leverage technology to deliver safe high quality healthcare. We take action on feedback from end users, stakeholders, and the test community that identifies previously unknown issues to enhance the functionality of the system. ▪

EVOLUTION IN COMBAT MEDIC PREPARATION

Prior to the creation of the Medical training concept use by MSTC, combat medics were trained to civilian standards of care. An evolution in tactical combat casualty care (TCCC) has brought about a standardization of instruction tailored to the combat environment.

By Master Sgt. Rodel A. Gonzalez, Senior Enlisted Medical Advisor, JPM MMS, MedSim

Soldiers at Kelley Hill at Fort Benning, GA, train one another on using the Tactical Combat Casualty Care Exportable (TC3X) system, a medical trauma training mannequin. Personnel from the office of the Program Executive Officer for Simulation, Training and Instrumentation (PEO STRI) brought new, technologically advanced medical training mannequins to Fort Benning to increase the realism of medical trauma training and ultimately to save lives and limbs. (U.S. Army photo by Patrick Albright, Maneuver Center of Excellence, Fort Benning Public Affairs)

Although tourniquet as a last resort and patient stabilization prior to movement as medical practices are not bad, they simply were not created with combat in mind. Eventually, and after a serious study, tourniquets were no longer treated as a last resort and the movement of a patient prior to being fully immobilized (depending on the combat situation) was no longer frowned upon. In reality, and prior to the introduction of medical simulation and training centers or MSTCs, combat medical training was not standardized throughout the military. Soldiers would arrive at their new unit "medically trained" only to find out that their training was either sub-standard or not in accordance to the way the receiving unit expected.

MSgt. Rodel Gonzalez

Modulation in TCCC Standards Training

The concept of the MSTC changed both the type of training combat medics receive and standardized the way TCCC training is performed across the Army. Each MSTC had a standard set of equipment and instructors

Soldiers at Kelley Hill at Fort Benning, GA, train one another on using the Tactical Combat Casualty Care Exportable (TC3X) system, a medical trauma training mannequin. Personnel from the office of the Program Executive Officer for Simulation, Training and Instrumentation (PEO STRI) brought new, technologically advanced medical training mannequins to Fort Benning to increase the realism of medical trauma training and ultimately to save lives and limbs. (U.S. Army photo by Patrick Albright, Maneuver Center of Excellence, Fort Benning Public Affairs)

that implements and maintains a standardized training curriculum throughout. The TCCC training and curriculum, now the gold standard, and is being used by other agencies and by the nation's partners and allies around the world. The focus of the curriculum within the MSTC is tactical combat casualty care. The three main causes of preventable battlefield death, (hemorrhage, airway, and tension pneumothorax) combined with the "when" or sequence to perform those lifesaving procedures. This training requires a hands-on approach, however, placing a tourniquet on a live patient for training purposes can be dangerous. Because of this, physiologically accurate and high-fidelity simulators are an important requirement. The training requirements for Soldiers continue to become more and more challenging. In order to ensure that the Soldiers are trained to meet their mission, they require realism and simulated combat environment stressors in the training. It is this realism in training that advances the simulation and greatly improves transfer of learning efficacy and retention. This not only includes patient simulators, but it also includes atmospherics such as buildings, weapons, vehicles, and weather.

In the past, training was adjusted to meet the training device capability thus causing negative training. Today, requirements drive the capability of simulation devices thus improving the training event. With the improvements of technology, the MSTCs are better able to conduct After Action reviews (AARs). The AAR helps not only the instructor to catch a mistake but it can also help capture the proper performance of individual or collective tasks. This in turn helps the instructor to explain through both audio and video how the Soldier performed and offer corrective analyses. Also, because of the technology improvements, one instructor is able to operate multiple devices at the same time through a control room vs one item at a time. This allows for a much better usage of time and also increases the time available that the instructor has to work with their students.

Collective training is perhaps one of the better lessons learned within the MSTC. With the Combat Lifesavers training course, now established because of the MSTCs, a medic is able to work with the Combat lifesavers within a platoon, who serve as an extension of themselves giving them the ability to care for more wounded Soldiers as opposed to working by themselves. Also, knowing that combat is not usually conducted within a classroom, the training area is established and is attached to the building. This training area comes with a mini MOUT site thus adding more realism to the training event. Future implementations will begin to focus on enroute care along with prolonged field care. Both of these implementations will require significant changes to the curriculum and training devices but are considered to be significant enhancements to Army combat medical training.

Hurdles Ahead

Current challenges to the MSTC system are getting everyone to buy into the concept that this training is not just "Medic" training. It is a collective training that improves a unit's ability to perform as "one". There is still a long way to go to make the simulators look and respond in a realistic manner. Today, many medical simulator companies use terms such as realistic, Hyper-realistic, life-like when in fact, they still have a long way to go. Additionally, and perhaps most importantly, there is no one simulator that can do everything required. Physiology vs durability vs fidelity will always be a challenge.

Finally, with MSTC as a system, the continuum of medical care is also being considered. This requires a significant shift in the way the Army currently trains combat medical procedures in association with the advancement of the simulators currently in use today. Proprietary information no longer works in a system that is becoming streamlined. The employment of multiple types of simulators to accomplish equally multiple critical life-saving tasks places an injustice on both the student that must learn how to operate each type of simulator and the soldier whom the medic is charged with saving in the future. ▪

FUTURE HEALTH SUPPORT TO MANEUVER FORCES

The Military Health System, or MHS, is undergoing the most significant reform in decades and is a top focus for many Army senior medical leaders.

By Master Sgt. Richard Jarrett, Health Readiness Center of Excellence

The ALC (68W Technical Training) is a 2 week course of instruction which includes 80 hours of instruction. The purpose of the 68W Technical Track is to provide all 68W ALC students advanced training in tactical combat casualty care and focusing heavily on prolonged field care regardless of additional or special skill identifier. This enables all 68W ALC graduates to be considered capable of performing prolonged field care in a deployed environment with direct supervision by a medical officer. Graduates are also considered capable of performing advanced tactical combat casualty care and prolonged field while deployed with remote supervision by a medical officer. (HRCoE)

While Military Treatment Facility, or MTF, reform tops military medical headlines, a renaissance is underway for Army medicine. MHS reform has presented a significant and strategic opportunity for the Army Medical Department to get back to its roots; To Conserve the Fighting Strength. After all, supporting the Warfighter is the fundamental purpose for the Army Medical Department's existence. This renaissance to put the "Army" back into Army Medicine will require a cultural and paradigm shift in mindset, strategy, and the metrics we use to define success. Acknowledging that as the Army and Joint Force modernizes and resources remain at a premium, every capability, force modernization and training decision must be made with the Warfighter in mind. We must ask ourselves, "how does this support the Warfighter and how does this make the Army more capable to fight and win in Multi Domain Operations." We must also re-examine what support to the Warfighter truly means in the next fight, our supporting strategy and what metrics we are using to define success.

Lethality and MDO

Increasing lethality is a top Army priority, and for good reason. It is no secret that Multi Domain Operations, or MDO, against peer or near-peer adversaries will require a more mobile and lethal force enabled by agile, adaptive, fit and durable leaders and Soldiers. Large scale combat operations within future operating environments will challenge every facet of our current AHS capabilities, which had been forged through more than 18 years of war. The relatively unconstrained freedom of

maneuver exhibited during this period in both the Afghanistan and Iraq theaters set the conditions for the highest survival rates in history.

In 2009, Secretary of Defense Robert Gates implemented a "golden hour" policy which mandated that urgent casualties were evacuated to an MTF within one hour from notification. In essence, the joint force did not adapt to its environment, the force adapted the environment to a U.S. standard of care. In most cases, a combat casualty had a higher chance of survival if injured in Iraq or Afghanistan than if injured in any city within the United States. It is widely anticipated that in a future MDO with a near peer adversary, the Army will not experience the same freedom of maneuver and will require a drastically different approach to provide Army Health System capability.

So how do we support lethality, the warfighter and develop capability to support MDO? It starts with a mindset focused on knowing our role. Plain and simple - we enable lethality through our capability and capacity to keep more guns pointed at the enemy, for longer periods of time. We enable lethality by preserving combat power and conserving the fighting strength!

Strategy

The changing face of how the Army will operate in the future will require supporting and value-added capabilities that enable lethality. One such capability that is on the precipice of change here at the Health Readiness Center of Excellence, or HRCoE, is the 68W Combat Medic. Where the rubber meets the road across the Army, you will find these combat medics, affectionately known to the warfighter they support as "Doc."

Doc will play a critical role for Commanders in the future fight. Doc will be relied upon to not only care for and evacuate the sick and wounded, but to also preserve combat power and articulate risk to mission and force regarding capabilities and finite resources. Doc must first be a master of the basics, especially adept at providing Tactical Combat Casualty Care to save life; force health protection to prevent disease; and focused primary care to preserve combat power by returning to duty those that are able. Doc must also be tactically sound; grounded in a solid understanding of doctrine, tactically proficient and engaged in all aspects of the tactical plan. Doc must additionally be trained and proficient in providing care in mass casualty situations and in situations when evacuation is not tactically feasible within doctrinal timelines. Doc is required to be a trainer of Soldiers, Combat Lifesavers, and other Medics.

In order to provide these critical capabilities in a cohesive Casualty Response System, Doc must be supported and enabled by unit leadership. In 1998, 75th Ranger Regiment's Commander COL Stanley McChrystal made medical training as one of their "Big Four" priorities. This directive enabled the Rangers to implement Tactical Combat Casualty Care, or TCCC into all facets of unit training. According to Kotwal and others in Eliminating Preventable Death on the Battlefield (2011), this command emphasis directly contributed to a 3% potentially survivable death rate versus 24% for the Department of Defense from 2001 to 2010. It is time for the rest of the Army to follow suit.

In my current role as the Noncommissioned Officer in Charge of Prehospital Medicine at the HRCoE, I am asked, "What do we need to change with the 68W to meet future MDO needs? Can't we just make them all Paramedics?"

While the 68W will need a greater breadth and depth of knowledge and skills, the reality is that the Army doesn't need to buy a fully loaded sedan, or Paramedic to use an analogy. While the fully loaded sedan is fully capable for most jobs in the city, it's still a car with inherent limitations. A car is not designed for off-road excursions and if I need to move some furniture, I'm calling my buddy to help with a truck. Moreover, while heated leather seats and keyless entry are nice features to have, do they really contribute to the performance or capability for the added cost?

SGT Russel Tumaliun, 68W Combat Medic with the 566th Area Support Medical Company at Fort Hood, TX , straps a simulated causality into a Kendrick Extraction Device (KED) at the Expert Field Medical Badge test event at Camp Bullis, TX, hosted by the 32d Medical Brigade. (HRCoE)

I like to say that what the Army really needs in a combat medic is a practical 4WD work truck with the frame and suspension to handle the challenging and unknown terrain ahead; a more adaptive 68W combat medic. A "work truck" can handle jobs off-road and around town and is easier to modify when needed for tougher jobs. You can "beef up" the suspension, throw bigger tires on it, and even tow a camper for those longer road trips.

Furthermore, a work truck gets used daily because it's functional, capable, and versatile. To make this analogy work for our combat medics, commanders will need to learn how to drive, or employ them both in garrison and during deployments. Commanders must enforce preventive maintenance to maintain their medic's skills and keep them "fueled up" with challenging and realistic training to ensure they are always ready.

Metrics of Success

What we choose to measure when judging the quality of combat medical care has a profound effect on where we place emphasis for performance improvement. Potentially preventable death on the battlefield has become the single most important metric in battlefield medicine that guides performance improvement. Yet by not establishing a prehospital performance improvement system, Army medicine has chosen to only focus on potentially preventable deaths within MTFs. If we can agree that our purpose in the Army Medical Department is to support the warfighter and our role in increasing lethality is to preserve combat power, we must enforce prehospital accountability and also redefine our metrics of success to include prehospital return to duty rates and missions enabled. ▪

ENSURING CONTINUITY IN AEROMEDICAL COMMS

U.S. Air Force Air Mobility Command, Scott AFB, IL, is working to further integrate Aeromedical Evacuation System (AES) capabilities within air medical evacuation squadron portfolios for enhanced casualty outcomes.

By Col. Russ Frantz, HQ, AMC

U.S. Air Force Capt. Chandry Brown, center, a flight nurse assigned to the 183rd Aeromedical Evacuation Squadron, applies a tourniquet to a simulated casualty during an air evacuation training at Naval Air Station Barbers Point, Kalaeloa, HI. This was the 18th AES first intratheater air evacuation training on the island. (U.S. Air Force photo by Staff Sgt. Jasmonet Jackson)

The Aeromedical Evacuation System, or AES, was first developed in World War II. Since that time, the Air Force has developed the Aeromedical Evacuation System to take maximum advantage of the increases in speed, range and capacity of our airframes to keep our promises to troops on the ground. Additionally, the Air Force has expanded its en-route clinical capability through its use of specialty medical teams to take care of critically ill and injured patients. By providing a safe, responsive, reliable evacuation system the patient gets to United States specialty medical care normally within 72 hours. This means the combatant commander can employ a much smaller, more flexible medical footprint in theater without sacrificing world class care for the patient. No other country can match both our clinical capability and capacity in the air.

From a Tactical Viewpoint

We are developing more refined tactical solutions to execute the aeromedical evacuation system if command, control or communication capabilities between crews and headquarters become degraded or disconnected.

Air Mobility Command (AMC) has shared personnel readiness priorities with the purpose to ensure the entire enterprise is working toward the same goals. Along with our counterparts in the National Guard Bureau and Air Force Reserve Command, we have met face to face with our Aeromedical Evacuation Squadron commanders to make sure they understand these priorities and are adapting their training plans and sourcing accordingly. We have operational guidance in coordination which will give the down range commander more flexibility in mission execution and risk management. Our training guidance has also changed to be more adaptive to the squadron's needs and can be rapidly revised to address any training gaps identified in qualification trends or exercises. Our Aeromedical Evacuation exercise priorities have changed across the total force. Over the last year, we have made our AE exercises to face Airman

Two Aeromedical Evacuation Airmen attend to their simulated patients during a training mission aboard a KC-135 flying from Glasgow, Scotland, to Scott Air Force Base, IL. Overseas flights allow instructors to work with the aeromedical evacuation Airmen for longer timeframes enabling them to gain more hands-on experience. (U.S. Air Force photo by Staff Sgt. Diana M. Cossaboom)

with the toughest challenges identified in operational plans, and we use analysis of their performance to refine training and guidance.

From a Patient Perspective

AMC always endeavors to make sure patients get the same treatment in the air as they would in any hospital. There are several equipment upgrades currently in the approval process that would expand our power distribution, better airway and respiratory care, enhance our cardiac monitoring, and provide better in-flight patient diagnostics. Additionally, we are working to make our overall allowance standard more flexible to take advantage of aircraft of opportunity.

Both our Aeromedical Evacuation Squadrons and Air Force medical treatment facilities are establishing training affiliation agreements with joint and civilian medical treatment facilities. A great example of this is the partnership between Scott Air Force Base and Mercy Hospital in St. Louis, MO where the staff has graciously allowed both our nurses and medical technicians to work and train to their fullest capacity in areas of medical-surgical nursing, emergency treatment, and pediatric and obstetric care.

We are currently working with our line officer counterparts at this year's Weapons and Tactics conference to develop enhanced solutions suited for contested environments, and will test those concepts in upcoming exercises. ▪

MATURING CAPABILITY FOR ENABLED CARE

A Louisiana native, Colonel Buller began his military career in the enlisted ranks in 1982 as a Medical Laboratory Specialist. In 1985, he left active duty and entered the Louisiana Army National Guard while completing his undergraduate studies. During his undergraduate training, he concurrently attended Officer Candidate School at the Louisiana State Military Academy, where he was the distinguished honor graduate, followed by completion of the Infantry Officer Basic Course at Ft. Benning, Georgia. His first assignment as a military officer was as a platoon leader with C Co., 3rd Battalion, 156th Infantry Regiment.

After earning his medical degree, Colonel Buller completed his residency training in Obstetrics and Gynecology at Madigan Army Medical Center in Tacoma, Washington, followed by a three-year fellowship in Urogynecology and Reconstructive Pelvic Surgery at the Johns Hopkins Hospital in Baltimore, Maryland. He then served as the Chief of Urogynecology at Walter Reed Army Medical Center. In 2003, he deployed with the 801st Combat Support Hospital in support of Operation Iraqi Freedom. While serving as the Division Surgeon for the 1st Armored Division from 2006 to 2009, Colonel Buller again deployed in support of Operation Iraqi Freedom as the Multi-National Division-North Surgeon.

Colonel Buller, as an associate professor, served as the Director of the Telerobotics and Advanced Minimally Invasive Surgery Program and the OB/GYN Director of Simulation Education at Uniformed Services University, until June 2011. At USU, he was the Program Director for the National Capital Consortiums Fellowship in Female Pelvic Medicine and Reconstructive Surgery and also later served as Assistant Chief, Department of Obstetrics and Gynecology at Walter Reed Army Medical Center. After a one-year tour as the Command Surgeon for the National Defense University, Colonel Buller completed senior service college at the Dwight D. Eisenhower School for National Security and Resource Strategy. He subsequently was assigned as the Director, Directorate of Communications, Office of The Surgeon General and the U.S. Army Medical Command from July 2013 to May 2015 and as the Executive Officer to the Army Surgeon General from May 2015 to February 2016. From March 2016 to June 2018 he served as Brigade Commander, Uniformed Services University (USU) in Bethesda, Maryland, a DoD organization with over 1,500 Army, Navy, Marine, Air Force, and Public Health Service personnel. As Brigade Commander he was the senior active duty military officer and principal military advisor to the President of the University and the Deans of the School of Medicine, Graduate School of Nursing and Post-Graduate Dental College. He partnered with academic faculty on all matters of military affairs to ensure optimal development of U.S. and international students as military medical leaders.

COL Jerome Buller

Commander
U.S. Army Institute of Surgical Research

Combat & Casualty Care spoke recently with COL Jerome Buller, Commander, U.S. Army Institute of Surgical Research (USAISR), regarding various capabilities in surgical trauma care that USAISR is working to advance to a fieldable state of readiness.

C&CC: Provide some background into trends in field surgical care that USAISR is focused on to the present.

COL Buller: Since the inception of this Institute in the 1940's, we have focused on providing novel products and information that drive evidence-based, best clinical practice solutions and deliver advanced technologies to the Warfighter. The medical and medical research activities that we perform are focused on saving lives on todays' and tomorrow's battlefield. We are the home of the only Burn Center in the Department of Defense and the synergy between our laboratory scientists and clinical researchers makes us the U.S. Government's premier translational research center focusing on trauma, burns, and critical care of the combat wounded because we are able to take clinical problems to the laboratory and translate laboratory advances to the clinic, operating room, or the battlefield.

For example, in the early and mid-2000s we helped launch the modern tourniquet era. We validated several tourniquets, most notably the Combat Action Tourniquet (CAT) and conducted clinical studies on combat casualties that documented the life-saving effects of tourniquet application in casualties at risk of exsanguination from extremity injuries. We also performed a number of validation studies on junctional tourniquets, as well as studies on user training designed to reduce the incidence of tourniquet failure due to user error. Ongoing and future work will focus on development of "smart" tourniquets that can detect loss of hemorrhage control and potentially self-adjust to reduce risk of failure. In addition, studies are ongoing to help develop strategies for conversion from tourniquet to pressure dressing, thus reducing the risk of prolonged limb ischemia and amputation or poor functional outcome. One potential solution being explored is isolated limb perfusion in which blood or other resuscitation fluids could be perfused distal to the tourniquet to maintain viability of the limb without risking exsanguination of the patient.

We also helped launch the age of the modern hemostatic dressing. Prior to the Iraq conflict, the primary option for wound dressing was the venerable cotton gauze bandage. That's the same bandage used in similar format since the dawn of medicine in Ancient Egypt. Our research explored dressings incorporating fibrinogen as clot substrate, kaolin as a clot accelerator, chitosan for its muco-adhesive properties, and other substances to enhance hemostasis. Ultimately, kaolin-impregnated gauze, known as "Combat Gauze" was chosen for use by our Warfighters based on performance and cost. We are continuing to evaluate potentially improved dressings.

For non-compressible hemorrhage, intravascular approaches to hemorrhage control prior to the availability of surgical management have shown great promise, in particular, Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA). This approach dates from enterprising work of Army surgeons in the Korean War and was made practical through the pioneering work of Air Force surgeons, Todd Rasmussen and Jonathan Eliason, who developed devices that could safely be placed without the use of fluoroscopic guidance, thus making them practical for battlefield use. We continue to advance hemorrhage control by exploring how REBOA can used with other technologies to sustain patients at risk for or in hemorrhagic shock. A limitation of REBOA is that it occludes blood flow distal to the occlusion site, limiting blood loss from damaged tissue but also starving healthy tissue of oxygen-carrying blood. We are studying ways to improve perfusion of healthy tissue distal to the REBOA occlusion.

Another approach to controlling hemorrhage in the abdomen, where it cannot be readily controlled by external pressure, is to introduce a space-filling substance like a polymer foam into the abdominal cavity to provide pressure on bleeding vessels in a manner similar to the urethane foam used to re-inflate a flat tire ("fix a flat"). We have worked with industry partners to test this approach and work continues in this area.

Also, the concept of Damage Control Resuscitation (DCR) was developed from the U.S. military experience in Iraq, and we play a central role. DCR was the natural extension of the Damage Control Surgery (DCS) concept proposed by surgeons at the University of Pennsylvania in the mid-90s. DCS prioritizes hemorrhage control surgery and defers staged, definitive repair of injury-induced anatomic defects until after physiologic stabilization. DCR incorporates a modern understanding of the role of blood products in restoring hemostatic function and oxygen delivery while preventing the physiologic disturbances such as acidosis, dilution and hypothermia associated with the administration of intravenous fluids such as normal saline or lactated ringer's solution, which were the mainstays of resuscitation prior to the wars in Iraq and Afghanistan. Recent improvements to DCR based on our research and in collaborating research groups funded by the DoD includes the adoption of 1:1:1 transfusion ratios of red blood cells, plasma and platelets, in an approximation of whole blood, for patients requiring resuscitation from hemorrhagic shock.

More recently whole blood, particularly blood from group O donors with low titers of anti-A and anti-B antibodies (low titer O whole blood or LTOWB), has been widely adopted in military and civilian trauma programs for urgent resuscitation of exsanguinating patients. Finally, analysis of data from the DoD Trauma Registry (DoDTR) revealed that early (within the first 30-40 minutes post-injury) blood transfusion was the single most important factor in decreasing combat casualty mortality. Therefore, our research and development efforts have been focused on improving the delivery of blood to the point of injury on the battlefield through shelf life extension, improved storage and delivery systems and the development of products that extend the therapeutic effects of blood in shocked trauma patients.

Additionally, the Blood Far Forward (BFF) concept grew from the observation that delaying resuscitation in hemorrhaging patients would essentially increase shock depth and duration or shock dose, and that doing so would worsen outcomes. In Basic Life Support (BLS), CPR is started as soon as cardiac arrest is diagnosed to minimize duration of tissue hypoperfusion; so it is with hemorrhage: the heart does not need to be compressed, it needs to be filled with blood. Anecdotal observations from WWI suggested that the common sense remedy to blood loss might be replacement of lost blood. A century of experimentation with every conceivable alternative to blood for hemorrhage resuscitation has not yielded a better alternative. U.S. and United Kingdom forces in Afghanistan fielded blood products in the pre-hospital setting and the outcomes of these interventions were captured in the DoDTR. The results are clear by looking at the data: early resuscitation of hemorrhaging patients with blood resulted in decreased mortality. These results have also been confirmed in randomized trials conducted at several locations in the U.S. So some of our current research efforts are focused on delivering blood products with both oxygen carrying capacity and hemostatic function in the pre-hospital setting.

Something else that we have done is to realign some of our research efforts to better support multi-domain operations (MDO). Swift medical evacuation may not be an option; ensuring that Warfighters remain mission capable even while injured is crucial. Previously, some of our research efforts focused on decreasing complications of open fractures (primarily preventing infection and nonunion) and improving long term outcomes by restoring function by regenerating missing skeletal muscle. With the anticipated inability to quickly evacuate casualties, infections will go from becoming a complication to limb and life-threatening. Fractures and soft tissue injuries will take able bodied Warriors out of the fight in order to care for those who have been injured until they get medevacked. Tourniquets, which saved lives and caused little to no morbidity in recent wars, will likely cause loss of limb and even life when left on too long. So, we are focusing on getting solutions into the hands of medics and Warfighters like local antimicrobial irrigants and other treatments to prevent infection; an exoskeleton or brace that will

allow wounded Warriors with lower extremity wounds to remain mobile and stay in the fight; and strategies to allow tourniquets to remain on limbs safely for longer periods of time.

C&CC: With a growing focus on prolonged field care (PFC), talk about some focus areas of field surgical care that USAISR is working to promote.

COL Buller: We are working on delivering hemorrhage control products and blood products for far forward resuscitation, without which there will be no prolonged field care (bleeding, non-resuscitated patients simply die). We are also working on pharmaceutical interventions that increase the body's ability to handle the metabolic stress of shock so that blood-based resuscitation will be even more effective. Furthermore, we are developing diagnostic technologies and decision support systems that will enhance the ability of the combat medic to diagnose life-threatening bleeding and intervene with the right products at the right time to the right patient.

One of our research departments, funded by Telemedicine and Advanced Technology Research Center or TATRC, is working to provide an overall life support system, parts of which initially can be placed on the ground or a stretcher with a wounded Warrior. Then, given availability transport, these components would be attached to the stretcher in compact form and managed by an autonomous master controller maximizing the stabilization and maintenance of a casualty, to include transfusion control, continued aspiration, respiration support, REBOA catheter balloon control, and potentially extracorporeal membrane oxygenation (ECMO) and many other life support systems. Ideally, our goals for this system will be compactness, ruggedness, and simplicity, so components can be quickly attached to a stretcher and loaded onto an unmanned aerial vehicle, unmanned ground vehicle, or manned transport.

Additionally, we now have the capability to support research protocols designed to address field surgical care concerns. This capability allows us to perform long-term intensive care research studies to address prolonged field surgical care in the same focus areas that I've described above.

C&CC: From a damage control surgery (DCS) perspective, what are some challenge areas USAISR is shedding light on to better point of injury surgical care?

COL Buller: Autonomous systems that aid in intelligent tourniquet deployment and vascular access will greatly improve care at the point of injury. We hope to show that autonomous systems will help the clinician accurately assess patient's condition, deliver clinical care guidance and potentially improve outcomes when timely medevac is not available and/or when operating in resource constrained environments.

We are developing software and evaluating use cases for usage in the field by clinicians trained at different levels of care. We expect augmented reality to have several roles to fulfill: bidirectional communication tool to facilitate the skills of the trained physician at the location of the untrained medic or first responder; a convenient deployment platform for decision support apps; a light-weight display tool to provide displays of medical devices without the traditional size and weight of conventional medical devices; niche rolls in dark or noisy environments where sight or sound cannot be effectively utilized, such as transport on an aircraft; and an enabler for hand-free operation.

Also, as mentioned before, tourniquet use has proven to be an extremely effective tool in controlling bleeding; however, extended use of tourniquets can be detrimental to limbs due to the lack of tissue perfusion. This can lead to limb dysfunction and/or amputation. Finding novel approaches to extend tourniquet time is absolutely essential due to the decrease in evacuation time.

Additionally, traumatic eye injuries are a common occurrence and a leading cause of blindness in military Warfighters. Unlike civilian corneal trauma, battlefield ocular trauma involves high morbidity with complex multiple full thickness lacerations, severe ocular hypotony, or intraocular pressure and iris prolapse, which happens when the iris tissue is outside of the wound. Another issue is the loss of intraocular fluids due to gaping corneal wounds, which results in damage to the posterior segment, including retinal detachment and choroidal hemorrhage. So we're looking for interventions that can temporarily stabilize the eye and seal corneal wounds to protect it until the appropriate clinical treatments or operative procedures can be performed.

C&CC: As capabilities advance what's possible in field surgical care, such as telemedicine and even robotics, speak to some areas USAISR sees as most promising.

COL Buller: We are developing capabilities such as miniaturized extracorporeal life-support (ECLS) that will make it possible to provide care that has previously been available only in the hospital

setting. Our goals is to provide this capability for our troops in the field and during transport. ECLS is a life-saving therapy that involves taking part of the patient's blood out of the body through a system of small tubes, similar to dialysis, and then returning it back after adding oxygen and removing carbon dioxide (replacement of lung function); removing waste products (replacing kidney function). ECLS can also be connected to the patient in a way that permits replacing the patient's heart function, thus making ECLS useful for returning circulation to patients who suffer cardiac arrest, myocardial infarction or severe trauma with stoppage of the heart. Various iterations and efforts on ECLS are ongoing within the DoD from miniaturized wearable system testing to development of new prototypes, to making the plastic catheters of ECLS circuits friendly to blood.

Also, the evolving theme in trauma and critical care medicine generally is that earlier intervention prevents problems and improves outcomes compared to reactive strategies that attempt to reverse established patterns of organ failure. Overall, we are teaming up with our collaborators to seek technologies that enable a shift from in-hospital care to delivery of advanced care at the point of injury and during patient transport. ECLS, REBOA and semi-autonomous/autonomous surgical intervention technologies represent a suite of technologies that would move the most advanced life support systems available in Level One trauma centers and move them to far forward environments. ECLS, as currently implemented, generally depends on heparin anticoagulation to prevent circuit thrombosis. This is not compatible with the care of trauma patients who have not had definitive surgery to repair all injury-induced anatomic defects. A major goal of our research is to design ECLS systems that do not require anticoagulation medicine.

Also, REBOA is effective in controlling hemorrhage but results in ischemia in large vascular beds, often involving uninjured tissue, which thus suffers an iatrogenic insult. Some or our research aims to develop strategies to use REBOA to prevent exsanguination while maximizing perfusion of uninjured tissues. Eventually, these efforts will contribute to development of semi/autonomous systems that may be able to carry out life-saving interventions on combat casualties.

On telemedicine, we are looking at how to improve clinical performance and decision making when taking care of a critically ill patient in a prolonged field care environment. We are also investigating how local decision support systems can correspondingly improve clinical performance and workload when communications are down and telemedicine is not available. Additionally, we are researching how multiple medical algorithms can be combined to eventually be used in a semi-autonomous medical evacuation system.

We are also conducting research in novel technologies such as augmented reality; it has immense capabilities, such as line of sight visualization and holographic imagery that overlays on top of the real environment. This helps to provide additional information to help guide medics through complex procedures such as mapping a body and providing context for incisions. For example, we are developing holographic overlays on where incisions must be done for an escharotomy in order to properly release the compression for adequate perfusion and movement. Additionally, augmented reality devices can bring in a remote expert who can see in "first-person view" what the medic is undertaking to provide additional support when performing complex surgical procedures.

Similarly, we are working with TATRC and Stanford University for semi-autonomous surgical intervention using medical robotics. Through a collaborative effort, we are implementing virtual reality systems to remotely control a medical robotic system while also implementing artificial intelligence to complete surgical procedures when connectivity is lost.

Lastly, we want to develop an external fixation device (exoskeleton) that can help a Warfighter ambulate which would decrease the number of personnel required to care for that individual to free up more resources on the battlefield.

C&CC: Feel free to speak to other goals/challenges moving forward.

COL Buller: We are working with our colleagues at our headquarters, U.S. Army Medical Research and Development Command, U.S. Special Operations Command (SOCOM) and the Armed Services Blood Program (ASBP) to expand the program that supplies freeze-dried plasma (FDP) produced by the French Military to SOCOM. Specifically, plasma collected by ASBP will be sent to France for freeze-drying and then returned to the U.S. for distribution to U.S. forces. We have played a central role in the development and maintenance, and recently, in the expansion of this program. We continue to conduct stability studies on the FDP product and to inform our leaders and the Food and Drug Administration on product function and viability.

The DoD is funding a randomized clinical trial comparing the safety and efficacy of hemoglobin-based oxygen carriers (HBOCs) with or without FDP in the resuscitation of bleeding trauma patients compared to crystalloid fluids. The study will be performed in South Africa where these products are licensed. Ultimately, this study will assess the viability of HBOCs with/without FDP as a bridge therapy to blood transfusion in hospital. If successful, the combination of HBOC with/without FDP would be a much more logistically sustainable point of injury care bundle than labile blood products and would significantly increase resuscitation capability far forward.

At present, ECLS, or extracorporeal life support, is the flagship product within DoD as the next most promising life-saving technology. Various iterations and efforts on ECLS are ongoing within the DoD from miniaturized wearable system testing to development of new prototypes, to making the plastic catheters of ECLS circuits friendly to blood. We have formed a new department to lead these efforts.

For our burn casualties, we know that there's a need for a temporizing burn treatment. Burns sustained in Iraq and Afghanistan constitute five to 10 percent of injuries. Burns to a small surface area can be incapacitating for the Warfighter and strain the resources available for deployed military medical units. Burn patietns are particularly vulnerable to infections with more than 75 percent of all burn deaths (after initial resuscitation) result from infection.

For military burn injuries, the standard of care is described in the chapter "Burns" in the Emergency War Surgery Handbook. After burn casualties are stabilized, including fluid resuscitation, early burn wound care should be provided in a clean warm environment. The wound should be thoroughly cleansed with a surgical detergent such as chlorhexidine gluconate, followed by the application of topical antimicrobials. The topical antimicrobials include: 5 percent Sulfamylon solution applied to the dressings to maintain their moisture about every eight hours; and, the creams, Silvadene or Sulfamylon, applied as often as needed to keep the burns covered. Cream to cover a 20 percent total burn surface area burn weighs about 400 grams, just under a pound, which is not ideal for point of

injury and for prolonged field care. While Silverlon has advantages during casualty transport because it can be kept in place for 72 hours, its effectiveness depends on continuous moistening with water that may be in short in supply, which over longer periods risks oversaturation and possible hypothermia and maceration. Moreover, the existing standard of care is not designed to temporize burn wounds to limit deterioration and allow delayed excision and grafting.

In recent conflicts, burn casualties have been evacuated to our Burn Center in San Antonio, Texas, where they arrive on average about four days after injury for definitive care, including skin grafting. However, in future conflicts the time until definitive care may be delayed a week, or longer. We are developing the temporizing wound dressing to stabilize burn wounds for better outcomes.

For battlefield pain control, we are investigating and developing solutions that will close multiple critical knowledge gaps for pain management which includes inadequate alternatives to current opioid analgesics for severe pain management by the medic/corpsman on the battlefield; inadequate acute pain management in deployed locations, including battlefield and resource-limited environments; and inadequate strategies for management of acute pain under the care of a clinician in non-deployed settings. This research into novel compounds for analgesic efficacy will provide the valuable preliminary data required for eventual FDA submission and use in human trials. It is expected that the novel compounds tested will provide analgesic efficacy as evidenced by a reduction in pain related behavioral responses in a thermal injury research. It is also expected that the novel compounds, when paired with opioids, will provide analgesic synergy, thus reducing opioid requirements and their side effects. We expect that if a novel compound shows analgesic efficacy equal to opioids then the novel compound would be a candidate to replace opioids for combat medics. This could potentially completely eliminate physiological and cognitive deficits experienced when taking opioids; as well as, negate the possibility for abuse and diversion. If the novel compound is not as efficacious as opioids but does show analgesic synergy then it may be possible to reduce opioid amounts while providing the same level of analgesia. Combat medics could then carry less opioid analgesics and therefore reduce the potential for physiological and cognitive side effects as well as abuse and diversion.

As you can see, we have done a lot of work for our combat wounded, but we still have a lot of work to do. We're excited about the direction in which our research is taking us. It's all about our Warfighters who deserve the best care from point of injury to definitive care. We strive every day to fulfill our mission of "optimizing combat casualty care" on today's and future battlefields.

CASUALTY CARE PREP FOR REAL-WORLD COMBAT

Soldiers wounded on the battlefield, either real-world or in an exercise, may require immediate trauma care prior to being sent to a hospital. A recent annual U.S. Special Operations-sponsored tactical combat casualty care (TCCC) exercise called Flintlock 2019 involved 1,800 participants from more than 30 countries, and was the perfect venue to provide advanced medical training for those tasked with responding to injuries on the battlefield.

By Richard Bumgardner, U.S. Army Security Assistance Command

Chadian Army Maj. Ahmat Ali Abramane (right), applies moulage to a Nigerien soldier during a class on Tactical Combat Casualty Care, at Camp Pô, Burkina Faso. (Richard Bumgardner, USASAC)

At a small outstation called Pô in Chad, Africa, two members of the Chadian army's medical corps, using skills learned in Flintlock 2017, teach Tactical Combat Casualty Care (TCCC) to nearly 100 Senegalese, Nigerian and Burkinabe partner forces. TCCC is the U.S. Department of Defense's standard of care in pre-hospital combat zone medicine and injury management. TCCC provides data-driven, evidence-based, life-saving techniques and strategies for providing the best trauma care to soldiers on the battlefield. For Chadian Army Maj. Ahmat Ali Abramane, who has been to Flintlock many times before, always as a trainee, this year was different for him and his nurse partner, Sgt. Maj. Djeudonnè Bal-Bah Tchaga. Abramane and Tchaga used their training from Flintlock 2017, and experiences gained from deployments supporting various task forces and the United Nations Multidimensional Integrated Stabilization Mission in Mali, to become instructors for the Chadian army and partner forces.

"Chad is the first African nation to have its medical personnel certified by the National Association of Emergency Medical Technicians to teach Tactical Combat Casualty Care," said Col. Kelly Murray, command surgeon from U.S. Army Africa, who led many of the military training classes it took Abramane and Tchaga to get certified. Abramane and Tchaga are the first Chadian TCCC trainers teaching TCCC during Flintlock 2019.

Partnering for Advanced Readiness

U.S. Air Force Capt. Matthew McKinsey, a reservist from Pennsylvania, was a lead instructor for TCCC at Flintlock 2017 and happy to see his former students, the Chadians, step up and take the mantle. "I think the goal of any instructor is that your students apply and then later teach the same skills that you've passed down," he said. "That's sort of the circle of education. I think that partner nations in Africa appreciate the training that we bring them - and it's certainly valuable - but it's always more valuable when you are teaching your own."

Abramane agreed. "My biggest take away from several Flintlocks is the reality that African countries will benefit more if they are trained by Africans," Abramane said. "My hope is that at some point we can have 100 percent Africans training Africans and that will make Flintlock a bigger event."

As more and more African partner doctors and medics benefit from TCCC training, given by members of the DoD and African partner forces, that hope is closer to reality every day. ▪

ECS INTEGRATES VIRTUAL REALITY TRAINING WITH HAPTIC TECHNOLOGY TO TRANSFORM COMBAT MEDIC TRAINING

Adding lifelike touch makes training more realistic and helps save more lives

Tactical Combat Casualty Care (TCCC) provides combat medic training with step-by-step instruction to treat injuries sustained in battle. Fifteen years ago, Engineering & Computer Simulations, (ECS), began developing a medical trainer to meet U.S. Army evolving requirements for TCCC. By integrating emerging technologies, the ECS Tactical Combat Casualty Care Simulation (TC3Sim) resulted in more realistic training and eventually better outcomes for wounded service members and lives saved on the battlefield.

Most recently, ECS collaborated with technology firms to integrate TC3Sim with the transformational use of haptic technology and extended reality (XR) producing a multi-modal enabled version of TC3Sim. With the sense of touch and natural feedback within the training scenarios, TC3Sim allows for intuitive, immersive, and memorable training experiences, giving the trainee the opportunity to visually engage in the environment and current situations, and to feel what they are touching and interacting with. By creating this type of cognitive connection, the learner develops muscle memory which helps them successfully perform life-saving medical interventions on the battlefield.

Waymon Armstrong, CEO/president and founder of ECS explains, "Virtual Reality (VR) training has traditionally focused on learning through visual and auditory cues. By integrating the sense of touch, Warfighters shift their perspective from the typical point-and-click VR interaction to the integrated physical interaction of actually grasping a virtual object and feeling the pressure when, for example, inserting the needle. This type of contact and feedback allows medical teams to learn faster, retain training procedures and put them to use on the battlefield, and hopefully save more lives during the "Golden Hour."

Shane Taber, ECS Development Director, elaborates, "With the integration of haptic technology, we are able to expand training opportunities to feel and manipulate objects in virtual environments and experience scenarios like never before. A medic can experience highly tactile, dynamic procedures such as bandaging a wound or administering CPR, and immediately see and hear the effect, and feel the weight, sensation, or movement of the action."

As TC3Sim transitions to the Army's Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) it is being incorporated into the curriculum for Army Medical Department of the U.S. Army (AMEDD). In addition, TC3Sim serves as an ongoing testbed and technology platform for the Army Futures Command at Simulation and Training Technology Center (STTC) to support ongoing XR, haptics, and human factors research.

Armstrong adds, "This type of transformational use of XR is vital for advancing the capabilities and quality of military training. We are proud to assist our military by understanding their learning and training objectives and enhancing their performance in order to help them save lives."

CALENDAR OF EVENTS

AUG 19 - 22
MHSRS
Kissimmee, FL
Mhsrs.net

AUG 20 - 22
Military Police & Law Enforcement Expo
Ft. Leonard Wood, MO
Mpraexpo.com

SEP 8 - 12
GSX 2019
Chicago, IL
Gsx.org

SEP 9 - 13
Virginia Hazmat Conference
Norfolk, VA
Vahazmat.org

SEP 11 - 12
Tactical Communications Summit
Alexandria, VA
Tacticalcommunications.dsigroup.org

SEP 17 - 19
Modern Day Marine
Quantico, VA
Marinemilitaryexpos.com

SEP 24 - 26
VA Benefits Conference
Washington, DC
Idga.org/events-veteransaffairsbenefits

SEP 25 - 26
Autonomous Capabilities for DoD
Alexandria, VA
Autonomy.dsigroup.org

OCT 14 - 16
AUSA Annual Meeting
Washington, DC
Ausameetings.org

OCT 14 - 18
EMS World Expo
New Orleans, LA
Emsworldexpo.com

OCT 16 - 17
DoD VA and Govt. Health IT
Alexandria, VA
Iehrsummit.dsigroup.org

OCT 18 - 19
Hotzone Conference
Houston, TX
Hotzone.mobi

OCT 27 - 29
VA Patient Experience
Washington, DC
Idga.org/events-vapatientexperience

NOV 20 - 22
Homeland Security Week
Washington, DC
Idga.org/events-homelandsecurityweek

NOV 20 - 21
ISC East
New York, NY
Isceast.com

DEC 2 - 6
AMSUS Annual Meeting
National Harbor, MD
Amsus.org/events/annual-meeting-2/

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- DLA VIPA Agreement: VMP-1412-03
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