

2008
ANNUAL REPORT
TATRC



TELEMEDICINE & ADVANCED TECHNOLOGY
RESEARCH CENTER



TATRC

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 2008		2. REPORT TYPE		3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE 2008 Annual Report TATRC				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Medical Research and Materiel Command (USAMRMC), Telemedicine & Advanced Technology Research Center (TATRC), Fort Detrick, MD, 21702				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 80	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



The Telemedicine & Advanced Technology Research Center is a subordinate element of the U.S. Army Medical Research & Materiel Command (USAMRMC), located at Fort Detrick.

“A most solemn responsibility... is to provide world-class medical technologies to protect and sustain our service men and women across the full spectrum of military operations. We are all challenged to provide effective care for sick and wounded service members to minimize morbidity and hasten a full return to duty and a fulfilling life.”

**— Major General George W. Weightman
Commanding General,
US Army Medical Research
and Materiel Command**



Telemedicine & Advanced Technology Research Center

MISSION:

Explore science and engineering technologies ahead of programmed research, leveraging other programs to maximize benefits to military medicine.

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VISION: Be the model government enabler of technology transfer.

Message from the Director



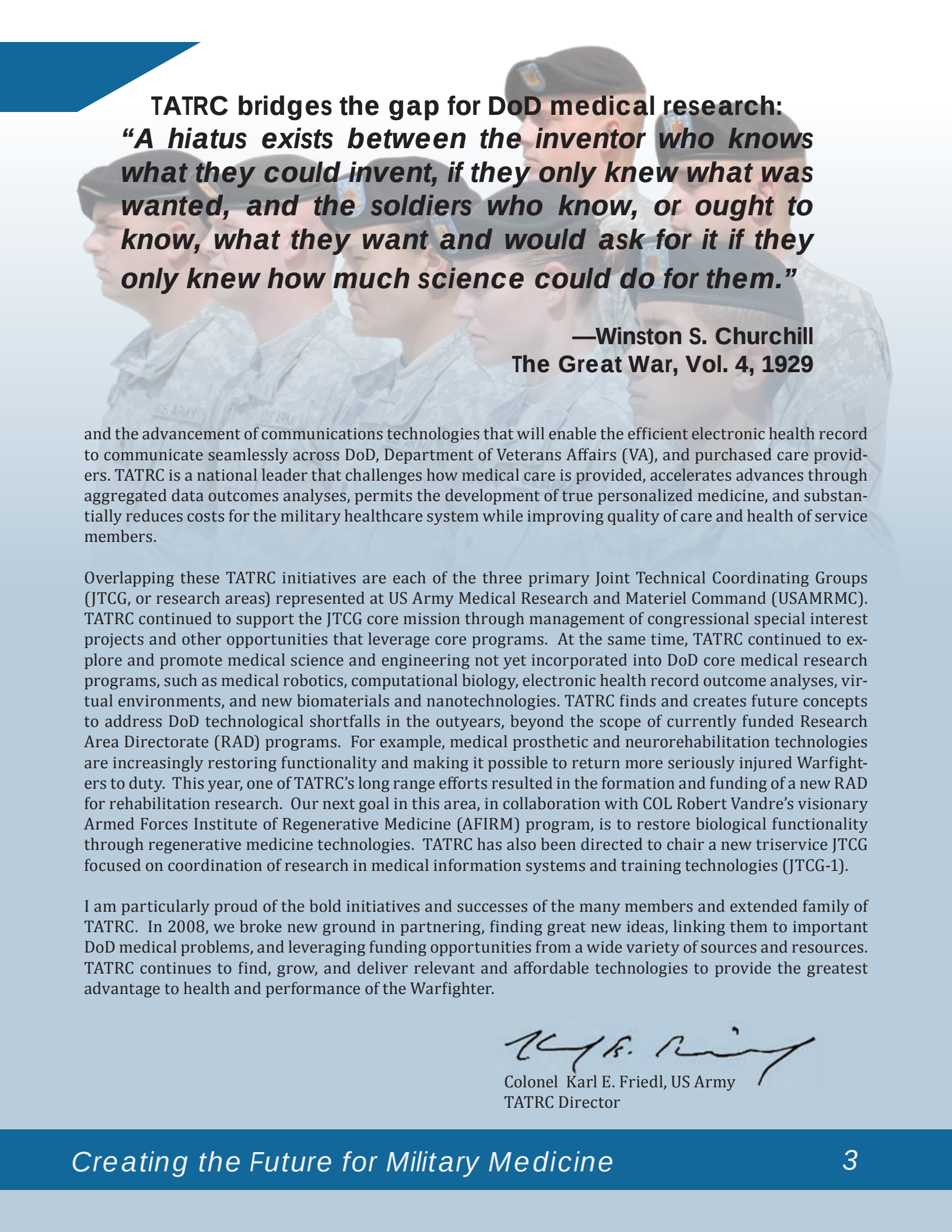
TATRC had many opportunities to support the deployed Warfighter in 2008. Highlights of our accomplishments are illustrated throughout this report. It is beyond the scope of this summary to present the important achievements of each one of our more than 500 active programs and projects. However, I want to highlight the activities of one important TATRC program area: the tele-traumatic brain injury (Tele-TBI) Program, led by TATRC Deputy Director COL Ron Poropatich.

At the request of the Office of the Surgeon General (OTSG), COL Poropatich and his team put in place a system to help injured Warfighters and their families' link to their healthcare providers by simple cell phone technology. They increased remote access for critical care monitoring by placing commercially available robots in several key medical centers. The team obtained approval through a Joint Urgent Operational Needs Statement (JUONS) to increase medical bandwidth in the US Central

Command (CENTCOM) operational theater. This one action will save lives thanks to the timely transmission of large amounts of data such as brain scans. COL Poropatich also obtained approval to connect NATO forces in Afghanistan into the successful Army Knowledge Online (AKO) Teleconsultation Service that allows rapid turnaround expert medical consultations from Army providers to health care providers operating in remote operational environments. These TATRC team efforts remind us that telemedicine provides relevant and affordable solutions that extend limited resources and provide better health care.

In 2008, neurobiology technologies were a pervasive focus, based on a congressional mandate to improve protection and treatment of psychological health and traumatic brain injury (PH/TBI) and ocular trauma in response to injuries associated with the signature weapon of the current conflict, the improvised explosive device (IED). TATRC was already leading the way, with prior investments in neuroprotectants, eye injuries, prosthetics, neuroimaging methods, neuromonitoring, neurorehabilitation and many other efforts to address brain-focused issues. As a result, many TATRC-supported efforts were prominently featured in key meetings, such as the Northern California Institute for Research and Education's (NCIRE) "Brain at War" symposium, the Scheppens Eye Institute's "Military Vision Research Symposium: Traumatic Eye and Brain Injury", and the Institute of Medicine's "Systems Engineering to Improve Traumatic Brain Injury Care in the Military Health System" workshop.

TATRC continued to shape opportunities and respond to evolving military needs and technological advances. The overall program is summarized as a conceptual research space of key competencies plotted onto five intersecting initiatives that reflect TATRC's lanes of exploration. Each of these areas are rapidly advancing and growing in response to Department of Defense (DoD) medical needs. With the establishment of Africa Command and continued requirements in Afghanistan, new approaches to providing medicine in austere environments are a high priority for which TATRC is well equipped. Building new medical facilities is an opportunity to promote centers with new efficiencies, state-of-the-art medical care, and with the flexibility to rapidly adopt new and emerging technologies, as well as novel concepts in medicine. These newer concepts include integrative medicine, a focus on personalized medicine, and promotion of disease prevention instead of treatment of chronic illness particularly in support of the new Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury (DCoE PH/TBI). Many advances will come from the modeling and simulation technologies that are especially dependent on computational biology, the central engine of digital soldier/human and the human phenome. All of these efforts are intrinsically linked to TATRC's original key capabilities in e-Health



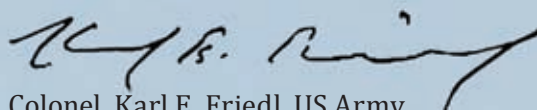
TATRC bridges the gap for DoD medical research:
“A hiatus exists between the inventor who knows what they could invent, if they only knew what was wanted, and the soldiers who know, or ought to know, what they want and would ask for it if they only knew how much science could do for them.”

—Winston S. Churchill
The Great War, Vol. 4, 1929

and the advancement of communications technologies that will enable the efficient electronic health record to communicate seamlessly across DoD, Department of Veterans Affairs (VA), and purchased care providers. TATRC is a national leader that challenges how medical care is provided, accelerates advances through aggregated data outcomes analyses, permits the development of true personalized medicine, and substantially reduces costs for the military healthcare system while improving quality of care and health of service members.

Overlapping these TATRC initiatives are each of the three primary Joint Technical Coordinating Groups (JTTCG, or research areas) represented at US Army Medical Research and Materiel Command (USAMRMC). TATRC continued to support the JTTCG core mission through management of congressional special interest projects and other opportunities that leverage core programs. At the same time, TATRC continued to explore and promote medical science and engineering not yet incorporated into DoD core medical research programs, such as medical robotics, computational biology, electronic health record outcome analyses, virtual environments, and new biomaterials and nanotechnologies. TATRC finds and creates future concepts to address DoD technological shortfalls in the outyears, beyond the scope of currently funded Research Area Directorate (RAD) programs. For example, medical prosthetic and neurorehabilitation technologies are increasingly restoring functionality and making it possible to return more seriously injured Warfighters to duty. This year, one of TATRC's long range efforts resulted in the formation and funding of a new RAD for rehabilitation research. Our next goal in this area, in collaboration with COL Robert Vandre's visionary Armed Forces Institute of Regenerative Medicine (AFIRM) program, is to restore biological functionality through regenerative medicine technologies. TATRC has also been directed to chair a new triservice JTTCG focused on coordination of research in medical information systems and training technologies (JTTCG-1).

I am particularly proud of the bold initiatives and successes of the many members and extended family of TATRC. In 2008, we broke new ground in partnering, finding great new ideas, linking them to important DoD medical problems, and leveraging funding opportunities from a wide variety of sources and resources. TATRC continues to find, grow, and deliver relevant and affordable technologies to provide the greatest advantage to health and performance of the Warfighter.



Colonel Karl E. Friedl, US Army
TATRC Director

TATRC 2008 Highlights

American Telemedicine Association's TATRC Day—*Personal Health Monitoring*

Held in conjunction with the American Telemedicine Association's (ATA) 13th Annual Conference in Seattle, WA, TATRC presented the 8th Annual TATRC Day symposium. The one-day event focused on personal health monitoring. The symposium was divided into personal health monitoring in the hospital, at home and in the field.

Dr. Eva Lai set the stage by presenting her TATRC research portfolio on physiological monitoring. This ranges from environmental biomonitoring technologies such as cardiomyocytes on a bioelectronic matrix, to implantable sensor systems that warn of impending risk based on acute change in physiological status.

COL Beau Freund, Commander of the US Army Institute of Environmental Medicine (USARI-EM), talked about the state-of-the-art personal health monitoring tools. COL Freund led the development of the Army's first field wearable "Warfighter Physiological Status Monitor," a system currently available as the Hidalgo Equivital™ Vital Sign Detection System (VSDS).

The keynote presentation by Dr. Jaques Reifman, Senior Scientist at USAMRMC addressed predictive modeling for a Soldier's physiological status. Dr. Reifman's project provides high-quality decision-support tools for patient management. An ideal decision-support algorithm would reveal nuanced gradations in casualty states that would be invaluable for precise triage and evacuation prioritization, and could forecast the need for additional in-hospital lifesaving interventions such as emergency surgery.



Presentation of the TATRC 2008 Max Thurman Award to Dr. James "Red" Duke Jr., in recognition of his extraordinary pioneering efforts in remote patient monitoring at the 2008 Annual ATA Meeting. Pictured (left to right): The Honorable Dr. S. Ward Cassells III (OSD(HA)), LTC Hon Pak (2007-2008 President of ATA), Dr. James "Red" Duke Jr. and COL Ron Poropatich (former ATA President, current Deputy Director of TATRC)

Dr. Julian Goldman from the Center for Integrative Medicine and Innovative Technology (CIMIT) presented an update on medical device interoperability and the integrated clinical environment. This represented the Medical Plug-n-Play project that seeks to improve safety in hospitals through standardization of systems.

Dr. Adam Darkins, from the VA summarized the VA's experience in personal health monitoring. Dr. Darkins has focused on changing the location of care to emphasize patient self management and to make more care available in the home and community.

Finally, Dr. Jay Shore, University of Colorado, summarized his experiences and research on the remote treatment and monitoring of mental health in rural American Indian veterans.

Other presenters provided unique perspectives from government, academia, and industry.

Key Accomplishments

- Established **tele-TBI** program across Army regional medical commands to serve injured service members and their families with better connectivity to health care providers (requested by OTSG to support improvements in care, TBI/PTSD funding from OTSG)
- Provided the concept of **soldier “reset”** and demonstrated feasibility of return-to-duty based on technological advances in rehabilitative medicine that led to the establishment of a new core-funded program in clinical and rehabilitative medicine research (“RAD 4”); this was made possible by a decade of prosthetics and regenerative medicine research investment at TATRC
- Contributed new concepts to **the plan for the US Army Dewitt Community Hospital (Fort Belvoir)** in support of the Health Facilities Planning Agency, based on research in “operating room of the future,” surgical simulation and training, and device standardization conducted at TATRC-funded centers including University of Maryland, CIMIT, and Center for Advanced Surgical and Integrative Technology (CASIT)
- Developed and published high-impact papers on new **genomics analysis software tools** for high performance computing applications, providing new capabilities to accelerate the nation’s ability to detect and respond appropriately to biological threats (Biotechnology HPC Software Applications Institute (BHSAI), DoD High Performance Computing (HPC) Program grant)
- Conducted a collaborative experiment between OTSG, TATRC, Medical Communications for Combat Casualty Care (MC4), and Army Battle Command Battle Lab (Fort Gordon, GA) connecting a surrogate Combat Support Hospital and Medical Company at TATRC’s OASIS facility; this demonstrated that WIN-T One network can support the **Army Medical Command (MEDCOM)’s bandwidth requirements** identified in the JUONS for deployed medical facilities (supported by TATRC’s Operational Telemedicine)
- Provided and helped deploy a brief **neuropsychological test battery (ANAM4)** for predeployment testing of every service member to aid in the evaluation of functional changes and recovery of injured service members mandated for DoD-wide implementation by OSD(HA) (University of Oklahoma/OTSG Rehabilitation Medicine Proponency Office/TATRC)
- Convened the National Forum on the Future of the **Defense Health Information System** in partnership with Georgetown University and the services’ clinical informaticians to make recommendations for the longitudinal health record, effective data warehousing, appropriate systems architecture, and syntactic and semantic interoperability for the DoD electronic health record
- Provided rapid turnaround fasciotomy procedures training program (DVD instructional video) to reduce damage from **compartment syndrome**; this training was offered to medical care providers before and in deployment (SBIR project developed in cooperation with TATRC, Institute of Surgical Research (ISR), and the American Academy of Orthopedic Surgeons)
- Conducted a comprehensive review of research findings in the Bone Health and Military Medical Research (BHMMR) program with scientists, military trainers, and other service and international military preventive medicine specialists at Fort Jackson, concluding that **stress fracture injuries** could be nearly eliminated in recruit training if we implemented the results of the current knowledge (CSI program managed through USARIEM/Center for the Intrepid)
- Joined the Joint Medical Distance Support and Evacuation (JMDSE) Joint Capabilities Technology Demonstration (JCTD, FY09) with responsibility for new concepts in **casualty evacuation (CASEVAC) and medical distance support and response**, including the use of unmanned aircraft systems

Program Execution

Focus of TATRC's Research Areas

TATRC's research areas can be organized in many different ways, such as by the types of products under development, or the part of the body or tissue being studied, or whether the research is at a nano, micro, or macro level. In this Report, the areas have been loosely organized by their overarching purpose, to protect the Warrior on the battlefield on all fronts, and to ensure a return to full capacity after leaving the battlefield.

TATRC's research projects are grouped and managed in portfolios, or program areas, along key product lines, and as new initiatives. Many of these overlap due to the nature of the research projects and the rapid growth in various technological areas, which generate new ideas and approaches. The projects may have a prime focus that place them within a given portfolio, and secondary foci that could easily put them in other portfolios.

Lt. Kurt Shingledecker and his men participating in an air assault mission conducted by the 101st Airborne Division, 3-187 Infantry Regiment on July 3, 2008. (Courtesy of US Army. Photo by Spc. Richard Del Vecchio)

TATRC Funding

TATRC's total funding for FY2008 was \$354M. Over 94% of the funds were Congressional Special Interest (CSI) Research, Development, Test and Evaluation (RDT&E) projects. Additional funds were distributed to the tele-TBI program (\$12M); Army Medical Department (AMEDD) Advanced Medical Technology Initiative (AAMTI) (\$4.8M); Biotechnology High Performance Computing (HPC) Software Application Institute (BHSAI) (\$2.2M); Bioinformatics Network Science (\$1.2M); and Small Business Innovation Research /Small Business Technology Transfer (SBIR/STTR) grants (\$8.2M).

TATRC funds research and projects that others may view as outside of core-funded DoD research. TATRC's focus is on starting and finishing, from medical research innovation through transition to medical application.

The AAMTI program is unique to TATRC and provides funding for transition of technologies and systems to Army medical practice through non-research demonstration projects.

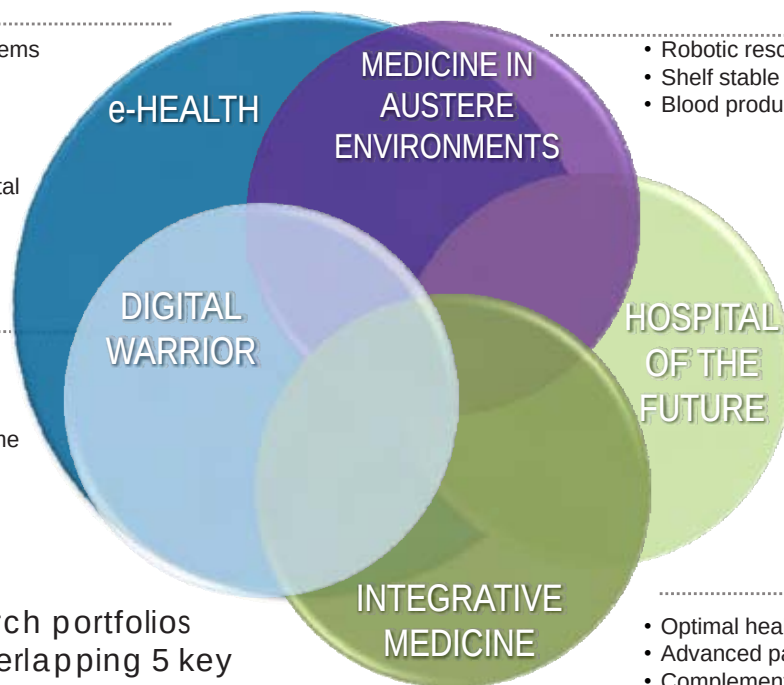
Soldiers carry a fellow Soldier away from a medical evacuation helicopter during medevac training Oct. 2, 2008, at Fort Hood.



- Cell phone-based systems
- Remote biomonitoring
- Global biosurveillance

- Health information portal unified EHR
- Research data cube/medical outcomes
- Pharmacovigilance

- Virtual environments
- Computational models & tools
- Human/soldier phenome
- Performance & injury prediction models



- Robotic rescue & evacuation
- Shelf stable diagnostics & vaccines
- Blood products & blood safety

- Natural orifice transluminal endoscopic surgery
- Advanced medical imaging
- Distance medical training & simulation

- Operating room of the future
- Prosthetics and human performance
- Regenerative medicine & biomaterials

- Optimal healing environments
- Advanced pain management
- Complementary and alternative medicine
- Neuroplasticity/resilience
- Genomics/personalized medicine

The TATRC research portfolios map to these overlapping 5 key initiatives.

"TATRC is leading the way in several medical technology fields, including development of a web-enabled eye surgery system, electronic dog tags and autonomous casualty care robots for the field. TATRC has been exploring and implementing telemedicine and other advanced medical technology solutions for more than 15 years. Equally important has been TATRC's partnership with numerous universities, commercial enterprises and other federal agencies that support approximately 500 ongoing research projects."

Honorable S. Ward Cassells,
M.D.
Assistant Secretary of
Defense for Health Affairs
Military Medical
Technology
Volume 12, Issue 1, 2008



Biomonitoring Technologies

Dr. Eva Lai

The Biomonitoring Technologies portfolio managed research projects and programs that address the challenges of enabling—whether continuous, wireless, or remote—monitoring of the Warfighter’s health and threats to health in the field, in the hospital, and at home.

The Biomonitoring Technologies portfolio aims are to provide successful operational management, ensure the best health outcomes, and minimize and mitigate harm to the Warfighter.

Wireless Personal Health/Medical Monitoring

This project is using miniaturized wireless implantable biosensors to monitor for analytes in body tissues. A University of Connecticut, Storrs team to include Drs. Diane Burgess, Faquir Jain, and Fotios Papadimitrakopoulos is developing the next technological advances in enabling continuous, remote situational awareness of a Warfighter’s physiological and medical condition. The device will be small enough to be inserted and removed via a 16-gauge needle. This minimally invasive biosensor has been designed with an outer hydrogel coating that releases inflammation-suppressing agents. The agents can minimize the negative tissue responses to the implant for up to 1 month. Future plans include integrating the com-

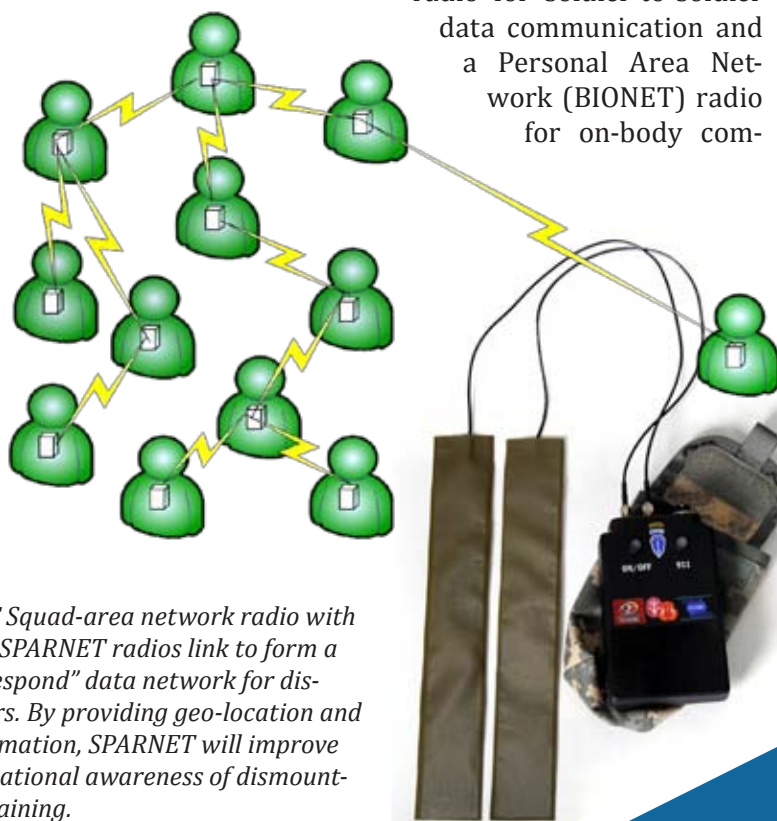


A miniaturized sensor platform that can be inserted with a 16 gauge needle has been developed.

ponents (i.e. multiple electrochemical sensors, wireless communication unit, programmable potentiostat, and signal processor) into a single implantable device for simultaneous detection of glucose, lactate, and oxygen concentration for up to 6 months.

Personal Area Network for Remote Health Monitoring

TATRC supported USARIEM in partnership with Elintrix to develop an integrated system to capture, analyze, communicate, display, and archive geo-location and physiologic-sensor data. Soldier-worn elements of this Spartan network (SPARNET) include a squad-area-network (SAN) radio for soldier-to-soldier data communication and a Personal Area Network (BIONET) radio for on-body com-



Prototype SPARNET Squad-area network radio with wearable antennas. SPARNET radios link to form a mobile “sense and respond” data network for dismounted Warfighters. By providing geo-location and medical status information, SPARNET will improve the medical and situational awareness of dismounted Warfighters in training.

TATRC supported Intelesense Technologies to provide real-time air quality monitoring and alerts for US forces at the Balad airbase in northern Iraq. This reduces the risk to preventive medicine personnel who would otherwise make these measurements.

munication. The BIONET radio is a modifiable, integrated, inductively-linked, minimalist module with processing capability for use with sensor systems like the Warfighter Physiological Status Monitor (WPSM).

BIONET supports transmission of data via a modulated magnetic field. Detection of the resulting short-range, bidirectional communications by hostile forces is made problematic due to the frequency and propagation characteristics of the magnetic field.

SPARNET enables continuous monitoring of a Warfighter's geo-location and health status in the field to improve force health protection.

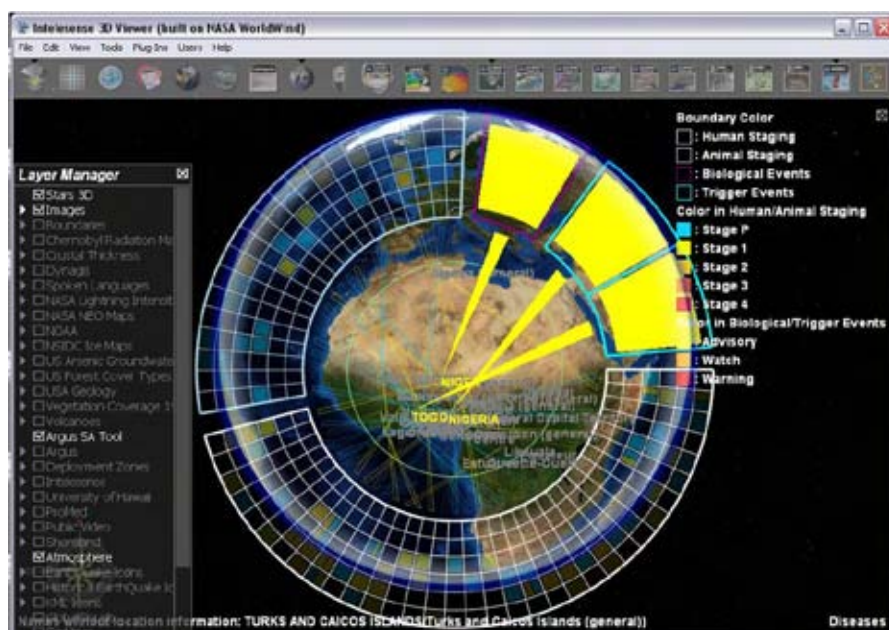
Intelesense Technologies

Intelesense Technologies, a company founded by Dr. Kevin Montgomery, uses a wireless sensor that integrates environmental, public health, and other data collected from anywhere in the world in real-time. Intelesense has developed a sensor network for air, water, weather, and imagery data that is collected from anywhere in the world and transmitted over the Internet from anywhere in the world. Intelesense integrates sensor and Geographic Information System data from thousands of sources automatically and provides a real-time georepository of all relevant information for a particular region.

Intelesense Technologies and Project Argus collaborate to provide real-time integrated disease monitoring and bio-surveillance worldwide.



The system can be used for a wide range of applications, including weather monitoring, water and air quality monitoring, biotelemetry, imagery and audio capture, field data collection, earthquake monitoring, buoy networks, tsunami warning, and emergency telemedicine and disaster response. At the same time, it provides wireless communication infrastructure for remote areas. Current projects range from tracking emerging infectious diseases (e.g. avian influenza), to helping the Centers for Disease Control and Prevention (CDC) provide therapies in Africa, to protecting environmentally sensitive places and to helping children from around the world to connect and interact with each other.



Medical Robotics

Dr. Gary Gilbert

TATRC established a program of projects to adapt, integrate and develop new robotic technologies to treat patients in fixed and mobile medical facilities and to locate, identify, assess, treat, and rescue battlefield casualties under hostile conditions. TATRC became part of the JMDSE JCTD which will evaluate several emerging semi-autonomous technologies as enablers for enhanced combat casualty care and CASEVAC.

Joint Medical Distance Support and Evacuation (JMDSE) Joint Concept Technology Demonstration (JCTD)

The JMDSE JCTD is an FY09 project which will provide both improvements and new combat casualty support capabilities to significantly enhance battlefield medicine, provide precision logistical delivery and be a force multiplier for casualty evacuation. It will integrate proven casualty support technology by providing virtual triage from secure areas with a battlefield telemedicine and closed loop critical care capability

and rapid provision of critical medical supplies to dispersed locations. It will also demonstrate the power of employing unmanned aircraft systems (UAS) for medical resupply and casualty extraction.

TATRC is the Deputy Task Manager responsible for the Joint Distance Support and Response – Medical and the Joint Unmanned CASEVAC Capability segments. All four Services are participating in the JCTD, and the US Coast Guard and Department of Homeland Security have expressed interest.



The robotic Serpentine Manipulator Arm and movable Gantry is housed in the TAGS UGV.

Developed by ChemImage Corporation with SBIR funding, the RBI Robot is a self-contained, teleoperated system for the detection and identification of CBE agents on environmental surfaces.



Robotic Combat Casualty Extraction & Evacuation System

Modular two-man installable patient transport pods and an optional medical attendant operator module were prototyped and installed on the Tactical Amphibious Ground System (TAGS) unmanned ground vehicle (UGV). This demonstrated a breakthrough operational concept for using fully modular payloads to transport wounded personnel via unmanned ground vehicles.

Serpentine Manipulator Arm

Designed and built under a TATRC research grant by the Carnegie Mellon University Robotics Institute to be mounted on the Army's Critical Systems for Trauma and Transport (CSTAT), the robotic Serpentine Manipulator Arm and movable Gantry is intended to enable remote tele-operated control of casualty examination and diagnostic instruments as well as a High Intensity Focused Ultrasound (HIFU) transducer. HIFU technology is potentially capable of detection of hemorrhage and cauterization of internal or external tissue in combat casualties without antibiotics or surgery.

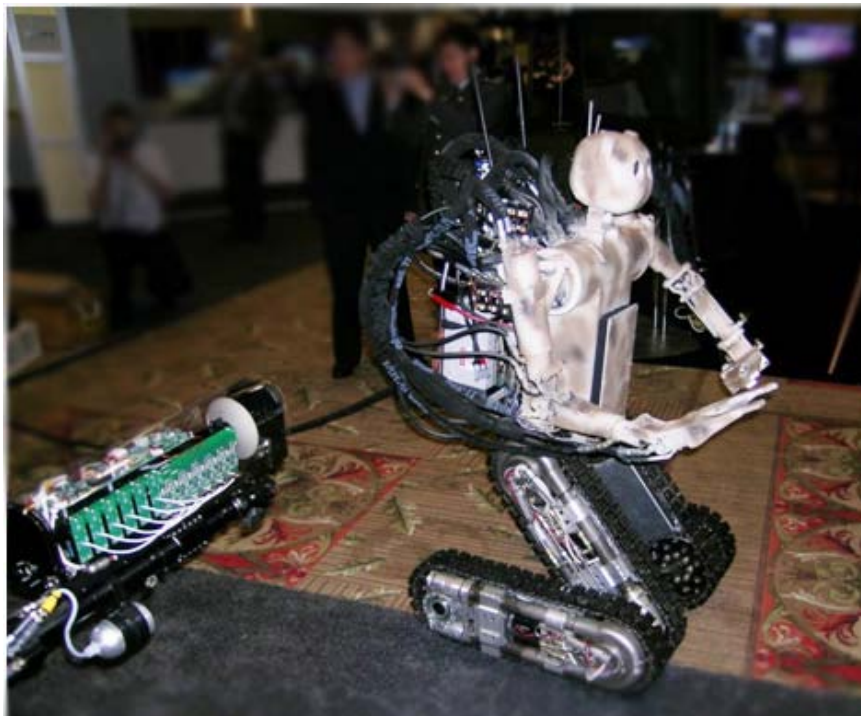
Raman Bio Identification (RBI)

RBI Robot project by ChemImage Corporation and the Robotic Targeted Ultraviolet Chemical, Biological, and Explosive (TUCBE) stand-off sensor by Photon Systems, proved the feasibility of both proximity and stand-off Raman spectroscopic Chemical Biological and Explosive (CBE) detectors implemented on a standard UGV. This work will have two major benefits: 1) the developed CBE detector payload modules will have great impact on the use of UGVs for environmental surveillance in battlefield, HAZMAT and unexploded ordnance situations and 2) the system requirement documents will form the basis of a de facto standard that could lead to an industry-wide standard for the implementation of chemical, biological, radiation and explosive detectors on UGVs.

Using Robots to Rescue Casualties

Battlefield Extraction Assist Robot (BEAR)

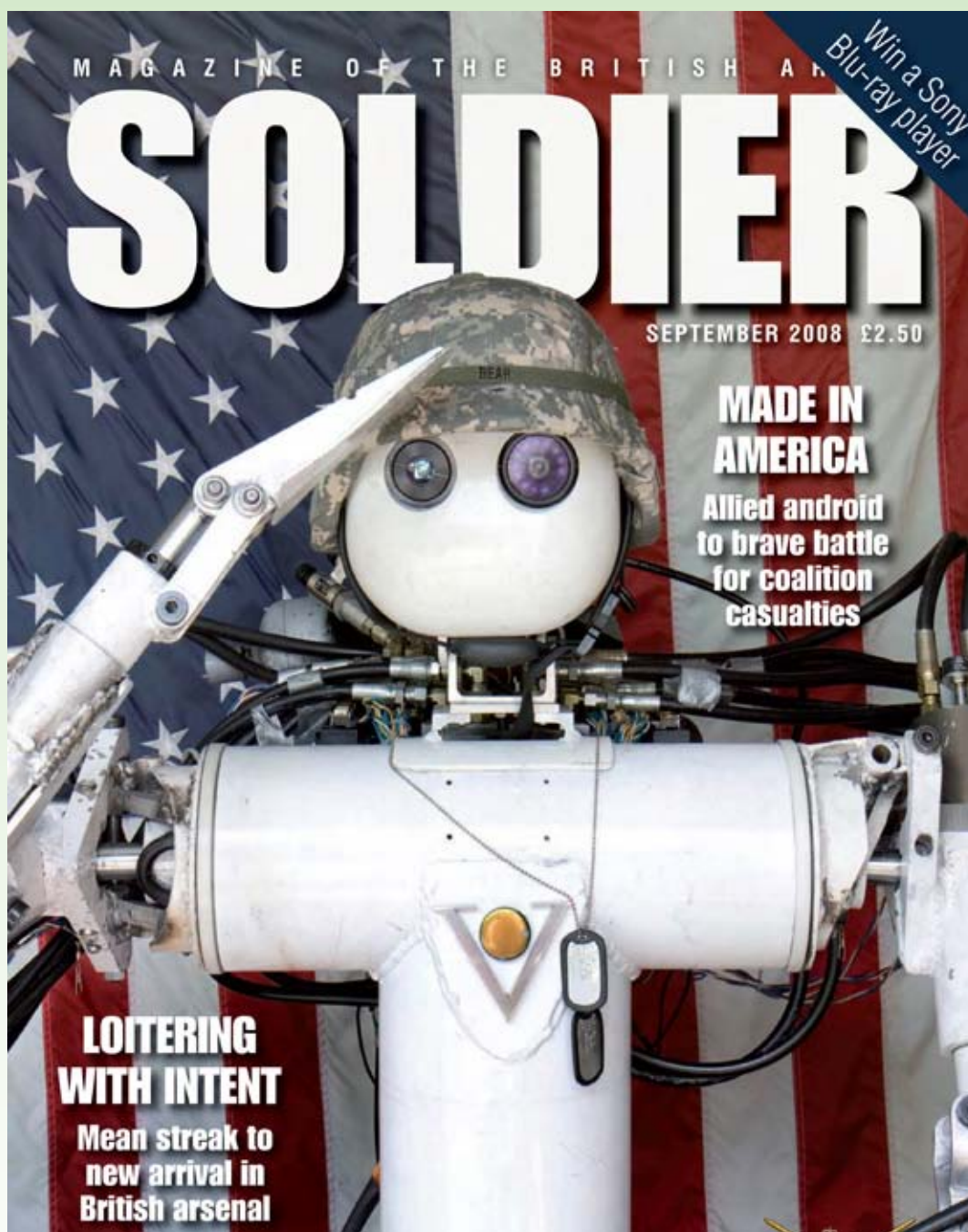
A highly agile and powerful mobile robot capable of lifting and carrying a combat casualty or otherwise injured Warfighter from hazardous areas or from under fire in varying terrain is the goal. This year's accomplishments included: improvements to the upper and lower torso; implementation of NASA's Actin 2.0™ software for coordinated control of limbs and upper torso, designing and testing of prototype BEAR "lower body" and separately articulated tracked leg subsystems; integration of lower body with upper torso subsystem; completion of first phase of operational simulation assessments at the Army Infantry Center Maneuver Battle Lab (MBL). Engineering design improvements included finger-like end effectors for the BEAR's robotic manipulator arms, a Laser Induced Breakdown Spectroscopy detector for CBEs that will be placed on the BEAR's arm, and a full function BEAR simulation entity for integration within the OneSAF (Semi-autonomous Forces) Infantry maneuver model.



Current version of the BEAR robot, demonstrated at the Army Science Conference in December 2008.

Standoff Remote Triage Sensor Array

Getting a robot to the injured is critical, but equally important is assessing the degree of injury. Perl Research, LLC is developing sensors for a casualty extraction robot under an STTR grant. Accomplishments included: a spinal injury assessment sensor for conscious patients; evaluation of candidate sensors for remote robotic triage; investigation of a novel technique for extracting physiological information from infrared (thermal) imagery; a user interface for the medic; and a probabilistic decision algorithm for remote triage.



The BEAR robot has achieved national and international attention ranging from a parody on "The Colbert Report" to the cover of the British Army "Soldier" Magazine. The concept of an evacuation robot is an example of a TATRC-supported technology that is disrupting conventional approaches with better and safer strategies.

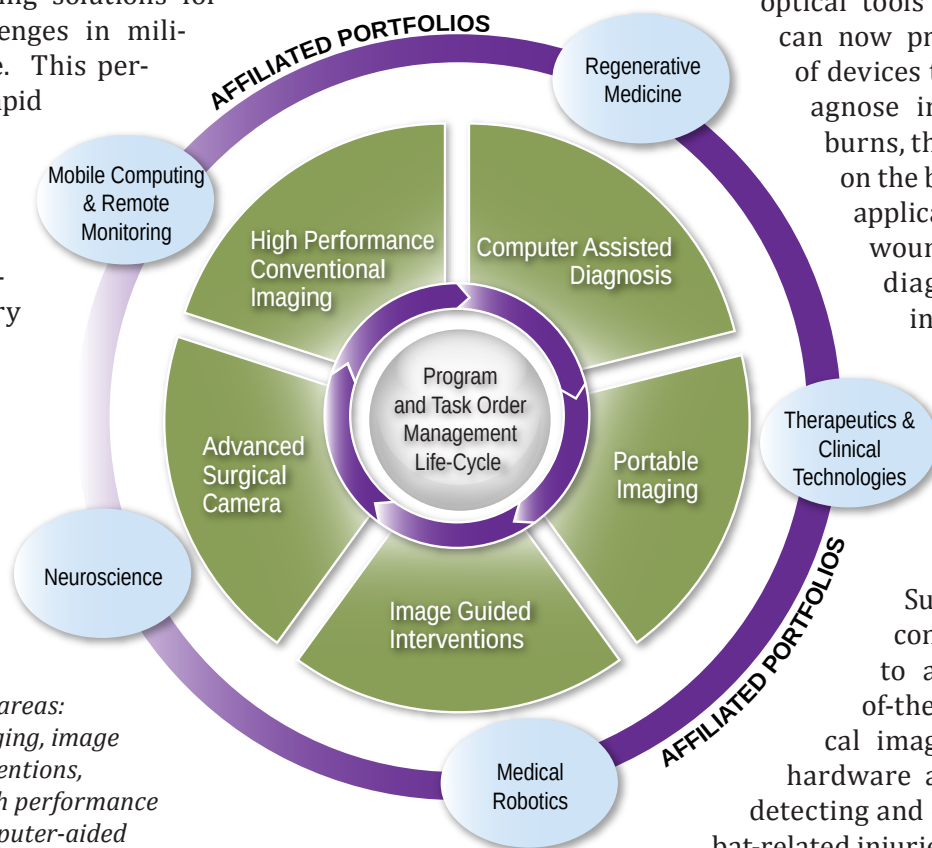
Medical Imaging Technologies

Dr. Anthony Pacifico

Innovation in medicine often starts with a problem, such as meeting military needs for the care of the Warfighter. This portfolio focused on the military's need for new forms of imaging in a concept termed "The Advanced Surgical Camera".

This portfolio is dedicated to the development of next generation technologies in the 5 primary portfolio research areas (shown in the graphic below). The portfolio encourages synergistic research projects that will rapidly integrate state-of-the-art materials and technologies with proven research and engineering solutions for current challenges in military medicine. This permits the rapid translation of discoveries from other fields into rapid advances for military medicine.

The portfolio includes 66 unique projects divided into five research areas: portable imaging, image guided interventions, advanced high performance imaging, computer-aided diagnostics for decision support and treatment planning, and optical/para-optical imaging techniques.



The Advanced Surgical Camera

Optical methods for detecting disease pathology have grown, partly due to advances in focal plane arrays and hyperspectral imaging. A number of optical tools have shown promise to detect the molecular signatures of cancer and are in clinical trials. These optical tools and techniques can now provide the basis of devices to detect and diagnose injuries, such as burns, that are sustained on the battlefield. Other applications include wound debridement, diagnosis/monitoring of intracranial pressure and the monitoring of dermal wound healing.

The Advanced Surgical Camera concept is intended to apply the state-of-the-art in optical imaging techniques, hardware and software to detecting and diagnosing combat-related injuries as far forward of the clinic as possible. There are

A number of optical tools have shown promise in detecting the molecular signatures of cancer, using photons that range from UV to IR. These techniques could be used to assess injuries, such as burns, when they occur on the battlefield.

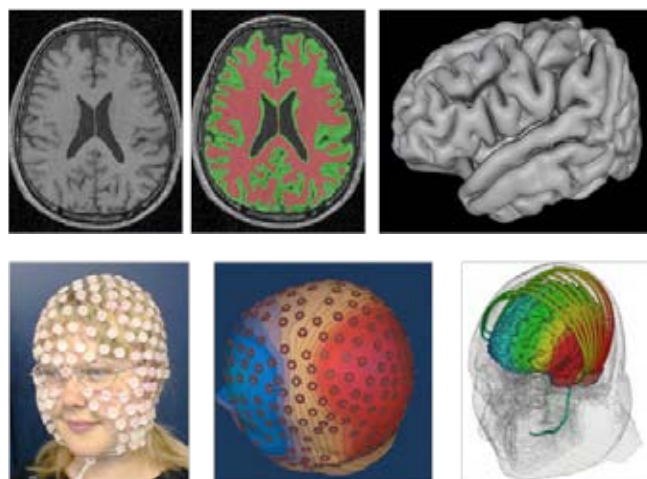


several new projects at TATRC that are dedicated to this concept. These projects are intended to 1) provide a better understanding of the optical signatures and molecular signatures of these pathologies/morbidities and 2) understand the current limits of software/hardware for future optimization. Each investigator working on these initiatives partners their knowledge of spectroscopy with medical staff that are experienced in the pathology of trauma care for their particular project.

Ultimately, the discoveries currently being made by these independent researchers are hoped to be brought together to produce an integrated tool that can be used to study several different types of injuries and their associated morbidities. The Advanced Surgical Camera has the potential to become a high-performance tool for combat casualty care.

High Performance Conventional Imaging—Brain Biology Machine Initiative (BBMI)

The University of Oregon is developing tools to advance the state-of-the-art in MR and EEG data processing in the areas of automatic head tissue segmentation and cortex extraction, computational head modeling, and EEG signal analysis. The tools will be internet-accessible to support distributed telemedicine applications. The University's Neuroinformatics Center and its external collaborators are developing neuroinformatics and neuromedical service products that deliver the next-generation of technology for dynamic brain evaluation and analysis.



Above: Terahertz (THz) waves have a variety of applications; they can be used specifically for subsurface imaging of tissue to depths of 1-2 millimeters with micron-level spatial resolution. THz imagers

can play a role in wound healing assessment, cancer progression tracking, soft tissue imaging, burn diagnosis, and breast cancer detection.

Right: Benefits of the University of Oregon research will include fast automatic and accurate tissue classification for identifying human head anatomy and extracting 3D cortex representations.

Medical Imaging Technologies

Computer Assisted Diagnosis (CAD)—Computer Aided Cancer Management

Despite decades of research, the five year survival rate for lung cancer remains around 16%. Advances in access to healthcare, pharmaceutical technologies and early detection are all required to boost the survival rate. CAD can provide a robust and cost-effective solution for detecting lung cancer at its earliest stages. It also offers the potential for remote monitoring of patients in rural areas by pulmonary experts along with monitoring of patients' response to chemotherapies. Researchers at the University of South Carolina are developing a multivariate statistical model of lung cancer malignancies. While further validation is required, preliminary data has shown that this approach can positively affect the accurate detection of lung cancer. It is envisioned that this software could eventually result in a routine lung cancer screening tool.

Portable Imaging—Electrical Impedance Scanning for Detection of Breast Cancer in Young Women

The current standard of care for breast cancer detection is the mammogram. While the mammogram generally offers high sensitivity and specificity for detecting breast cancer, it is uncomfortable and can produce a high rate of false negatives for women with dense breasts. This study at Walter Reed Army Medical Center (WRAMC) examined the value of using a new screening device based on electrical impedance scanning (EIS). In women aged 30 to 45, preliminary data has shown that this technique

can be available and specific for breast cancer as compared to conventional mammography. The superiority of EIS may lead to even more rapid diagnosis of breast cancer than currently available.

Image Guided Interventions—Finger-mounted Ultrasound Probe

Ultrasound represents a significant number of projects within this portfolio. Advances in ultrasound that promise to more precisely locate injuries represent life-saving technologies on the battlefield. This ultrasound probe, nicknamed the “Sonic-Eye” is finger-mounted, quickly disconnected, and can be immersed in sterilizing fluid. Still in the prototype stage, it is intended to be compatible with standard and portable ultrasound systems, which can provide high-resolution images.



The next steps for this finger-mounted ultrasound probe include testing its ability to withstand up to 200 sterilization cycles.

FAST promises to train the next generation of trauma care personnel to rapidly diagnose internal bleeding.

Focused Assessment with Sonography for Trauma (FAST)

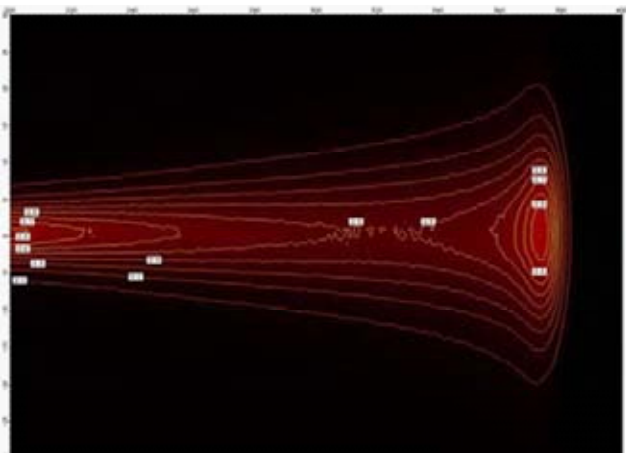
Understanding the fundamentals of ultrasound image generation and interpretation can be a daunting task. FAST represents an interactive virtual visualization system to teach transducer eye-hand coordination along with skills in image interpretation. The FAST exam is particular to detecting free intraperitoneal fluid within each of the four quadrants of the abdomen and therefore can be used to image internal bleeding. In addition to training medical personnel in the fundamentals of ultrasound, this tool could be used to provide refresher training to experts. This TATRC-funded project is developing an advanced easy-to-use, software-based strategy for teaching FAST.

Proton Beam Therapy (PBT)

External beam therapies such as Intensity Modulated Radiation Therapy (IMRT) have been shown effective against several cancers including lung, prostate and breast. Significant advances have been made over the years to more accurately plan treatments to spare benign tissues while optimally targeting ma-



lignancies. However techniques such as IMRT still have high levels of benign tissue morbidities associated with them. PBT offers a more precise form of treatment, mainly due to its lower dosimetry requirements as compared to X-rays. One unique application is the treatment of uveal melanomas, a type of eye cancer also called choroidal melanomas. Historically, these tumors were only treated by the removal of the eye. The current portfolio features two PBT projects, each committed to changing the standard of care for a plethora of diseases and conditions.



Dr. James McDonough is building a new PBT facility at the University of Pennsylvania designed to house a multi-leaf collimator for accurate dose delivery beginning in November 2009.

Teleconsultation

COL Ron Poropatich

Deployed physicians and medical technicians access medical specialists at military treatment facilities around the world using the Army Knowledge On-line (AKO) Teleconsultation Service.

AKO Teleconsultation Program

Since 2004, the AKO Consultation Service has been utilized by deployed medical providers to access expertise on a global basis. This service helps ensure that deployed forces receive the best possible medical care—no matter their location.

The AKO Teleconsultation Service is used by deployed providers needing access to military medical specialists for assistance in making a diagnosis, interpreting tests, developing treatment plans and coordinating care. Providers have used this service for treating patients as part of humanitarian or civil-affairs missions, as well as, for combat support.

Using the AKO system, providers in the field are able to enter a patient's medical history and chief complaint and specific questions for the consultant, attach digital images—such as photographs or x-rays—and route the consultation to specific experts. Currently, over 19 different types of specialties participate including dermatology, infectious disease, pulmonary medicine, orthopedics, cardiology, etc. This service offers a user-friendly mechanism to reliably communicate with experts when telecommunications infrastructure and bandwidth is limited and the location or names of available consultants across the military health system are unknown. The consult service has been embraced by deployed providers, many of whom are frequent users of the system. The simplicity of use along with the quality and timeliness of advice has been a key to its success and sustainability.



Tri-service members and humanitarian or civil-affairs mission specialty care providers use the AKO system to e-mail digital photos, like this one of a burn victim, for teleconsultation with US specialists.

Over the past four years, the AKO Teleconsultation Service has received more than 4,922 consultation requests from 1,349 different health-care providers from all branches of the military. Consults have been sent from 35 different countries and from ships at sea. To date, 68 unnecessary medical evacuations were prevented and 183 evacuations were facilitated. The average response time is five hours from submission of the consult until a consultant replies. Consultants from all services participate in the program. In 2008, a Memorandum of Agreement was signed between the US Army Medical Command and NATO for expanded use of this teleconsultation system by NATO Forces in Afghanistan.

Remote Presence

TATRC supported the demonstration of mobile robotic technology to enhance remote access to inpatient clinical settings and support medical training.

Remote Presence (RP)

RP is the use of telecommunications and mobile robotic technologies by physicians and other healthcare providers to access clinical settings like ORs and ICUs from any location, on-demand. A commercially available robot manufactured by InTouch Health®, Santa Barbara, CA provides two-way voice and video capability to support remote medical supervision and training, and expert consultation from a distance.

Using a laptop computer which has specialized software and a control stick, a clinician is able to access and remotely drive the robot from any location where internet access and sufficient bandwidth is available. Clinicians can drive the robot to the bedside using controls on the laptop to offer consultation during an emergency, conduct rounds or monitor patients, and supervise and/or train nurses and residents. The

robot's video telephonic capabilities allows doctors to check vitals, zoom in on the patient for closer physical examination or speak directly to the patient and their families or other healthcare providers.

As an unexpected benefit, MAJ Kevin Chung was able to utilize his RP7® Laptop Controller to access the Brooke Army Medical Center (BAMC) ISR robot while deployed in Iraq. In addition to continuing to care for his patients in the ISR burn unit while deployed, he was also able to coordinate care for patients being transferred from Iraq back to ISR for long-term care and facilitate a visit between a deployed Warfighter and his newborn baby delivered at BAMC.

RP holds promise for enhancing military healthcare systems by enabling medical experts to remotely participate in the delivery of healthcare and advanced medical training when and where they are needed in a high quality fashion to ensure the best possible interaction between the participants.

Right: Using a laptop computer which has specialized software and a control-stick, MAJ Kevin Chung is able to access and drive the RP-7 robot (left) from any remote location where internet access and sufficient bandwidth is available.



Infectious disease programs focused on the identification, characterization, and medical countermeasures to protect against endemic threats. These efforts augmented core programs by exploring novel and higher risk approaches with the possibility of major medical advances.

Human *in vitro* Lung Model for Infectious Diseases

University of Central Florida and VaxDesign researchers are developing *in vitro* (laboratory grown) models of human lung tissue to improve our understanding of how tissue cells interact with infectious agents. The *in vitro* model will provide a reliable and repeatable method for evaluating a human immune response in the laboratory. The model will be a way to test vaccines and other immune-related drugs rapidly, inexpensively and with consistent reproducibility by replicating the human immune response. It is the first real alternative to an animal model for biomedical research at the system level and will open the door to new methods of vaccine and immunotherapy development.



Figure A

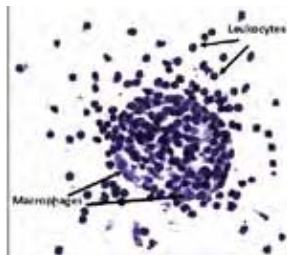
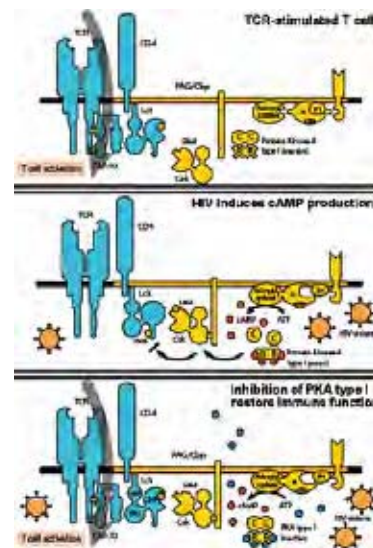


Figure B

The researchers have developed a model of lung tissue infected by tuberculosis (TB) in its dormant state. Figure A displays an aggregation of leukocytes and macrophages into granulomas that contain the infection. Figure B displays leukocytes surrounding infected macrophages to form a granuloma.

Immunostimulating HIV Therapy Program

Lauras AS is a Norwegian biotechnology company involved in developing immune-stimulating therapies for HIV and other immunodeficiency diseases. Lauras AS key discoveries are based on findings that a signal substance (cAMP) located inside white blood cells (T cells) can cause immunodeficiency in HIV-infected patients. This signal substance is increased in T cells from these patients. Drugs that either reduce the production or inhibit the action of cAMP may improve immune function in HIV-infected patients.



The signal substance cAMP is increased in T cells from HIV-infected patients (top and middle panel). Drugs that either reduce the production or inhibit the action of this signal substance will improve the immune function in HIV-infected patients (bottom panel).

Organisms like Candida (shown) and Staph are so difficult to treat because of their ability to rapidly evolve drug resistant forms.

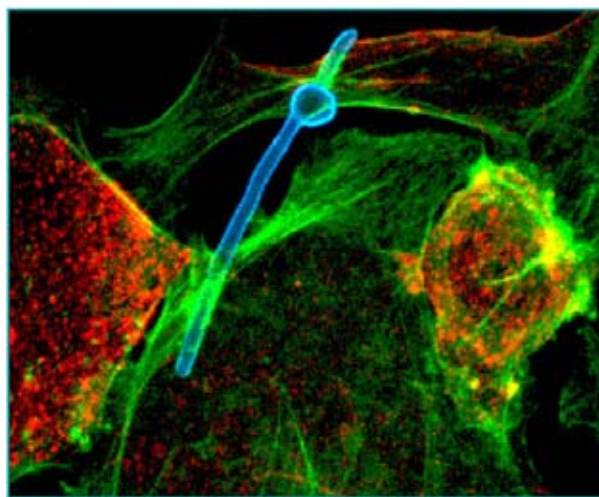
Candida/Staphylococcus Vaccine

NovaDigm Therapeutics in collaboration with TATRC, LA BioMed and University of North Dakota Research Foundation is developing a vaccine to prevent infection by both *Candida albicans* (a yeast or fungus found naturally in our environment) and *Staphylococcus aureus* (Staph). Warfighters' living and working conditions, whether in training or deployed, place them at increased risk of developing systemic infections from these organisms. These infections frequently lead to prolonged hospitalization, amputation, or even death.

NovaDigm scientists have demonstrated a vaccine that is immunogenic in animals and protects them against otherwise lethal infections by both *Candida* and *Staph*. NovaDigm is performing the necessary work to begin testing the vaccine in clinical trials, in early 2010.

Papaya Tree Genome Project

The papaya tree genome was sequenced in 2008 through the University of Hawaii Center for Genomics, Proteomics and Bioinformatics Research Initiative. The papaya is an important agricultural product in Hawaii, a highly nutritious fruit, and a key source of papain, a proteolytic digestive enzyme. In the early 1990s, Papaya Ring-spot Virus (PRSV) devastated the Hawaiian papaya crop. A genetically modified transgenic strain ("SunUp") that resists the virus was then produced and crop production



is now recovering. The Center led the efforts to sequence the genome of the new SunUp strain. The sequence, which spells out more than 90 percent of SunUp's genetic code, was the first to be derived from a genetically modified plant. From a homeland defense perspective, the importance of food security is illustrated as similar to PRSV, other bio-engineered weaponized pathogens could threaten vital food sources. The expertise and procedures developed will be essential in devising defensive measures, particularly as our food sources come from ever fewer but more productive plant clones. An understanding of genetic sequences will help identify candidate genes for developing pathogen, natural disease and insect resistant varieties to preserve the food supply.

The 372 million bases of the SunUp genome were sequenced over a two year period using a whole genome shotgun approach. The findings appeared as the cover article in the journal Nature on April 24, 2008. This effort was partially supported through the TATRC Hui since 2004. It illustrates the growth of biotechnology research in Hawaii, which is important to national defense initiatives requiring computational biology and genomics capabilities.

Because the papaya tree genome was sequenced from a genetically modified variety, it provides the most detailed picture available of the impact of particle bombardment on genome structure and function.

Blood Safety and Supply

Mr. Wilbur Malloy

Major advances were made in three important areas of Blood Safety and Supply—a new approach to rapid blood screening will provide on-the-spot blood typing; two different Pathogen Inactivation technologies will improve blood product safety; and a blood warmer that raises core body temperature of hypothermic patients during severe hemorrhage.

Active Thermal Resuscitation

Hypothermia and shock are common clinical problems experienced by those wounded in combat. Previous efforts have led to the development of a highly portable system to treat hypothermia in the field.

The system warms a patient's blood and then returns it to the patient, however it requires access to a major artery to drive the flow of blood through the warming system. The current rugged, miniaturized prototype weighs less

than one kilogram and uses arterial and venous femoral cannulae to warm a casualty's blood by ten degrees Celsius over core temperature, with a maximum fluid delivery rate of about 200 cc/minute. The goal of the current project is to integrate a small, highly-efficient pump into the



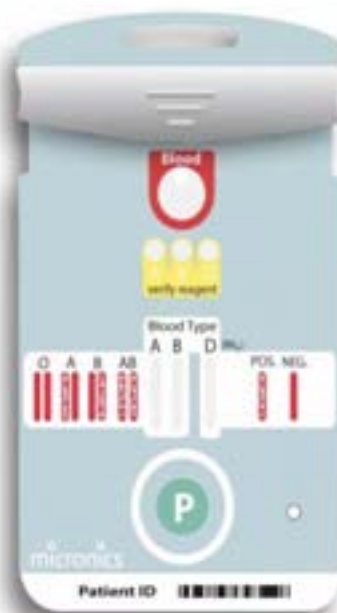
The goal is to integrate a tiny efficient pump into this prototype blood warming system, developed with SBIR funding, for treatment of hypothermia.

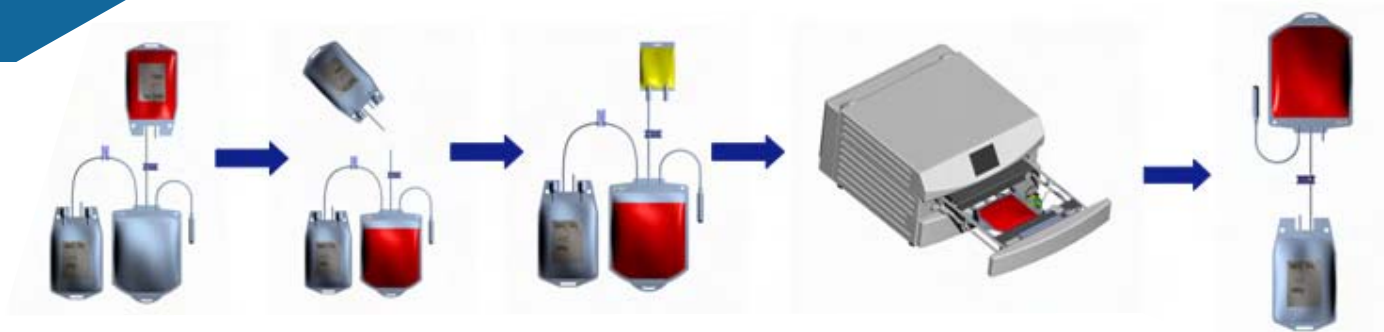
system to allow active thermal resuscitation in the field using a single femoral vein catheter. This will both eliminate the need for arterial access and also will allow the system to function as a rapid infuser.

Blood Transfusion Safety

Current blood screening methods are labor and time intensive and results are produced remote from the collection center and up to hours after the blood screening is performed. DoD has an unmet need for a fieldable, stable, cost effective and disposable means of quickly and accurately screening blood donors to determine their blood type. Fast turn-around screening is needed to register new donors and schedule blood draws in response to emergent medical needs. TATRC and Micronics are col-

Used in the field, this blood screening device will indicate blood type and Rh factor in less than 30 seconds.





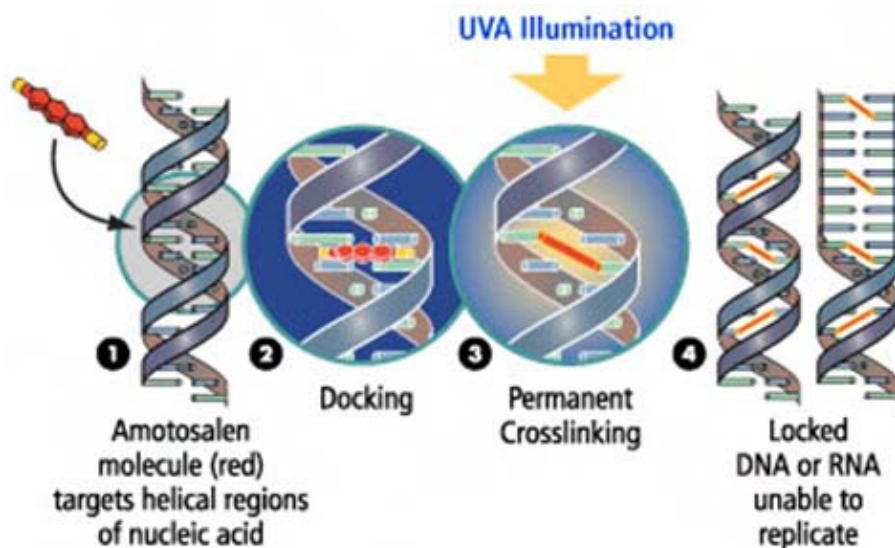
Abbreviated pathogen inactivation process flow diagram for treatment of whole blood with the Mirasol™ System. This illustrates the transfer of whole blood to the illumination/storage set, removal of the whole blood bag, the addition of riboflavin solution to the illumination bag, placement of the illumination/storage set in the illuminator, and draining of the treated whole blood into the storage bag after illumination.

laborating to develop a disposable, credit-card sized, manually operated, single use device to determine the ABO blood type and Rh factor from a single drop of blood in less than 30 seconds. After the completion of validation studies and approval by the FDA, Micronics anticipates introducing the commercial injection mold product in Fall 2009.

Pathogen Inactivation (PI)

PI is an advanced technology process to improve the safety of blood products (whole blood, red blood cells, platelets, and plasma), wherein the number of pathogens (bacteria, parasites, and viruses) are inactivated and/or reduced, and white cells are destroyed. TATRC is actively supporting two of the recognized leading researchers in this new technology. Cardian BCT Biotechnologies incorporates the use of Mirasol™ (riboflavin) in the presence of UV light to inactivate pathogens by inducing a chemical reaction within the functional groups of nucleic acids, making pathogens unable to replicate and

thus harmless. Cerus Corporation utilizes Intercept™ (a patented solution) to crosslink the nucleic acids present in susceptible pathogens thus blocking replication and preventing proliferation. Both processes also inactivate the donor's white blood cells that could pose risks for transfusion recipients. These approaches when approved by the FDA will revolutionize the safety of blood products and become a force multiplier in combat casualty care and force health protection worldwide.



A process is being developed to inactivate pathogens in whole blood by inducing a chemical reaction in their nucleic acids and rendering them harmless.

Training and equipment for emergency tracheotomies and compartment syndrome were developed with rapid turnaround to serve the current war effort. These simple lifesaving products required no new scientific discovery.

Universal Cricothyrotomy Kit

Safe, fast and effective emergency cricothyrotomies (tracheotomies) in support of injured Warriors in various field environments are currently difficult to perform. This is due to:

- inadequate lighting
- tissue incisions that are accidentally made too deep (opening both the trachea and esophageal tissue)
- lack of easy access to required components
- the wide diversity of products and components dispersed among various medical field kits

A single kit that contains all the necessary components, allows for one-hand execution of a safe depth incision and tissue-spreading, and provides infrared (IR) lighting for use in low



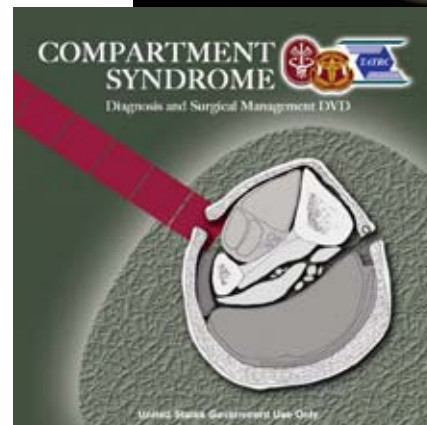
The Universal Cricothyrotomy Kit's capabilities are far superior to current capability in field execution as they provide for one-hand execution of a safe depth incision and tissue-spreading.

Subject matter experts from the US Army, Air Force, and Navy worked with TATRC, Touch of Life, and the American Academy of Orthopedic Surgeons to develop video-based training of a fasciotomy procedure for the US Army Institute of Surgical Research. The DVD addressed diagnosis and surgical management for CS to reduce tissue damage.

light conditions will significantly improve the delivery of life-saving emergency cricothyrotomies, both in the field of combat and under other disaster situations. This was developed in support of Navy and Marine Corps requirements.

Prevention of Compartment Syndrome with Ultrafiltration Catheters

Trauma to the limbs, or extremities, has always been common among injured Warfighters. The closely associated Compartment Syndrome (CS), in which elevated intramuscular pressure can cause tissue ischemia (a shortage of blood supply to an organ) is a significant source of morbidity. If left untreated, CS can result in permanent muscle and nerve injury, rhabdomy-



Inside a Forward Resuscitative Surgery System tent, Cmdr. Joe Taddeo (left) instructs corpsmen with 3rd Medical Battalion how to treat a casualty during a mass-casualty exercise. Photo by Lance Cpl. Bryan A. Peterson



olysis and renal failure, and death. Modern body armor and head protection, combined with improved evacuation and trauma care, has increased the number of surviving Warfighters with extremity injury. One consequence of the recent trend in point-of-injury trauma care is the increased use of tourniquets. Although life-saving, tourniquet use has further increased the risk of CS. Additionally, there are 150,000 civilian tibia fracture patients at risk of CS each year in the United States.

Twin Star Medical has developed an ultrafiltration catheter system to remove interstitial fluid and monitor pressure from muscle compartments in patients at risk for developing CS. In preclinical studies, ultrafiltration has been shown to reduce edema, reduce tissue pressure and improve tissue viability.

Compartment Syndrome Training

When CS occurs following trauma, the affected muscle tissue swells and puts intense compression on nearby nerves and blood vessels, causing significant damage and potential death. One way to relieve the pressure and prevent compartment syndrome is to perform a fasciotomy, a surgical procedure that involves making long incisions through the skin and underlying fascia on either side of the bone. Recognizing this as a critical issue, TATRC officials authored a research topic, which was approved by the Army SBIR program. Touch of Life, Aurora, CO is close to the end of a 2-year, Phase II effort to develop a simulation-based training system. The ob-

jective is to train medics who may not normally do fasciotomy procedures to do them correctly. In response to a request from the ISR for an interim solution while the simulator is being completed, a training DVD was produced by Touch of Life, with the assistance of the American Academy of Orthopaedic Surgeons. It is now being distributed by ISR.



Touch of Life, Aurora, CO is developing a simulator system for training medics in the treatment of Compartment Syndrome.

Hospital of the Future

Amy Nyswaner, RN, BSN

The Hospital of the Future (HOF) initiative is intended to improve patient safety, hospital design and interoperability. Construction of new military medical facilities provides opportunities for the military to be early adopters of revolutionary systems in facilities.

Technologies will become ever more important in medicine and the HOF, both military and civilian, and for both acute medical care and care of complex, chronic diseases. Not only will new technologies advance medicine but if used properly they will improve quality and safety and function to lower the cost of care. Further, technologies can potentially offset the shortage of healthcare professionals.

TATRC's vision for the HOF is to be a dominant agent of change to transform health care to a safe, cost effective, predictive, preventative, evidence based, and participatory system.

The HOF initiative leverages the efforts of existing HOF community to place existing and future technologies into current and planned military medical facilities in support of the Army's Health Facilities Planning Agency and DoD Patient Safety Program.

HOF Interoperability

Interoperability will enable the creation of integrated error-resistant medical systems to support advanced capabilities such as automated system readiness assessment; physiologic closed loop control of medication delivery, ventilation, and fluid delivery; decision support; safety interlocks; smart alarms; monitoring of device performance; plug-and-play modularity to support "hot swapping" of replacement devices and selection of "best of breed" components from competitive sources; comprehensive data collection (like a "flight data recorder") for the analysis of near-misses and adverse events; enhanced disaster preparedness and response capabilities; and other innovations to improve patient safety, treatment efficacy, and workflow efficiency. These improvements in workflow will reduce medical errors and healthcare costs to the benefit of patients throughout the continuum of care.



Ft. Belvoir Hospital is an example of a new facility that has planned for technologies developed through TATRC-sponsored programs such as a surgical simulation and training suite. (Artist rendering)

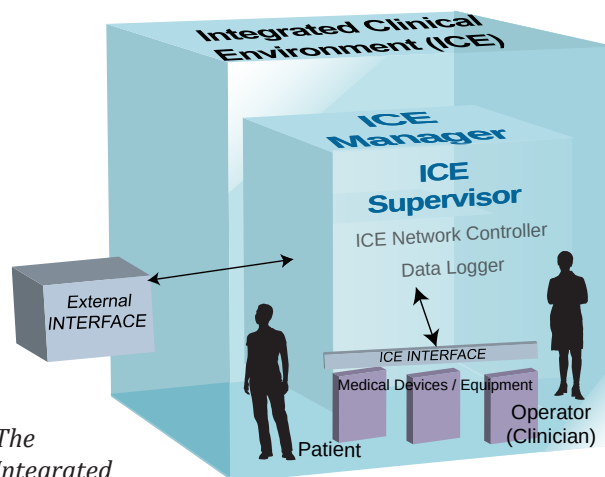
Simulation training research involving artificial intelligence (the Maryland Virtual patient) helps surgeons to better treat esophageal diseases.



The Medical Device Plug-and-Play program at Massachusetts General Hospital (MGH) and CIMIT serves as a catalyst for engaging other organizations (e.g. Moberg Research Inc, Live-Data Inc, and other partners) to work together to accelerate the achievement of interoperability. Medical Device Plug-and-Play convened a team from MGH/Partners HealthCare System, Johns Hopkins Medicine, and Kaiser Permanente to develop sharable contracting language for device procurement – this was released in October 2008 as Medical Device Free Interoperability Requirements for the Enterprise (MD FIRE). Use of such contracting language will pave the way for future hospitals to work with vendors to make interoperability a reality.

A set of interoperability standards called the Integrated Clinical Environment (ICE) is under development in ASTM International, led by the Medical Device Plug-and-Play program. Part I of the multi-part

ICE standard is in final approval stage. ICE will enable standards-based medical device system integration for high-acuity patient care. Moreover, TATRC is funding SBIR awards to productize enabling components of the ICE.



The Integrated Clinical Environment enables a patient-centric approach to patient care.



At the CIMIT Innovation Congress 2008, collaborators met from 5 institutions. This demonstration is of a prototype ICE-standard compliant plug-and-play network for medical device use.

Hospital of the Future

Robotic Telesurgery Research

This research focuses on the design and construction of an *in vivo* robot for surgical applications. This robot can be placed entirely within the abdominal cavity and provide real-time video to a remote surgeon. This will allow the remote surgeon to diagnose and aid in the triage of the patient. The system could be of great use in Single Port Access Surgery and Natural Orifice Transluminal Endoscopic Surgery (NOTES). The team at Nebraska consists of surgeons and engineers working together to advance the technology. They have produced several prototypes to date, and are planning to conduct animal studies in the next phase of research.

Spartanburg Regional Health System

TATRC is overseeing CSI Project HOF at Spartanburg Regional Health System in Spartanburg South Carolina. In part one, Spartanburg Regional Health System has created a “hospital room of the future” in a laboratory environment to test new architectural, equipment design, and workflow integration. In part two, DOD will test the ability to connect the Spartanburg Regional Health System McKesson

Horizon EHR to the DOD/VHA Bidirectional Health Information Exchange and to the adaptor to the gateway between the Nationwide Health Information Network (NIHN) and the Federal Health Architecture Systems.

Innovations in the Surgical Environment Research Program

Recently, the University of Maryland Innovations in the Surgical Environment Research Program made an important shift in their research paradigm from Operating Room of the Future to Innovations in the Surgical Environment.

The annual meeting of the research program was expanded to include international and national experts to highlight the four research pillars: Informatics, Smart Image, Simulation and Ergonomics/Human Factors. The theme of “Lessons Learned from

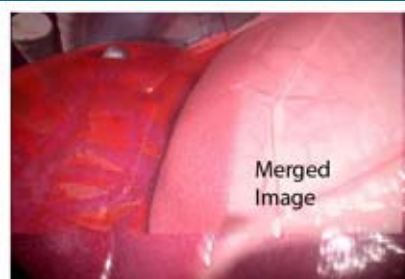
High Stakes Environments” included formal presentations by experienced aviators and surgeons, and by a keynote address from a surgeon/astronaut, Dr. David Williams.



Surgeons and aviators assembled to share lessons learned from training in high-stakes, high-performance environments, as part of the University of Maryland Innovations in the Surgical Environment program.

Telerobotics and Advanced Minimally Invasive Surgery (TAMIS) is the military's only surgical robotics program. At WRAMC, two integrated operating rooms have been constructed which support robotics, telesurgery, and minimally invasive surgical applications.





Being able to see underlying vessels and other internal structures before making a dissection has been a long-standing need of minimally invasive surgeons. The Smart Image project seeks to demonstrate the technical feasibility of live augmented reality—the fusion of instantaneous CT-generated views with laparoscopic views—allowing internal structures that are absent in laparoscopic views to be visualized.

Simulation Training

Research in simulation training included the refinement of a cognitive simulation system for the treatment of six esophageal diseases pertinent to clinical medicine through the application of artificial intelligence (the Maryland Virtual patient) and the study of multi-modal applications of physical models and virtual reality for the training of surgeons.

REVEAL: Reconstruction, Enhancement, Visualization, and Ergonomic Assessment for Laparoscopic Surgery

The goal of REVEAL is to develop and test new technologies that would enable more surgeons to attain and continue to practice (without injury or pain) high levels of skill in minimally invasive surgery, patient position, technology configuration, and instrument design. This project

deployed a complete flexible display system and performed physical and cognitive ergonomic tests in that environment.

Center for Advanced Surgical and Interventional Technology (CASIT)

CASIT's mission is to define and advance the state-of-the-art of surgical and interventional technology and to revolutionize surgical education and training.

CASIT was originally designed as a test bed for developing operating rooms, procedure rooms and interventional rooms for the new UCLA Ronald Reagan Hospital. The new hospital opened this year with *truly new* medical technology. As evaluation of instrumentation proceeded, it became clear that this laboratory provided critical information to optimize the design of the new facilities in terms of equipment, space requirements and efficiency. UCLA set aside space for CASIT to continue development of new instrumentation and procedures in the new hospital.



The REVEAL project used existing technology and built new techniques as needed to acquire crucial ergonomic data relative to key factors of patient position, technology configuration and instrument design.

Each of the military services has worked on development of a neuropsychological test battery for decades, culminating with the Automated Neuropsychological Assessment Metrics (ANAM). In 2008, the services were directed to conduct baseline testing using an abbreviated form (ANAM4). TATRC played a vital role in readying this first version of a neuropsychological test system for mass military use.

Research conducted under this portfolio examines a wide-range of military relevant problems. Among the outcomes sought are means to assess risk factors in operational environments for nervous system function, means of assessing neurological performance in operational environments, identification of biomarkers of neurobehavioral function, development and optimization of neuroprotectants to treat brain and spinal cord injuries, and development of nonpharmaceutical aids to enhance resistance to neurological risk factors.

Automated Neuropsychological Assessment Metrics (ANAM) Instrument Functional Brain Testing

Dr. Kirby Gilliland and Dr. Robert Schlegel at The University of Oklahoma's Center for the Study of Human Operator Performance in collaboration with other DOD elements, optimized a neuropsychological battery for assessment of Warfighter neurobehavioral function. The ANAM instrument is a library of over 30 computer-based tests of specific neuropsychological domains (e.g. short-term memory, long-term memory, executive function, logical reasoning, complex processing, mathematical reasoning).

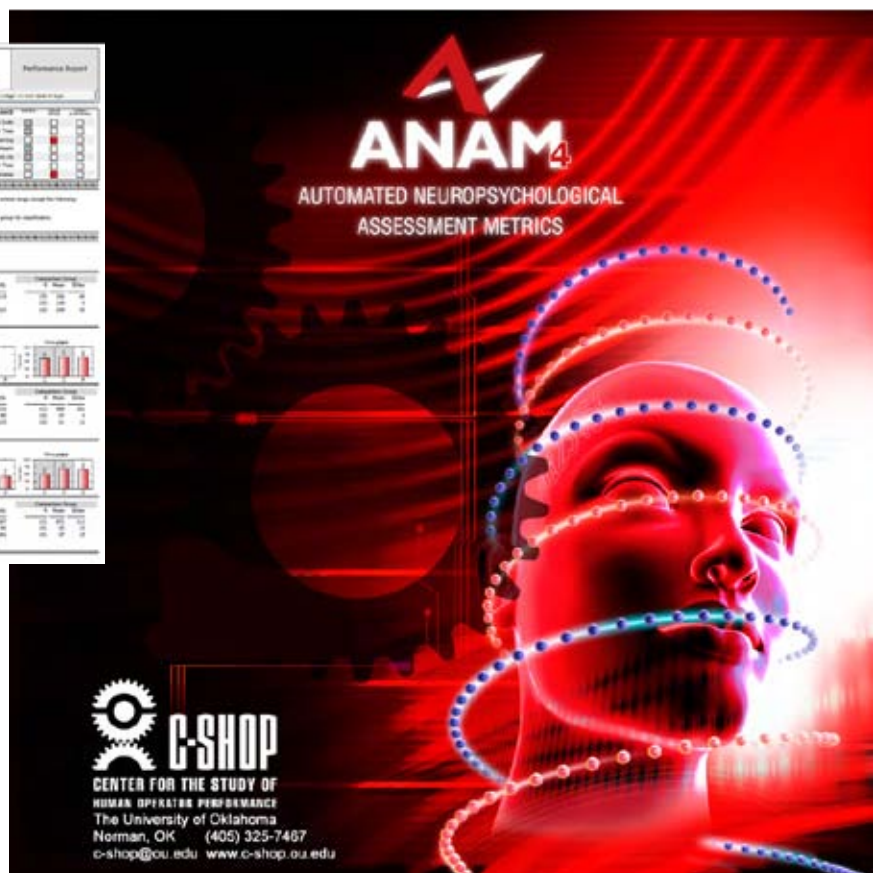
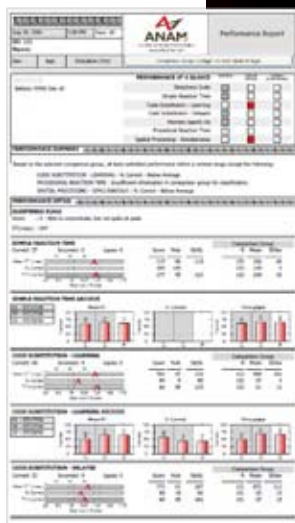
The ANAM is the result of some 30 years of development by the military services. The combination of distinctive test modules, constructed for sensitivity and specificity to individual neuropsychological domains, permits construction of tests for various assessment purposes. Assessment batteries are available for general neuropsychological assessment as well as for standardized assessment of neuropsychological alterations consequent to neurodegenerative disease or deleterious effects of exposure to pharmaceutical or environmental chemicals.



The ANAM4 battery permits determination of an initial baseline function of an individual's performance prior to deployment. Should an injury occur, post-injury performance assessment can be compared to the baseline to determine alteration in specific neuropsychological functions. The comparison will be invaluable as an aid to determining specific problems facing the injured individual and in developing rehabilitative programs.

As of August 2008, all service personnel deployed overseas receive baseline neuropsychological assessment – a policy which provides a means of both safe-guarding the long-term health and welfare of service personnel as well as providing objective criteria for evaluating mission resources and maintaining force health protection.

The ANAM questionnaire is administered confidentially to Warfighters prior to deployment. It provides a baseline indication of a Warfighter's neuropsychological status that can be used for comparison if brain injury is suspected.



“In an effort to understand the long-term outcomes of traumatic brain injury, including consequences that might be related to blast, the committee recommends that all deployed military personnel undergo predeployment neurocognitive testing.”

—Institute of Medicine Committee on
Traumatic Brain Injury
Gulf War and Health: volume 7:
Long-Term Consequences of
Traumatic Brain Injury
p. 376, 2008



The Neurotoxin Exposure Treatment (Parkinson's) Research Program (NETRP)

Parkinson's Disease (PD) provides a solvable model for a better understanding of a wide range of neurological dysfunction, including important threats to Warfighters: suspected or known health threats include head impact, neurotoxic chemicals, psychological trauma/stress, and neurotropic viruses.

Data from prior projects currently supports efforts to identify a panel of peripheral blood markers of brain injury and provided the basis for the ANAM4 test battery, now used for pre-deployment neuropsychological testing of every deployed service member. Current studies enhance efforts at disease prevention, diagnosis and treatment of brain injury useful for Parkinson's patients, the general public and the military Warfighter.

Prevention: Studies in Florida and Georgia demonstrated alterations in dopamine transporter protein correlated with behavioral effects in acute exposure to permethrin, a pesticide used by DOD to protect against insect disease vectors; but also demonstrated compensation with continued exposure, suggesting that permethrin is one of the least harmful of available insect repellents.

Preliminary data on exercise-induced alterations in dopaminergic activity from the University of Southern California suggest mechanisms for the neuroprotective role of

exercise, a non-pharmaceutical means of maintaining performance and health from military operational risks.

Neurological studies in Hawaii revealed correlations between the retention in the brain of three World War II era pesticides and clinical symptoms, providing evidence for structure-function relationships of neurotoxic chemicals and opening an avenue to identify mechanisms of specific environmental risk. Registries initiated in California and Alaska will expand knowledge of environmental chemical exposures and neurodegenerative disease risks; while studies at Rochester University, the University of Pennsylvania and in New Haven Connecticut will correlate clinical symptoms, alterations in neurobehavioral function and human imaging outcomes to link population exposure risks, clinical outcomes and biologic mechanisms of disease initiation and progression.

Diagnosis: Studies at Weill Medical College of Cornell University demonstrated the ability to separate PD patients and controls based on serum profiles using high performance liquid chromatography coupled to electrochemical coulometric array detection. Separate



Some pesticides are a risk factor for development of PD. The NETRP established that permethrins in current military use are among the safest available pesticides to protect against military-relevant vector borne diseases.

NACTN staff receiving standardized assessment training with the assistance of a spinal cord injured patient volunteer at Frazier Rehab Institute, Louisville, KY. (Courtesy of Christopher Reeve Foundation)



studies reported by investigators at Georgetown University demonstrated the ability, based on principal component analysis of white blood cell transcripts, to similarly separate PD and control populations. Additional studies are in progress to identify transcripts specific for particular brain cell types and regions for use in developing markers specific for injury in specific central nervous system regions. Links between central and peripheral alterations will also be examined to improve clinical cohort constructs and develop strategies to identify treatment interventions. These studies, correlated with imaging using newly derived ligands of CNS neurotransmitter and inflammatory alteration should be valuable aids in diagnosis and treatment of the injured Warfighter.

Treatment: Three new categories of drugs are being developed at Intra-Cellular Therapeutics, Inc, supported by funding from NETRP and PD community partners. The compounds provide pharmaceutical means for treatment of sleep irregularities, anxiety/stress dysfunctions, depression and a candidate for improvement of brain executive function. These have been developed on the basis of new understanding of neuronal biochemical pathways from funded programs at leading universities and offer the promise of selective therapeutic treatments for co-morbidities associated with PD as well as important applications for treatment of injured service members.

NACTN data entry forms like these are resulting in rigorous clinical trials of spinal cord injury treatments. (Courtesy of Christopher Reeve Foundation)



The Christopher Reeve Foundation—North American Clinical Trials Network (NACTN)

NACTN, led by Robert Grossman, MD, was created by the Christopher Reeve Foundation in 2004 to conduct clinical trials of promising therapies for spinal cord injury. It is a network of hospitals that is enrolling newly injured patients into a data registry which relies on standard definitions and protocols, thus providing the infrastructure and expertise necessary to conduct trials of therapy for spinal cord injury. NACTN organized a Phase I clinical trial, "Safety and Pharmacokinetics of Riluzole in Patients with Traumatic Acute Spinal Cord Injury." The master protocol and informed consent are under review by the Army Human Subjects of Research Review Board.

NACTN consulted closely with Novartis Pharmaceuticals in the development of the company's anti-Nogo antibody protocol for acute spinal cord injury. Dr. Grossman was invited by

Continued on next page.

Novartis to represent the United States and Dr. Michael Fehlings, University of Toronto, to represent Canada at a world meeting in Zurich to participate in the writing of the Phase II anti-Nogo protocol.

Innovative Treatment of TBI via Regeneration of Neuronal Microtubules

TATRC is working with MAPREG, a start-up biotechnology company created by Professor Etienne E. Baulieu and his research team, on a novel mechanism for the protection and repair of nerve connections. This innovative treatment for spinal cord and traumatic brain injuries has shown considerable therapeutic potential in animal models. The research also involves the Institut de Médecine Navale du Service de Santé des Armées in Toulon, France.

In acute brain injuries, the neuronal microtubules, a major component of the neuronal cytoskeleton, depolymerize and the neuron networks become disorganized. MAPREG has developed a synthetic neurosteroid, MAP4343, which stimulates microtubule assembly. It has a proven effectiveness in the experimental treat-

ment of spinal cord injury and has shown preliminary effectiveness in treating TBI. The compound is injectable and is



Above: Specific brain regions of interest, such as the red section in the image can be analyzed for metabolic changes that may indicate mild TBI.

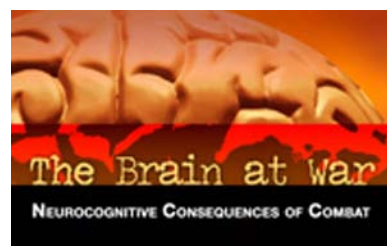


not metabolized into other hormonally active steroids. No other products are as active in animal models as MAP4343. This is a completely new mechanism of steroid action representing a potentially important breakthrough in neuroprotection.

DOD-VA-NCIRE Neuroscience Center of Excellence

The Northern California Institute for Research and Education (NCIRE) projects are focused on PTSD/TBI and other behavioral pathologies of war, neurodegenerative diseases, and neuroimaging. NCIRE funds peer-reviewed projects performed by clinicians and scientists affiliated with the San Francisco VA Medical Center and the University of California at San Francisco in the DOD-VA Neuroscience Center of Excellence.

Examples include the demonstration of metabolic derangements and subtle structural alterations of mild TBI. This work is expected to lead to new imaging and biochemical biomarkers for mild TBI. A similar project is researching biomarkers for targeted treatment of PTSD.



NCIRE hosted "The Brain at War: Neurocognitive Consequences on Combat", symposium at the San Francisco VA Medical Center. The meeting brought together national leaders and clinicians in PTSD/TBI research.

Left: Dark Horse medics carry a casualty to a UH-60 Black Hawk during 4th Squadron, 9th Cavalry Regiment, 2nd Brigade Combat Team, 1st Cavalry's Air Medical Evacuation at the Expert Field Medical Badge site, July 24, 2008.

Traumatic Brain Injury Initiatives

Dr. Francis McVeigh

Traumatic brain injury is a key concern following exposure to blast from IEDs, the signature weapon of this war. The effectiveness of modern body armor, combined with the devastating force of weapons used against the Warfighter, has led to increased survivability but also concomitant increases in severe injuries to the central and peripheral nervous system.

Recent advances in prevention, diagnostics, therapeutics and rehabilitation will be leveraged from ongoing research in the academic, industry and government sectors. Biomarkers, imaging technologies and neuropsychologic test batteries will be refined to improve diagnostics and prognostics. Study of the pathophysiology of neurotrauma from the sub-cellular to whole body will enable the development of novel therapies. Advances in neuro-protection strategies, regenerative medicine and materials science will enable retention or restoration of function. Advances in brain and nerve-machine interface technologies will enable the development of advanced neuroprosthetics to replace lost limbs, restore sensory function such as vision and replace damaged portions of the central and peripheral nervous system.

TATRC manages over \$17M in Program 8 (operation and maintenance) funding dedicated to expanding telemedicine applications for the diagnosis and management of TBI across the



Teleneurosurgery at Landstuhl Regional Medical Center, Germany. (L to R) CDR Ken Green, Team Communication representative and CONUS program coordinator for RP-7 initiative; COL Ron Poropatich Army Telemedicine and Informatics Consultant and TATRC Deputy Director LTC (P) Rocco Armonda, USUHS grad ('90) and Neurosurgeon Subject Matter Expert for the project.

MHS. Examples of Program 8 projects include establishment of a Tele-TBI network to expand the reach of military TBI care teams to geographically isolated or small posts, to include interactions with community based healthcare organizations that can reach Guard and Reserve service members.

AMEDD-Wide Regional Medical Commands' Initiative

The AMEDD-wide Regional Medical Commands' Tele-TBI Project will put into place a personnel and equipment infrastructure that will serve as the foundation for providing tele-TBI care. It is an effort to develop a tele-health network infrastructure throughout five RMCs in a coordinated, collaborative method. Each region will position telemedicine equipment and support personnel in locations where service members with TBI can receive maximum access to specialty service.

The business process for these programs will leverage best practices of existing programs, but expand them appropriately for widespread implementation. TATRC

Continued on next page

Traumatic Brain Injury Initiatives

has been spearheading this effort, but will work closely with the DoD Centers of Excellence for PH/TBI's Telehealth and Technology (T2) Directorate, AMEDD's PTSD/TBI personnel for long term oversight of this tele-health network. Under this effort patients will receive access to TBI related specialty care.

TBI related specialty care includes:

- Auditory/Vestibular Care
- Behavioral Health/ Psychological Health
- Neurology/Neurosurgery Specialties

- Provider Education
- Rehabilitation

AMEDD RMC's benefits include:

- Connect Warfighters to specialists
- Minimize travel time
- Provide quicker assessments
- Reduce referrals

Cell Phone Initiative

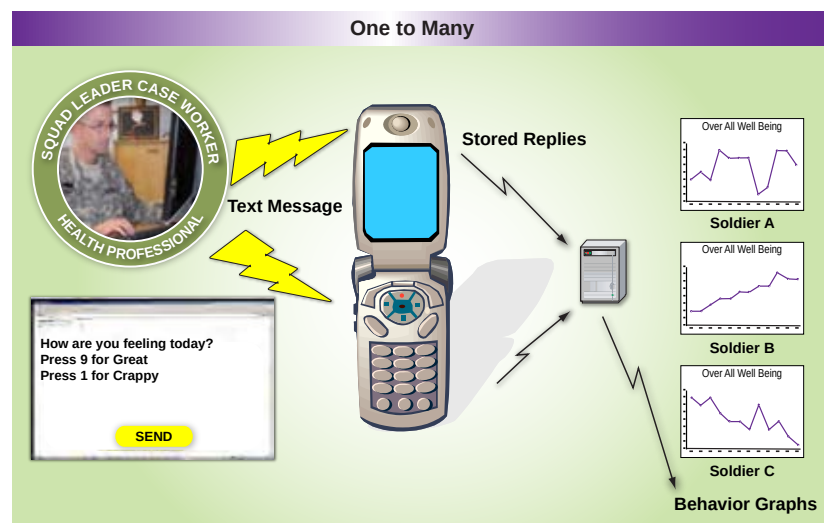
The Tele-TBI Cell Phone Initiative is a project leveraging cell phone data exchanges between patients and providers for the expressed purpose of modifying behaviors and improving clinical outcomes.

Once an ideal implementation process has been established, it will be expanded to additional locations and ultimately Army wide.

The Community Based Warrior Transit Units (CBWTUs) Cell Phone Project will create a two-way means of communication between the Warfighters and their families with the CBWTU's platoon sergeants and nurse case managers- utilizing a web interface to initiate and manage messages to the Warfighters' personal cell phones. The program will utilize the service member's existing cell phone and service provider to receive text messages and return simple data exchanges. The text messages will be generated from a secure web-based platform where members of the clinical coordination team can enter in specific notifications, reminders and

These 8 CBWTU locations coordinate care for returning National Guard and Reservists. The Tele-TBI Cell Phone project will be conducted in phases. Phase I will be at the IL, MA and VA, Phase II at the NARMC (IL, MA, & VA) and SERMC (FL and AL), and Phase III will potentially include CA and UT.

Map of Community Based Warrior Transit Units (CBWTUs)



Overarching TATRC Tele-TBI initiatives include the use of cell phones to connect providers with returned military in need of assistance.



Using the patient's existing cell phone, a web-based software platform sends & receives information between the Case Manager & TBI patients. The intent is to augment care provided by the Case Managers using the patient's self-reported data which is automatically sent back to the web server.

AMEDD Transcranial Doppler (TCD) Program

The AMEDD TCD Ultrasound Monitoring Program for Patients with TBI is a part of the OTSG's overall TBI Action Plan. Severe TBI, especially if caused by an explosive blast, can cause a cerebral vasospasm. Over the past 5 years, approximately 30% of these wartime severe TBI patients then experienced cerebral ischemia as a secondary effect of the vasospasm. The TCD brain ultrasound is a safe, noninvasive, and repeatable procedure to assess and monitor cerebral vasospasm. It will be used to prevent patients from suffering further ischemic injury to the brain.



Dr. Rocco Armonda performs a TCD study on a TBI patient at NNM. The patient sustained a head injury following an explosion in Iraq. The purpose of this TCD study was to determine impact of atmospheric pressure on the patient's cerebrovascular structure following a craniectomy.

This program will expand the reach of neuro-critical care assets through existing teleneurosurgery program by building a network across military treatment facilities to allow capture of vital TCD ultrasound and other neuro-critical care data necessary for rapid and comprehensive response to neurotrauma. The program has been implemented at WRAMC and NNM and is slated to expand to BAMC/Wilford Hall. This tri-service approach is designed to focus on three direct care components: identifying, treating, and preventing secondary insults to the brain. In the program's first 3 months, the use of TCD has contributed to significant alterations in the clinical management of 27% of the patients studied, demonstrating its early utility and impact on the management of neurotrauma.

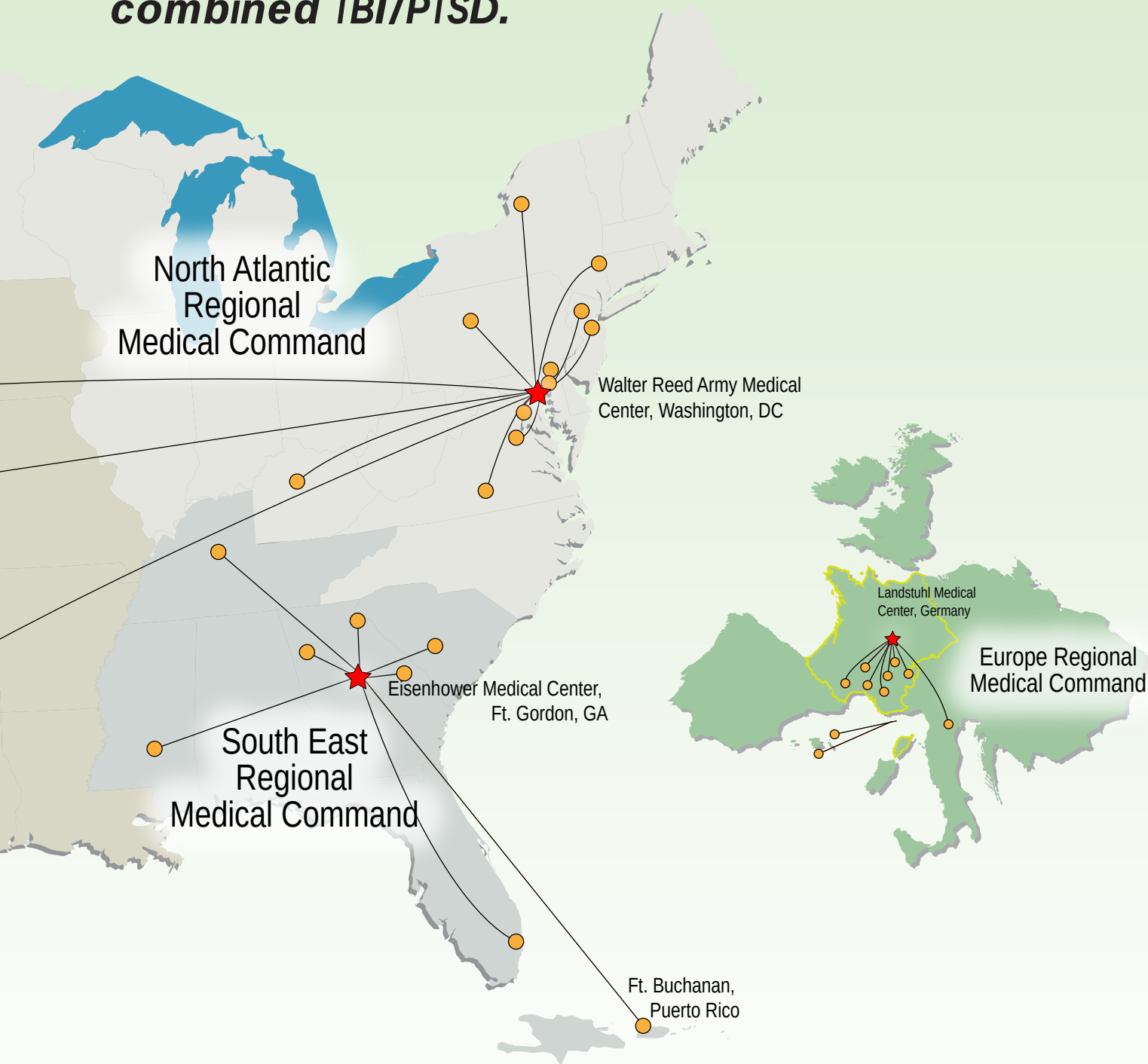
questionnaires that are scheduled at predetermined intervals. The patient's self reported response (typically a simple numerical response) will return to the secure web server for trend analysis of patient responses. Providers will be able to analyze utilization, trends, results, and outliers and will also have the ability to "push" messages out on an individual and group basis. Capabilities include an encrypted HIPAA compliant system that provides personal privacy and secure bi-directional communication.

To evaluate the impact of the Tele-TBI Cell Phone Initiative, a systematic, phased approach will be implemented to assess how cell phone data exchange technology can be utilized to improve efficiencies of care within a performance improvement plan. Furthermore, the project will assess the technology impact on patient behaviors and provider decisions points in a research study. This project is being conducted by TATRC in partnership with subject matter experts from the North Atlantic Regional Medical Command (RMC), Southeast RMC, Defense Veterans Brain Injury Center, the Sister Kenny Research Center, and the Minneapolis Veterans Administration.

Tele-TBI Regional Medical Commands



TATRC has been engaged in the management of TBI related projects since 2005. Between 2005 and 2008 we have managed nearly \$50M in congressional special interest projects dealing with TBI or combined TBI/PTSD.



Regenerative Medicine

Dr. Eva Lai

The Regenerative Medicine portfolio currently covers at least another 9 projects (an additional \$27M) that fall under other TATRC portfolios such as Neuroscience, Nano-Medicine and Biomaterials, Chronic Disease Management, and Advanced Prosthetics and Human Performance.

In a collaborative effort, TATRC has been working closely with COL Robert Vandre, Project Director of the newly formed *Armed Forces Institute of Regenerative Medicine* (AFIRM) in 2008, to help meet the institute's mission: *to develop new products and therapies to treat severe injuries suffered by US service members in the current wars*. AFIRM encompasses two large academic-clinical consortiums spanning 30 institutions, the US Army Institute of Surgical Research, and several dozen companies. The two primary leads include the Wake Forest University in partnership with the University of Pittsburgh (i.e. Wake Forest-Pittsburgh Consortium) and the Rutgers State University of New Jersey in partnership with the Cleveland Clinic (i.e. Rutgers-Cleveland Clinic Consortium). A significant number of currently funded TATRC partners are members of these two consortia. Their funded research will help accelerate the AFIRM mission.

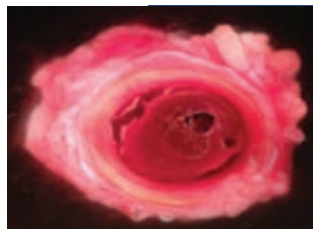
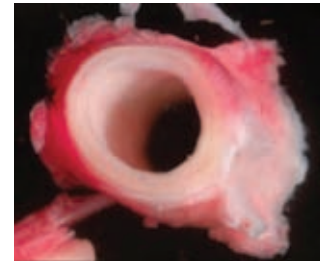


Isolating Autologous Cells for Injury Repairs

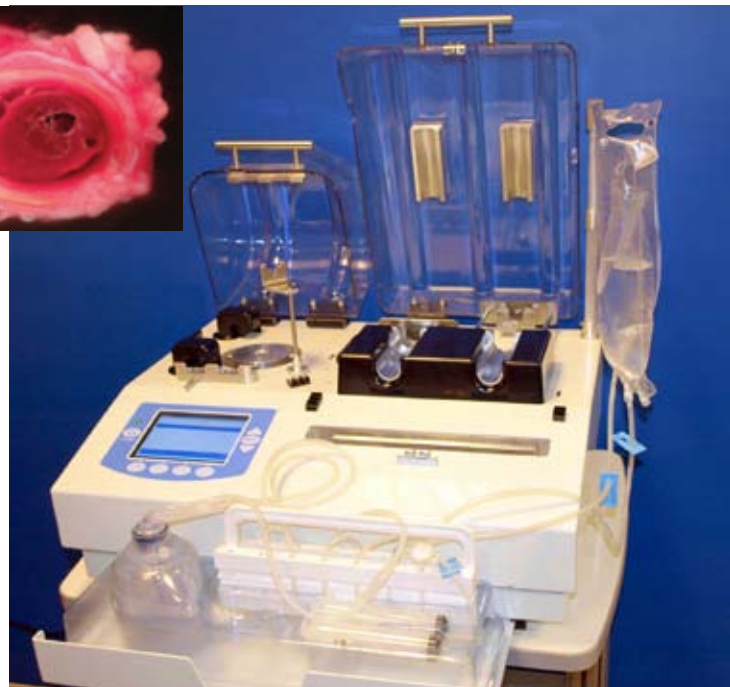
Hawaii's Tissue Genesis (TGI), Inc. has successfully developed a portable, automated cell separation system and patented process that can isolate and sort a small amount (60cc) of human fat tissue into approximately 30 million therapeutic cells (e.g., microvascular

endothelial cells, adult stem cells, etc.), which can be delivered back to a patient with severe

Artificial artery graft coated with TGI's fat derived cell mixture (top right) compared to an uncoated graft after 3 months (below left)



TGI™ Cell Separation System isolates adult stem cells from harvested fat tissue. (Courtesy of TGI)



vascular damage. The current process has been developed to treat peripheral vascular disease (PVD) where the therapeutic cells can be delivered to a patient in a coated vascular graft or stent, or directly injected into damaged tissue. Depending on the type and level of tissue damage, some treatments can be done in a single operation. Results and product development will advance research in regenerative medicine for treating traumatic war injuries. Ongoing product enhancements will enable the provision of treatment for PVD without use of human donor parts — addressing the shortage of donors and available acceptable cadaver parts, as well as reducing rejection rates. Potentially, this could address tissue trauma for battlefield injuries to Warfighters.

Generating Microvasculature Structures to Support New Tissues

Dr. Joyce Bischoff and coworkers at the Children's Hospital, Boston, MA have established a robust *in vivo* model for blood vessel formation using human endothelial progenitor cells (EPCs), isolated from peripheral or cord blood, and mesenchymal stem/progenitor cells (MPCs), isolated from bone marrow or cord blood. The most recently peer-reviewed research published in *Circulation Research* 2008 demonstrates robust vasculogenic activity *in vivo* can be accomplished via implantation of these two cell types. As noted in the editorial of this issue, this research provides “a significant step forward in the vascularization process necessary for tissue engineering and regenerative medicine.” Demonstrating an extensive and functional microvascular network connected with the host blood supply is a significant achievement. This

“The future of regenerative medicine is truly amazing. We’re embarking on a new generation of research that’s going to redefine Army and military medicine as we know it today.”

**— The Army Surgeon General
Lieutenant General
Eric B. Schoomaker
April 17, 2008**



proven concept that a functional microvascular network can be achieved through the use of human progenitor cells easily obtained through noninvasive procedures is another important milestone.

Nano-Medicine and Biomaterials

Dr. Warren Grundfest

The Nano-Medicine and Biomaterials Portfolio focused on identifying novel developments in materials science, MEMS systems, and biomaterials that can address significant problems in military healthcare.

Nanotechnology investigates the properties of material at very small scales. At these small sizes common elements such as gold, silver, carbon, silicon, and titanium acquire unique properties that are radically different from the bulk material. Within this portfolio, investigators are applying nanotechnology to improve drug delivery, develop unique biomaterials, and build new physiologic sensors.

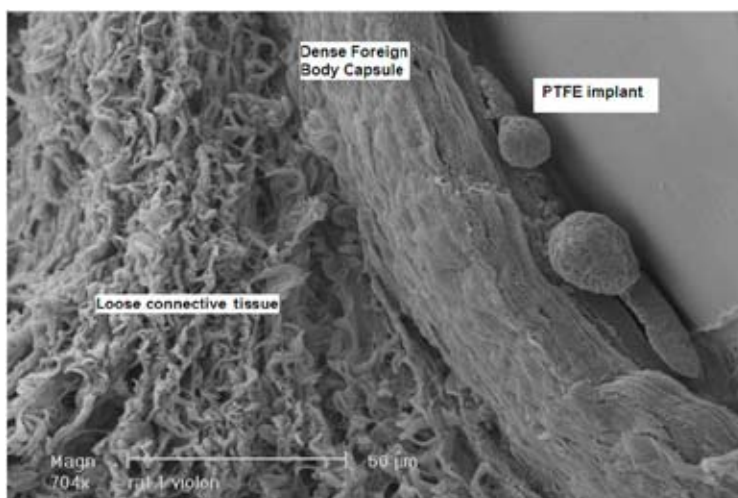
Nanotechnology Solutions for Long-Term Implantable Devices

An Integrated Research Team (IRT) was held at the University of Texas Health Science Center to discuss the current state-of-the-art in glucose biosensors and identify limitations of current technology. Monitoring of physiological parameters provides valuable information on the health of the Warfighter, thus TATRC has a long-standing interest in metabolic monitoring technologies.

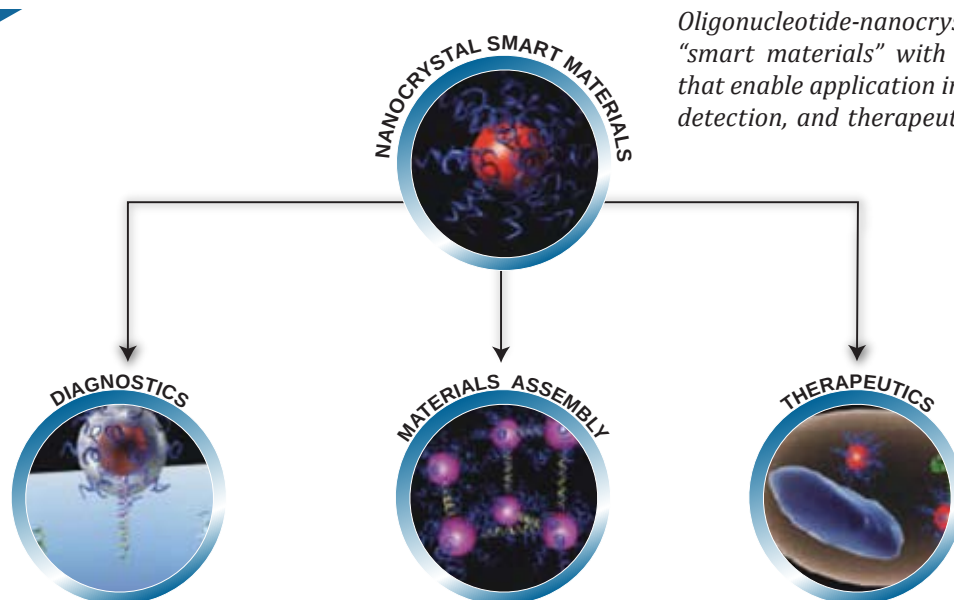
Both short-term and long-term physiological monitoring provides real-time assessments of the health and performance capabilities of the Warfighter. In an effort to explore these possibilities, TATRC has chosen to assess the current status of implantable glucose sensors and the associated research. In addition, this IRT examined the larger picture of immunological response to implantable devices and the need for new methods to modulate the body's reaction to implantable devices.

Development of implantable biosensors remains challenging due to the lack of appropriate sensors, biomaterials, and bio-coatings. The emergence of nanotechnology, and the capability to build materials at the nanoscale, holds the

promise of constructing new biosensors, materials, and coatings that can function effectively within the body. Significant research questions remain with respect to immunology, tolerance, energy and power supplies, device operation, functionality, form factor, safety, integration into pa-



This is an image of tissue surrounding a subcutaneous polytetrafluoroethylene (PTFE) device in a rat six weeks after it was implanted. Experts recommend additional research be performed on the encapsulation environment that forms as part of the immune response to implants. Source: Ward, WK. The Foreign Body Response to Implanted Biomaterials: A Review Progress in Inflammation Research. Nova Science Hauppauge NY (2005).



Oligonucleotide-nanocrystal conjugates are “smart materials” with assembly properties that enable application in materials synthesis, detection, and therapeutics that are not possible using conventional materials.

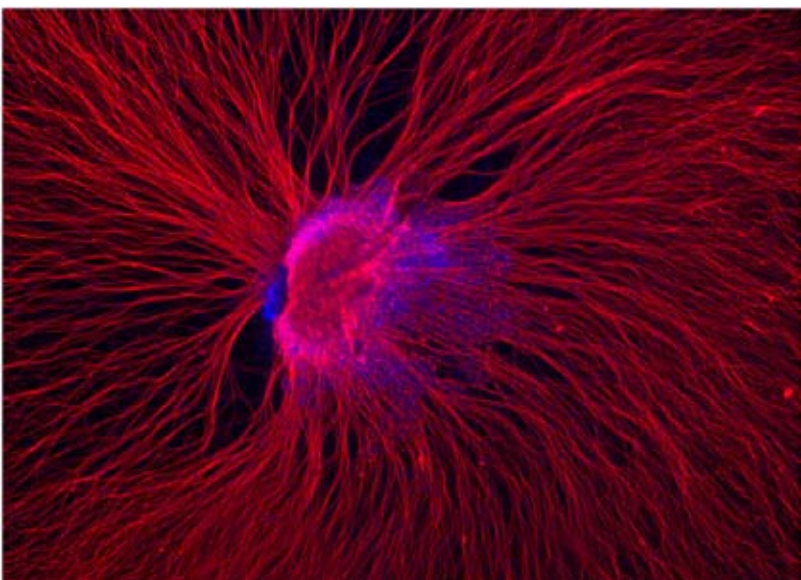
tient care, evidence-based practice guidelines, benefits, complications, and cost.

Fabrication of Biomaterials

Micro/nanotechnologies can be applied to the fabrication of biomaterials that mimic tissue. These constructs can be used to replace lost bone and other tissues. These biomimetic materials encourage the growth of cells, the integration of bone into implants, and the regeneration of tissue after traumatic injury in various applications.

In the last year, TATRC has seen a significant expansion in the portfolio with the addition of

unique projects using DNA coded gold nano-shells to bind toxic metals (Dr. Mirkin, Northwestern University), carbon nanotubes for cancer therapy (Dr. Vitetta, UT Southwestern), and quantum dots for neurotransmitter tracking (Dr. Vu, Oregon Health & Science University). Project funding in the prior period has attracted significant additional support from other agencies due to success in the development of new imaging agents, new biomaterials, and novel drug delivery technologies. TATRC assists each program in identifying military needs, defining performance metrics, and comparing new technologies to existing methods. TATRC has played a key role in encouraging collaborations between sites to build strength in this portfolio.



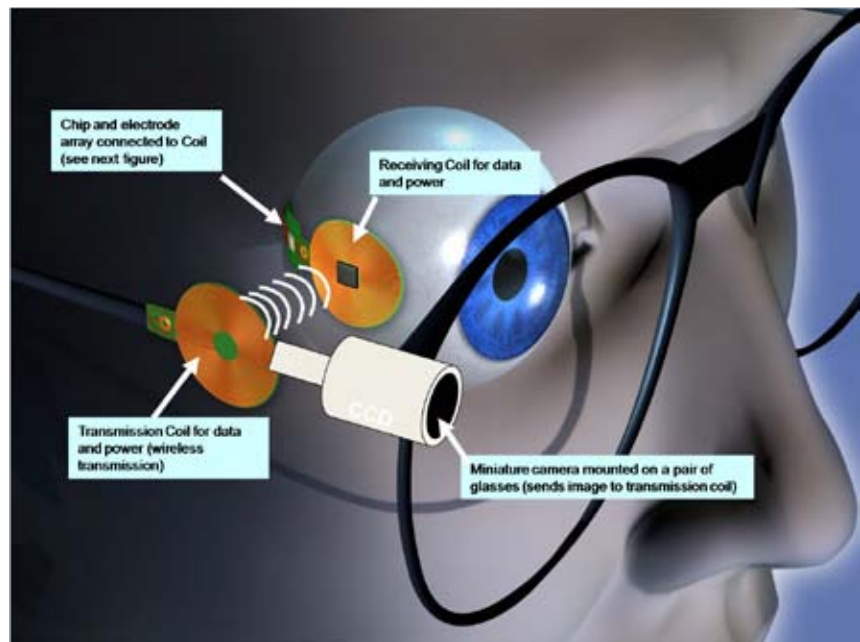
Dr. Vu’s work demonstrated that quantum dots (QD) can be used to specifically bind important classes of surface neurotransmitter receptors, permitting tracking, expression and mobility of these receptors. This work provides a technical and methodological basis to clarify variation in neuronal response to, as an example, anti-depressant drugs such as Prozac. The QD probes, in collaboration with the Greengard Laboratory at Rockefeller University, are also being used to study neural receptor regulatory mechanisms at the molecular level.

As of May 2008 the Joint Theater Trauma Registry (JTTR) has data on 15,462 military patients with both battle and nonbattle injuries, of those 1606 have sustained eye injuries. Current research targets the degeneration of the critical components of the eye and impairment or loss of vision. This comprehensive and coherent program of ocular trauma research supports the new Defense Center of Excellence for Traumatic Eye Injury.

Massachusetts Eye and Ear Infirmary

Investigators at the Massachusetts Eye and Ear Infirmary are developing a novel retinal prosthesis that is designed to restore vision to some blind patients. This device will be modular and configurable so that customized adjustments can be made to accommodate the visual needs of each patient and improve their quality of life. This retinal prosthesis is a complex device that captures visual images; communicates the images to electronic components that interface with the retina; and selectively delivers electrical pulses to the retina to create vision.

Researchers are also developing the Virtual Mentor Cataract Surgery Trainer, which is a computer based cognitive simulation of cataract surgery. The scenarios in the Virtual Mentor are designed to place residents in the situations associated with the most common or the most catastrophic mistakes. The Virtual Mentor allows the learner to improve competency through practice in simulated environments. The value of simulation training is to increase technical skills of the user and improve patient safety through realistic scenarios prior to use on patients in the operating room.



Development of retinal implants is underway at the Massachusetts Eye and Ear Infirmary. These devices capture images and send electrical impulses through electronic retinas to create vision.

Schepens Eye Research Institute

The Schepens Eye Research Institute fosters multiple projects each year focusing on preventing trauma to the eye and if injured, developing novel techniques for treatment. Two such projects are: Determining Mechanisms Induced by Retinal Laser Burn that Abrogate Ocular Immune Privilege and Developing an Anti-Infective Corneal Bandage.

Ophthalmic surgical simulators such as this one from Touch of Life Technologies help train surgeons outside of the operating room to enhance their skills, thus reducing the likelihood of errors inside the operating room.

National Eye Evaluation and Research (NEER) Network

The Neer Network has established a network to be composed of five clinical treatment and evaluation centers to advance the science of therapeutic and preventive interventions for inherited orphan retinal degenerative diseases and dry age related macular degeneration through the conduct of clinical trials and other clinically relevant research.

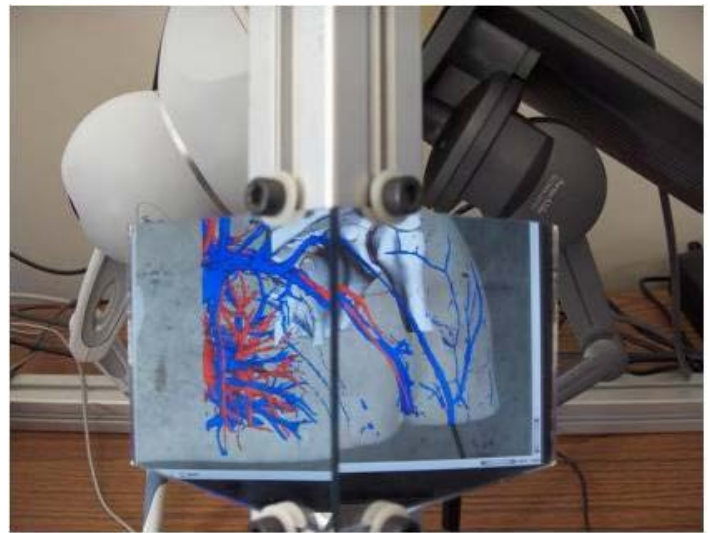
Center for Ophthalmic Innovation

Bascom Palmer Eye Institute's Center for Ophthalmic Innovation will focus on prevention, treatment, and restoration of damage to the visual system in order to improve the outcome of blinding eye trauma and disease. Created as a transformative mechanism to support a set of "interdisciplinary" research programs that bring together ideas, people, and cutting-edge technology from diverse backgrounds and venues—across medicine, biotechnology, and biomedical engineering—the overall objectives of the project are (1) to catalyze the conceptualization of practical solutions and (2) to facilitate teams' efforts to develop and implement their ideas.

Ophthalmic Surgical Simulator

Touch of Life Technologies is developing an ophthalmic surgical simulator which will allow students to practice globe repair, most steps of phaco-emulsification, and the use of ultrasound for diagnosis and measurement. The simulator

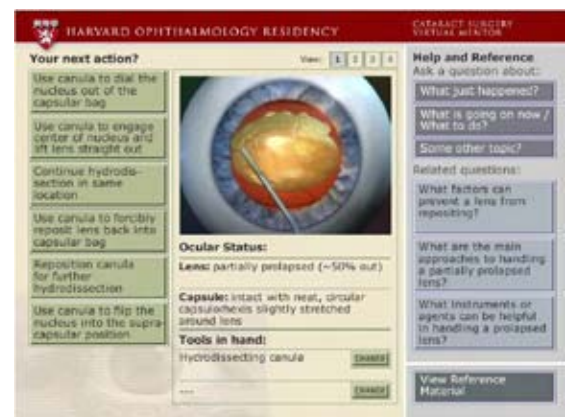
This Virtual Mentor Cataract Surgery Trainer assists new surgeons in acquiring hydrodissection skills before operating on patients.



will be coupled with a mentor program, which combines HTML, interactive anatomic animations, and direct proficiency measures from the simulator.

Wills Eye Institute

The Wills Eye Institute project is focusing on two research areas. The first is Education for Military Eye Care Professionals (www.willsmmed.org), a distance-based learning application through a secure internet site for every uniformed ophthalmologist, which will be expanded to include optometrists and technicians. The second is Clinical Tele-Ophthalmology using a non-mydratic camera for a diabetic retinopathy assessment at the Institute, the Thomas Jefferson University Outpatient Internal Medicine Service and at Madigan Army Medical Center.



Sight Restoration Research

Bradley Greger, PhD and Richard Normann, PhD at the Moran Eye Institute at the University of Utah are conducting studies on sight restoration through the electrical stimulation of the visual cortex in the brain via arrays of penetrating microelectrodes. Service members who have been blinded by blast or other trauma are the driving force behind this effort as there are few treatment options available to the profoundly blind. While retinal visual prostheses have made great headway, they cannot be used when the eye has been severely damaged or removed.

This team developed a vision prosthesis which could potentially restore limited, yet useful vision to profoundly blind patients. This vision prosthesis will bypass damaged sections of the visual pathways and provide visual input to patients by sending signals from a charged coupled-device (CCD) video camera directly to the vision processing parts of the brain. A proposed study will determine if patterns of cortical micro-stimulation evoke discriminable patterns of visual perception, provide quantitative design input for optimizing a vision prosthesis, and serve as the pre-clinical support to obtain FDA approval for undertaking clinical studies in profoundly blind human volunteers.

Eyegenix™

Cellular Bioengineering, Inc., based in Honolulu, HI, has been developing new bioengineering technologies to repair injured, diseased, and aging corneas. Since eye injuries account for more than 10% of battle-related wounds—re-



The cortically based visual prosthesis uses the Utah Intracortical Electrode Array. With the use of an ultra-miniaturized CCD video camera mounted on a pair of glasses, an image bypasses damaged sections and is transmitted. This device is intended for use when the eyes have been too severely damaged or removed and retinal visual prostheses cannot be used.

sulting from rockets, mortars, and improvised explosive devices—developing an alternative solution for treating corneal blindness without use of human donor tissue is essential. TATRC funding has supported both the culture and transplantation of corneal endothelial cells on corneal substrates, and the development of a bio-integrating polymer. Both arms of the program had milestone successes this year. The cellular regenerative research component received an FDA Investigational New Drug Application to perform a clinical trial for autologous endothelial cell transplants in humans to start in 2009. The materials science research portion, in collaboration with the University of Ottawa, has conducted a pilot clinical trial supporting the development and transplantation of a synthetic collagen-based bio-integrating polymer cornea. Preliminary results demonstrate improved optical clarity, epithelialization, return of sensation, and histologic evidence of tissue integration at 9 months.

This is a sample Joslin CDMP webpage containing patient information regarding the patient's whole health - not just his/her diabetes.

Joslin Diabetes Center

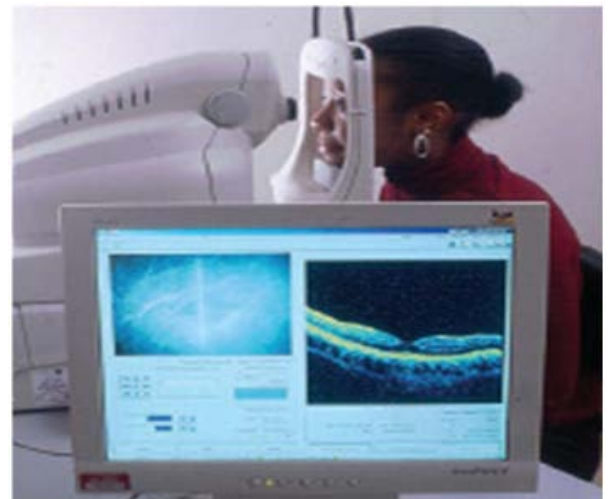
The JVN Comprehensive Diabetes Management Program (CDMP) is a web-based, one-stop, customizable, software tool that considers the whole patient – not just his or her diabetes. CDMP was designed for the entire Care Team – care/case managers, nurses, educators, exercise physiologists, nutritionists, physicians and behavioral clinicians. The CDMP development now incorporates a patient portal for home monitoring devices in collaboration with iMetrikus.

The Joslin Vision Network™ (JVN)

The Joslin Vision Network™ (JVN) is a proven retinal imaging device and clinical service designed to prevent blindness and vision loss for people with diabetes. Using Joslin's custom software and specialized cameras, patients can be evaluated for diabetic eye disease within their primary care physician's, endocrinologist's, ophthalmologist's or other medical office. JVN images, along with other key patient data, including blood pressure and A1c scores (average blood sugar levels over a period of 3 months), are transmitted securely via the internet to the JVN Reading and Evaluation Center at Joslin Diabetes Center in Boston. There the images are evaluated by an expert team of ophthalmologists, optometrists and clinical staff. Joslin's expert team interprets images, identifies specific levels of diabetic retinopathy and provides appropriate treatment guidance for each patient. The Joslin team also identifies ocular pathologies other than diabetic retinopathy if observed.



By reducing barriers to eye care, JVN increases the rate of ongoing disease surveillance and facilitates appropriate and timely referral of patients to eye care specialists when needed. With early detection and appropriate treatment, vision loss can be prevented.



A patient's eyes are being imaged by the Joslin non-mydriatic camera. This imaging process requires no dilation of the pupils.

Military Amputee Research Program

Intramural

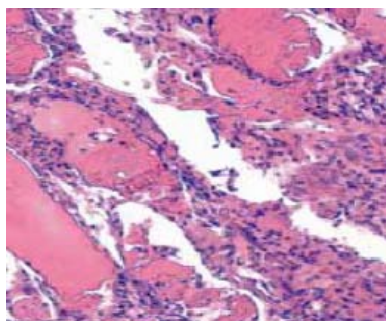
LTC Rachel Evans

Research at two new Army centers, the Military Advanced Training Center (MATC) and the Center for the Intrepid (CFI), continued to advance the early adoption of new prosthetics and new treatment and training technologies for seriously injured Warfighters. Injured Warfighters were provided with the best available new science and technology.

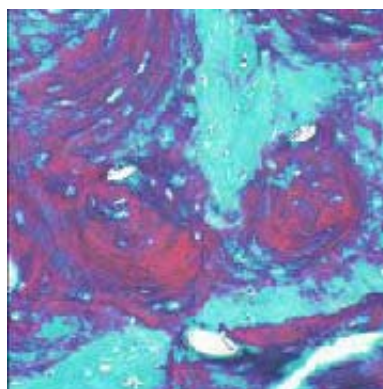
Mechanism of Heterotopic Ossification in Traumatic Injury

Over sixty percent of patients with traumatic amputation following a blast injury develop Heterotopic Ossification (HO). HO is associated with pain, extended recovery time, poor prosthetic fitting, revision surgeries, limb shortening, breakdown of soft tissues, and nerve damage. MAJ Leon Nesti and his colleagues at WRAMC and the National Institutes of Health (NIH) received funding through this program to investigate the key factors contributing to the development of HO in Warfighters who have sustained traumatic war injuries.

They identified a cytokine gene expression profile of traumatized muscle tissue. The team has also been able to identify cells with a progenitor cell in the traumatized muscle tissue that they believe are responsible for HO formation. MAJ Nesti and team have already started to localize the trauma-related cytokines to the progenitor cells in the tissue. The progenitor



Development of calcification in traumatized soft tissue produces complications for amputees. MAJ Leon Nesti and his team have identified steps in the progression of this pathological change that may lead to targeted interventions.



cells harvested from traumatized muscle have several characteristics of mesenchymal stem cell. These include a similar morphology, proliferation rate, and cell surface markers. They also differentiate into osteoblasts, adipocytes and chondrocytes. The next step will be to determine how the trauma-related cytokines alter their differentiation potential. Overall, through a greater understanding of how traumatic cytokines are regulated and localized in injured muscle, the findings of this research could define the key events that contribute the identification of novel targets for prophylactic or therapeutic interventions.

Mirror-box and Mental Visualization Treatments on Phantom Limb Pain (PLP)

CDR Jack Tsao, Department of Neurology, Uniformed Services University of the Health Sciences, is leading the research investigation to assess the efficacy of mirror-box and mental visualization treatments on PLP. Most frequently associated with traumatic limb amputation, an estimated ninety percent of traumatic amputees experience PLP. Current pain management strategies for PLP are not very effective.

CDR Jack Tsao is shown supervising patient therapy involving the use of mirror images at WRAMC. Mirror-box therapy has been shown to reduce phantom limb pain.

The goal of this research is to develop an objective measure of the response of PLP to mirror therapy, which could aid in the overall development of improved treatments for PLP. The study addressed the hypothesis that the observation of moving an intact limb reflected in a mirror while moving the amputated or “phantom” limb in a similar manner will reduce PLP more than when the mirror is covered to remove visual feedback or mental visualization of movements in the phantom limb alone.

At Walter Reed, mirror therapy is now offered routinely. CDR Tsao believes that this treatment has the potential to benefit amputees worldwide. He has already taken the therapy to Cambodia, a country that has a large and increasing amputee population because of mines left over from its civil war.

The Computer Assisted Rehabilitation Environment (CAREN) System

Advances in combat medical care are allowing severely wounded individuals to survive previously fatal injuries. The improved survivability has resulted in a substantial number of individuals who require intensive rehabilitation to maintain or maximize their daily living capabilities, and yet want to return to living in their homes as soon as possible. Researchers at the CFI, led by Dr. Jason Wilken, are testing a virtual reality system called the CAREN to improve gait performance and walking efficiency in lower extremity amputees. Early results indicate that

The Computer Assisted Rehabilitation Environment (CAREN) virtual reality system is being tested as a way to improve gait performance and walking efficiency in lower extremity amputees.



visual feedback while walking in an immersive virtual reality environment can yield substantial improvements in just three weeks of training. The goal is to develop inexpensive treadmill based treatment interventions that could be used in the home environment while speeding recovery.



Advanced Prosthetics and Human Performance

Mr. Troy Turner

The technological advances in prosthetics engineering including devices such as SPARKy (a robotic foot) and powered knees have now made it possible to restore functionality to a level where seriously injured Warfighters can return to duty. TATRC's continued efforts in this area led to the recognition this year that rehabilitation medicine is no longer simply a VA mission and needed to be a new Army core-funded research program.

Advanced Prosthetics and Human Performance is a growing portfolio of projects aimed at providing advanced prosthetics, orthotics, and other assistive devices, treatments and interventions for patients with major limb amputations, fractures, and other orthopedic related injuries. It includes orthopedic injury prevention, rehabilitation, and performance optimization projects and other areas of research under the umbrella of polytrauma.



Arizona State University's Human Machine Integration Lab

Arizona State University's Human Machine Integration Lab is building a new generation of smart, active, energy-storing, and dynamically tunable, transtibial prostheses. The device will supply 100% of the needed power during the gait cycle and will store and release energy to minimize the power and energy requirements. The new prosthetic technology will allow Warfighters to have enhanced function in civilian daily lives. The Army is transforming into a future force that is survivable and sustainable. Advanced prosthetics have allowed Warfighters such as Major David Rozelle, a below the knee amputee, to quickly return to active duty.



Top Left: Dr. Hugh Herr and the MIT Lab aim to produce human-like ankle mechanics during steady-state level-ground walking and stair climbing using a prosthetic ankle.

Top Right: MAJ David Rozelle, a below-the-knee amputee, is the first amputee to return to active command in Iraq.

Bottom: SPARKy III is an example of the many artificial limbs being developed through TATRC-sponsored research to improve the lives of amputees.



The ability to manipulate the immune system to tolerate the transplant of human hands has implications for other organs and diseases like multiple sclerosis.

Translational Research Program in Composite Tissue Allotransplantation (CTA)

Two co-principal investigators, Dr. Ildstad and Dr. Breidenback (position pending at publication) at the Jewish Hospital Foundation's Institute for Cellular Therapeutics, are working to improve the immunological tolerance the human host has for a composite tissue allotransplant. A low toxic, reduced-intensity conditioning approach is significantly reducing the need for immuno-suppressant drugs. This approach has worked successfully to transplant human hands and is proposed for human kidney, heart, and larynx transplants.

This work is rooted in an area of enormous importance, not only for transplantation biology but also for understanding the immune system. The ability to manipulate and control the immune system has far-reaching implications in the management of many types of patients, such as patients with multiple sclerosis and other auto-immune diseases.

“What are you going to do if your artificial leg gets damaged in the field?”

“I’m going to replace it and continue the mission. What are you going to do if your biological leg is injured?”

The amputee Warfighter esprit-de-corps is exemplified by this statement. (Overheard from an amputee)



Integrative medicine is focused on health rather than disease, and the patient plays the critical role in their health with help from medical care providers and modern medicine. Pain management, relaxation methods, nutrition and exercise habits are all part of the focus on sustaining health and performance of Warfighters.

Complementary and Alternative Medicine (CAM)

As part of a larger program of system wellness and integrated health, TATRC has collaborated with the DCoE to investigate the use of non-traditional treatments for addressing the psychological health of our Warfighters. Previous research efforts conducted by the Samueli Institute revealed several key findings for use of CAM in military personnel. A survey investigating the use of dietary supplements and CAM among 16,146 active duty military personnel revealed that 45% reported using CAM approaches regularly. The Samueli Institute has conducted several studies evaluating the effectiveness of CAM on pain reduction. Based on the results of this study and others, the Samueli Institute developed and evaluated an auricular acupuncture training program for Air Force doctors.

Army Regional Anesthesia and Pain Management Initiative (ARAPMI)

The ARAPMI at WRAMC in partnership with Conemaugh Health System (CHS), Johnstown, PA is engaged in a collaborative research, educational and clinical practice program in advanced regional anesthesia and acute pain management. The objective of the ARAPMI is the establishment of regional anesthesia and acute pain management as standards of care on the modern battlefield. This vision is anchored by the belief that if acute pain is treated early and aggressively, as a disease process, chronic pain syndromes, if not eliminated, may be greatly reduced or attenuated. This vision is founded on four principles: advanced practice, clinical research, professional education and practice improvement through outcomes evaluation. In support of the first principle, ARAPMI has established a Regional Anesthesia Section and acute pain team at Walter Reed and is creating a similar service at CHS flagship hospital, Memorial Medical Center (MMC), in Johnstown, PA. Next, ARAPMI and CHS are engaged in collaborative clinical trials that will serve as models of integrated acute and chronic pain management. The third principle is the continuing education of health care



TATRC is collaborating with the DCoE to investigate non-traditional treatments such as acupuncture to improve pain management for the Warfighter.

professionals in understanding the pathophysiology of acute pain, its contribution to chronic pain syndromes, the use of regional anesthesia for acute pain control and the importance of an evidence-based practice.

The fourth pillar is the ongoing evaluation and self-assessment of our practice through tracking outcomes for advanced regional anesthesia and quality improvement programs at WRAMC & MMC.

Bone Health and Military Medical Readiness (BHMMR)

A major workshop on stress fracture research at Fort Jackson (Feb. 2008), led by LTC Rachel Evans, concluded that stress fracture injuries during initial entry training in the military could be virtually eliminated if the knowledge produced from a decade of CSI-funded BHMMR projects were implemented today. Participants included key intramural and extramural program scientists, military trainers, US Army Training and Doctrine Command (TRADOC), Military Entrance Processing Command (MEPCOM), US Army Center for Health Promotion and Preventive Medicine (USACHPPM), Navy and Air Force uniformed researchers, as well as key international military medical research collaborators from Israel, UK, and Australia. The product of the symposium is a summary of the best evidence-based practice for prevention, diagnosis and treatment of stress fracture injury in military personnel that forms the basis for a



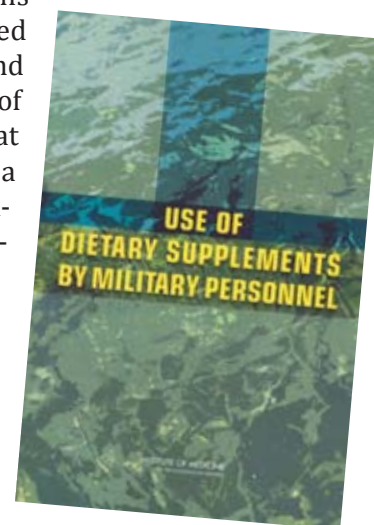
Left: Pennsylvania Congressman John Murtha dedicated the Regional Anesthesia and Acute Pain Medicine Center at WRAMC in Washington, D.C. Above: Dr. (COL) Trip Buckenmaier has pioneered new nerve-blocking techniques that permit regional anesthesia, reducing the need for general anesthesia and speeding recovery through better pain management.

decision briefing to OSD(HA) to institutionalize and continue to evaluate the effectiveness of recommended strategies such as Vitamin D supplementation.

Dietary Supplement Report

This study was sponsored by USARIEM, the Samueli Institute, the NIH Office of Nutritional Supplements and TATRC. A request was directed to the Institute of Medicine (IOM), National Academy of Sciences to convene a committee to review the use of dietary supplements by military personnel and make recommendations. The activity of this committee was carried out over 18 months and led to the publication of a detailed report that provides the DoD with a process model for evaluation of dietary supplements.

The Dietary Supplement Report provides authoritative recommendations to assist the DoD.



The Medical Logistics Portfolio supported the defense medical logistics community by promoting research and development which will advance the execution of medical logistics both for the Military and Industry.

The portfolio's mission is to focus on potentially transformational technologies to be applied to the core logistics systems and processes used to support operational medicine. This will be accomplished by encouraging the conduct of research and further development of state-of-the-art and emerging technologies to create prototype devices and processes that will enhance the conduct of the business of medical logistics. These broad areas of technology are: enterprise-wide integration technologies; asset management and visibility, to include maintenance and life-cycle management; supply chain management and visibility, to include real time condition monitoring; energy management and conservation; (medical) waste management and disposal/destruction; materials, transportation and environment research and development.

Radio Frequency Identification (RFID)

Radio-frequency identification (RFID) technology is rapidly emerging as a key technology that has the potential to reduce the medical "footprint" and increase medical mobility, while ensuring Warfighters have ac-

cess to essential medical expertise and support wherever they deploy.

Track and Trace Records Management

In 2008, the 3M Company completed a significant medical logistics effort by moving its Track and Trace records management project at Darnall Army Medical Center into the final phase of maintenance support and data collection. Hardware and software were developed and installed in the main records rooms at Darnall AMC and several outlying clinics. In excess of 150,000 medical records were tagged with passive RFID tags. Early indications are that the system provides significant improvements in the efficiencies and accuracy of managing the medical records at Fort Hood.



RFID labels were attached to paper medical records at Darnall AMC and outlying clinics. An unobtrusive shelf antenna system under the paper records enables rapid access through their RFID labels.

Medical Logistics Portable Deployment Kit

A MedLog Portable Deployment Kit (MedLog PDK) will give deployed medical supply Warfighters the ability to establish a RFID enabled warehouse and/or distribution

center in whatever environment they find themselves working. The “kit” will provide the capability to establish an RFID system in an open field, a tent or building(s) of opportunity. This technology will enable the medical supply personnel to better manage the resources they are charged with and to better and more efficiently meet the requirements of their customer base under difficult and austere conditions.

VerdaSee Development Corp. is in the early stage of a Phase II SBIR award to create this capability. VerdaSee is integrating and further developing state-of-the-art technologies and new developments to make this a reality.

Ad Hoc Network Tags (ANT)

A prototype of a system with low-cost, sensor-enabled RFID tags for monitoring small shipments of sensitive medical items is being developed by InfinID Technologies Inc. in their Phase II SBIR project. These tags have an on-board capability to establish an “Ad Hoc Network” (ANT).

The ANT tags report their information to the central system through the gateway or through each other as distance and topography require. This greatly extends the range over which information can be transmitted without requiring the establishment of a large infrastructure.

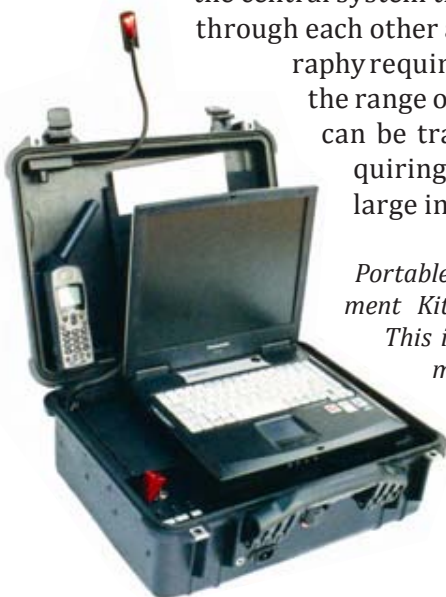
Portable Warehouse RFID Deployment Kit Mobile Command Center. This is the centerpiece of deployment kit which will permit the establishment of an RFID enabled medical supply center or resupply point in a deployed location, whether it be an open field, or in tents.



The Ad hoc Network Tags (ANT) prototype under development by InfinID Technologies has the capability to report information either to a central system through a gateway unit, or through each other, as required by distance or topography, which greatly extends their range.

RFID Tags with Sensor Capability

Another project being undertaken as a Phase II SBIR by Eigent Technologies LLC is the development of inexpensive, disposable RFID tags with sensor capabilities. The intent is to use these tags to track small quantities or individual items of medical supply especially through the “last tactical mile” of the supply chain. The sensor capability will not only provide the logistician with in-transit visibility but will also monitor the condition of critical medical supplies as they are exposed to environmental conditions or mishandling. This awareness may then provide an opportunity for intervention to prevent loss of the shipment. Items seen to be damaged in transit can be replaced even before they are found to be deficient by the ultimate consignee.



Prototype breadboard of low cost disposable sensor enabled RFID tag to be used for monitoring the shipment of small quantities of medical supplies to the end user.

Medical Logistics

MEDCOM Bandwidth Evaluation and Expansion JUONS

An evaluation was conducted concurrently at Ft. Detrick, MD and Ft. Gordon, GA to determine if the US Army Signal Corps can optimize new technologies by expanding bandwidth to provide a robust telemedicine solution. Validation of the bandwidth requirements was conducted in the simulated environment of the Ft. Detrick OASIS facility, in which bandwidth was used to support both the flow of Command and Control traffic and Medical Information. The experiment proved that WIN-T One can support AMEDD's Information Exchange Requirements (IERs) for tele-radiography, tele-consulting, voice, and all MC4 applications and has the flexibility to scale bandwidth to meet future medical technologies but must be incorporated into Signal Corps planning to meet future needs. Validation of

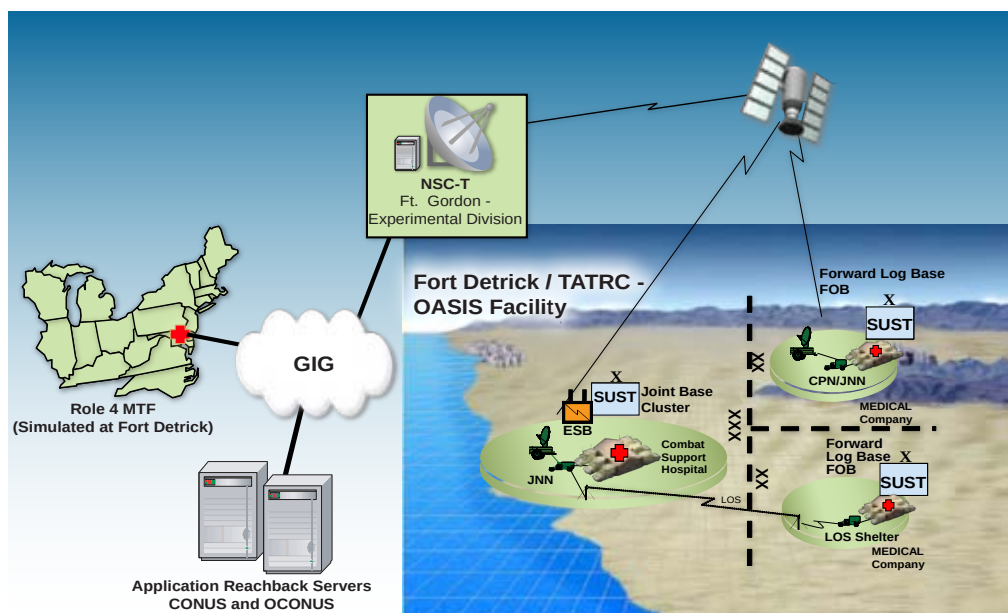


The MEDCOM bandwidth expansion is essential for optimal tele-consultation by enabling the flow of Command and Control traffic and Medical Information including ultrasound and x-ray images.

the bandwidth requirements verifies that the current system can support requirements for both Command and Control and medical IER's.

Finally, completion of the bandwidth evaluation establishes the parameters for development of in-theater information management architectures of the future. Bandwidth has recently been dedicated for the transmission of ultrasound, x-ray and other images.

Experiment Network was a live WIN-T One network connecting a surrogate CSH and medical company located at TATRC's OASIS facility, FT Detrick, MD.



Medical Humanitarian Logistics

TATRC repositioned to the changing operational environment and new era of low level persistent conflict by preparing for medical needs in support of stability operations. LTC Steve Downs conducted extensive investigations of technology and business process reengineering to meet the unique demands of medical logistics support in developing nations.

Through extensive travel and direct contacts in Europe, he identified knowledge gaps regarding humanitarian relief operations, nongovernmental organization relationships, cultural considerations, and commercial supply chains operating in developing countries and military to civilian operations. LTC Downs participated in key training such as the International Red Cross course at Johns Hopkins University on humanitarian assistance (health emergencies in large populations) and key meetings such as the Army interagency discussion on Stability, Security, Transition, and Reconstruction (SSTR) operations at the Center for Army



Toyota car parts are utilized in these neonatal incubators for use in third world countries. Head lights provide the heat source; a car door alarm serves as an emergency alarm; and an auto air filter and fan circulate air.

Analysis to develop the Army campaign plan, and the United Nations Supply Cluster meeting at UNICEF Supply Division headquarters in Copenhagen, Denmark.

The African Command Surgeon requested USAMRMC/TATRC support, with LTC Downs on loan to help develop projects and work logistics issues related to development of US military-to-military in specific areas of operation.

A wide range of TATRC-supported projects contribute to SSTR; the CIMIT program is a key example. The CIMIT Global Health Initiative led by Dr. Kris Olson developed an isolette for neonates exclusively from Toyota car parts so that maintenance and repair in developing countries is feasible and affordable.

Rapid and practical diagnostics are another problem in developing countries and other austere environments. CIMIT microfluidic diagnostics projects are developing an integrated microfluidic platform for detection and diagnosis

of avian influenza and also a microfluidic detector for rapid and practical CD4 T-cell counting in HIV/AIDS.



Health Information Technology

LCDR Steve Steffensen

TATRC is the Research and Development Program Office for the Military Health System (MHS). This program shaped projects with a clinical informatics focus to include: improved human-computer interfaces; developed clinical decision support through automated practice guidelines and alerts; prototyped new data models; explored new ways of improving semantic interoperability; and helped to define the future state architecture for the MHS through work on the Nationwide Health Information Network (NHIN).

With the advent of the Armed Forces Health Longitudinal Tracking Application (AHLTA), the MHS arguably has one of the largest repositories of semantically constrained, highly structured clinical encounter data. The Health IT portfolio is dedicated to finding new approaches to access, analyze, exchange, distribute, and archive this information using cutting-edge technologies and maximizing collaboration with our federal and civilian partners.

National Forum on the Future of the Defense Health Information System

A key TATRC accomplishment in 2008 was hosting the National Forum on the Future of the Defense Health Information System on 26 to 28 March 2008. In partnership with the Georgetown University ISIS Center, TATRC planned and conducted a watershed meeting to reformulate the path to the development of a seamless DoD and VA electronic health record. Key leaders from across the DoD Health Care System and Department of Veterans Affairs joined in this 3-day workshop. Recommendations and a blueprint for the future were developed and will be disseminated in a special supplement of Military Medicine in March 2009.

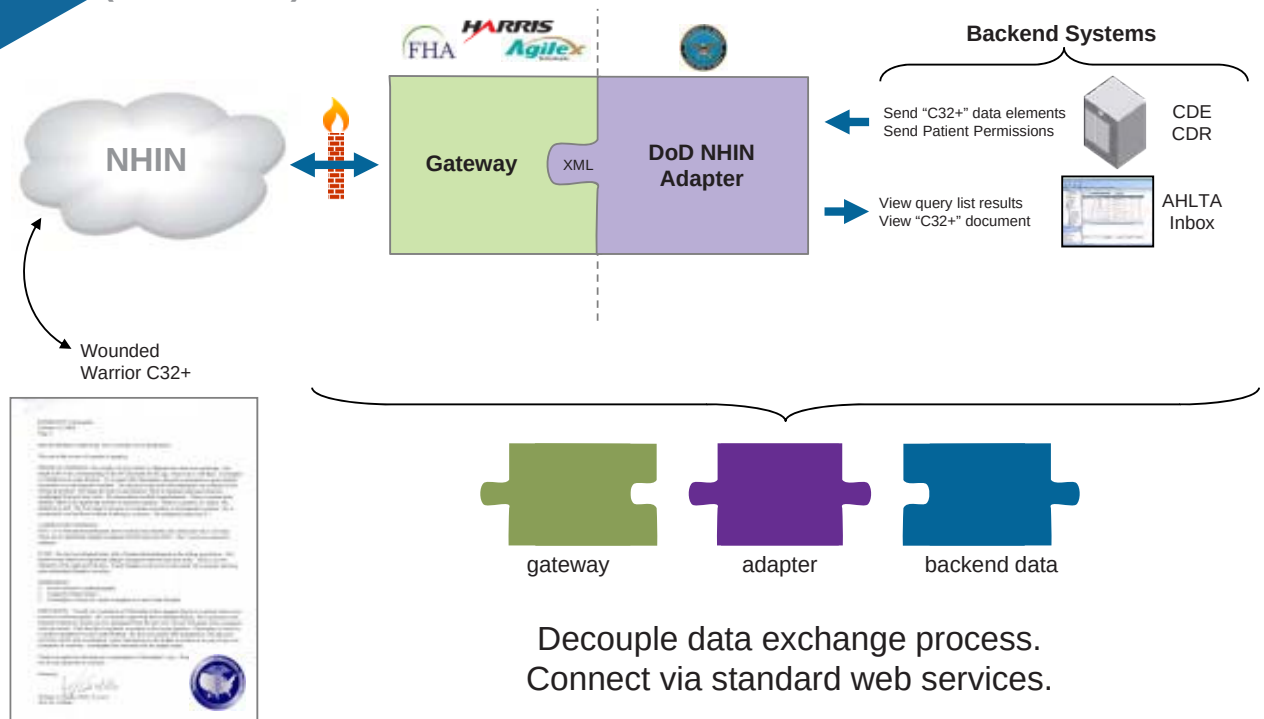
Emerging Health IT, Inc. Prototypes the Clinical Looking Glass

In 2008, TATRC continued to work with an FY06 Congressional recipient, Emerging Health IT, Inc., a subsidiary of Montefiore Medical Center, Bronx, NY, to prototype the Clinical Looking Glass application. The Clinical Looking Glass is a revolutionary clinical decision support tool which allows a clinician to build cohort study groups for quality assurance studies, and make statistical comparisons of those groups on-the-fly.

Unlike many on-line-analytical processing tools, Clinical Looking Glass is easy for the clinician to use at his/her desktop at the point of care. The plan is to pilot this tool with clinicians at WRAMC and the NNMCC.

Clinical Looking Glass incorporates the power of clinical intelligence to improve health outcomes.





TATRC's goal is to facilitate the development of the federal adapter to the Nationwide Health Information Network for the purpose of standards-based exchange of health information. This infrastructure will facilitate health information exchange between the Department of Defense, multiple federal partners, and many more civilian participants on the NHIN.

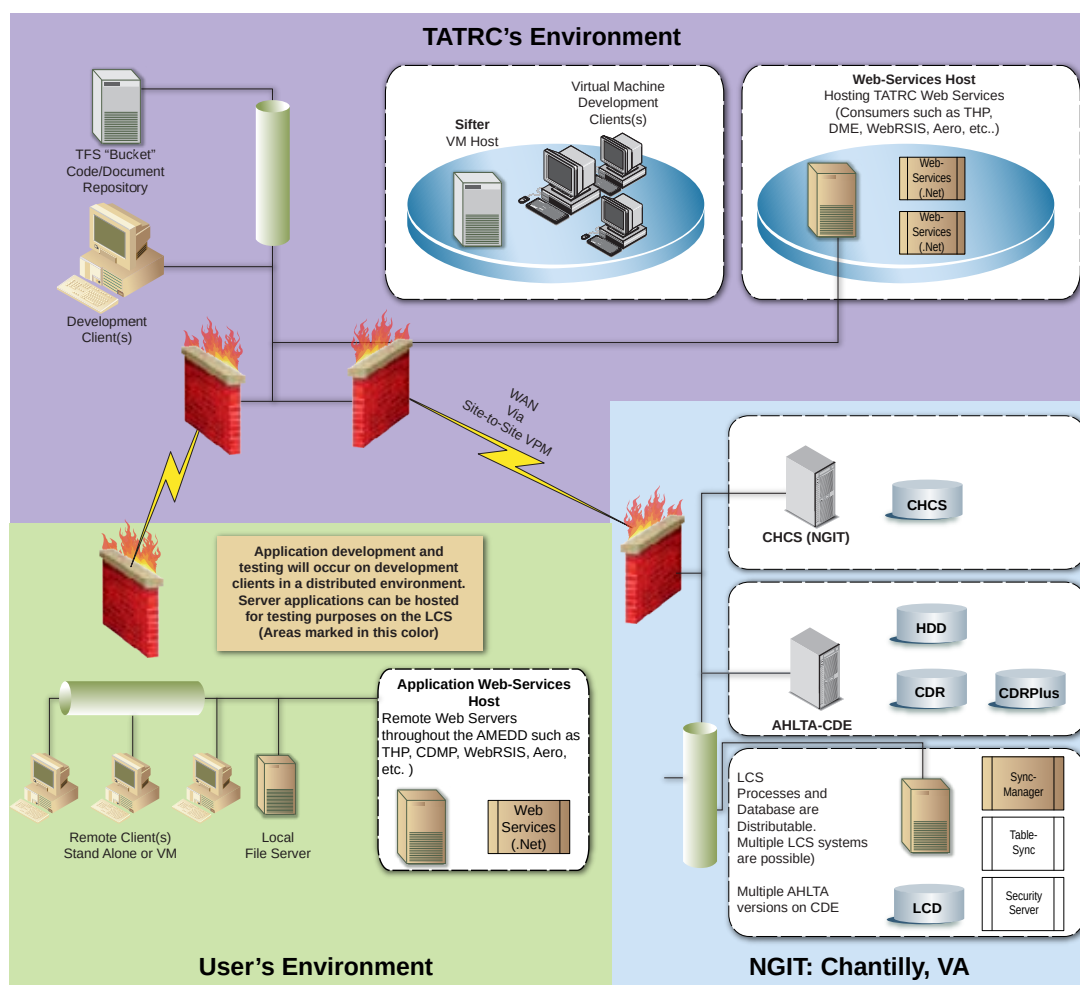
A Reference Implementation of a Service-Oriented Architecture for Healthcare: The DoD Nationwide Health Information Network (NHIN) Interface

TATRC has been instrumental in leading an MHS team to create a connection between the NHIN and the DoD. In December 2008, the DoD participated in a national demonstration of the NHIN sponsored by the Department of Health and Human Services and the Office of the National Coordinator for Health IT. During this demonstration, a summary of care document on a "wounded warrior" test patient was exchanged with civilian and federal partners using this infrastructure.

Speech Recognition and Natural Language Processing

Doctors frequently dictate their findings after a medical exam in addition to making notes in charts. In 2007 and 2008, TATRC conducted an evaluation to determine if clinicians' use of Nuance Dragon Naturally Speaking™, for front-end speech recognition use with AHLTA, increased clinicians' acceptance of AHLTA. More than 200 multi-specialty clinicians across the three services participated in a pre-use and post-use survey. TATRC is engaged in other efforts to take free text and transform it to coded concepts or facts, using natural language processing, based on both ontological and statistical approaches. Ideally, speech recognition can be combined with natural language processing, and human validation of generated codes, to ease clinician data entry into AHLTA.

Health Information Technology



The AAMTI-funded TATRC CDE provides users an opportunity to experiment with improvements to the EHR.

Common Development Environment (CDE)

TATRC has developed and manages an AHLTA development and testing platform capable of supporting 100 users called the CDE. The CDE provides the MHS a "sandbox" in which to evaluate new ideas, foster innovation and improve collaboration between MHS Centers of Innovation and the TRICARE Management Activity. The CDE is available to authorized DoD partners, researchers and Government facilities and reduces the cost to Government by providing a shared resource and knowledge partnership. The CDE's web services environment supports 12 AHLTA data domains providing AHLTA test data to clinical web applications throughout the MHS.

Electronic Information Carrier (EIC)

The Electronic Information Carrier (EIC) is a device that houses a complete medical record that the Warfighter carries with them and can access when it is needed.

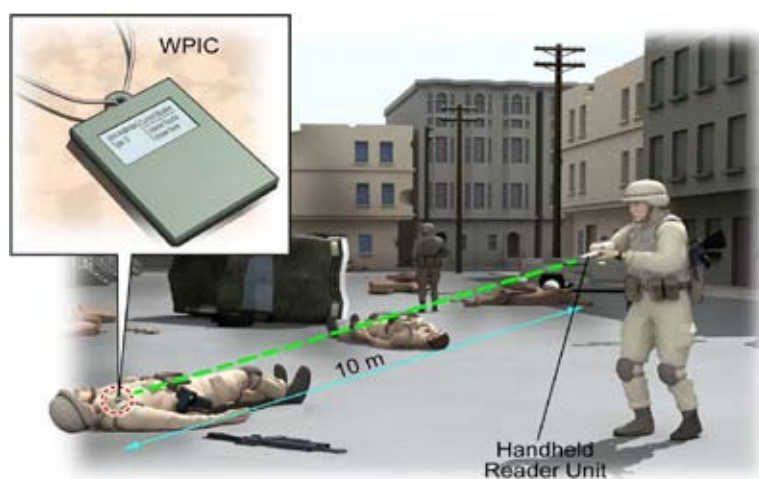
The device allows for saving and transporting a complete medical history for a single Warfighter as well as digital medical images and even video and audio. The additional wireless capability makes the EIC a revolutionary prototype for future military medicine. The EIC leverages encrypted secure communication that meets or exceeds the DoD security requirements. The patient tracking capability allows the EIC to in-

tegrate with Transition Minimized Differential Signaling (TMDS), JTTR and any other adopted military storage and tracking system. The EIC can transmit an emergency beacon that is virtually undetectable by the enemy, that includes critical local data (health status, GPS, etc.).

A complementary demonstration of synchronization functionality took place the first week of December 2008. This demonstrated automatic data synchronization between EIC and a health information system (HIS) such as AHLTA, to include any civilian health information systems that are “interface enabled”.

The development of the EIC began as an SBIR program, which then transitioned to a Congressional Special Interest program and was augmented by several Broad Agency Announcement and operational sponsored initiatives. By leveraging the best of breed industry leaders and using competitive rapid development, the EIC has reached a Technology Readiness Level of 6.

At the conclusion of the current congressional program, TATRC will have completed the research and demonstration for the EIC. This device is now ready for technology transfer to the appropriate organization as identified by the MHS and the DoD.



A medic can save a copy of the encounter data to the patient's dog tag wireless and conversely pull treatment data off of the tag within a 2-10 meter range.



“We’re standing on the shoulders of generations of basic scientists who have laid the foundation through bench research to do this. We are plucking some of the very best ideas and some of the very best products that can be found and moving that as quickly as possible to the bedside and into the operating rooms for our patients.”

**— The Army Surgeon General
Lieutenant General
Eric B. Schoomaker**

Computational Biology

Intramural

Dr. Jaques Reifman

TATRC led and continued to promote computational biology research, providing new insights into physiologic modeling and prediction algorithms. High performance computing (HPC) software applications substantially enhanced the ability of the biological defense community to respond to new biological threats.

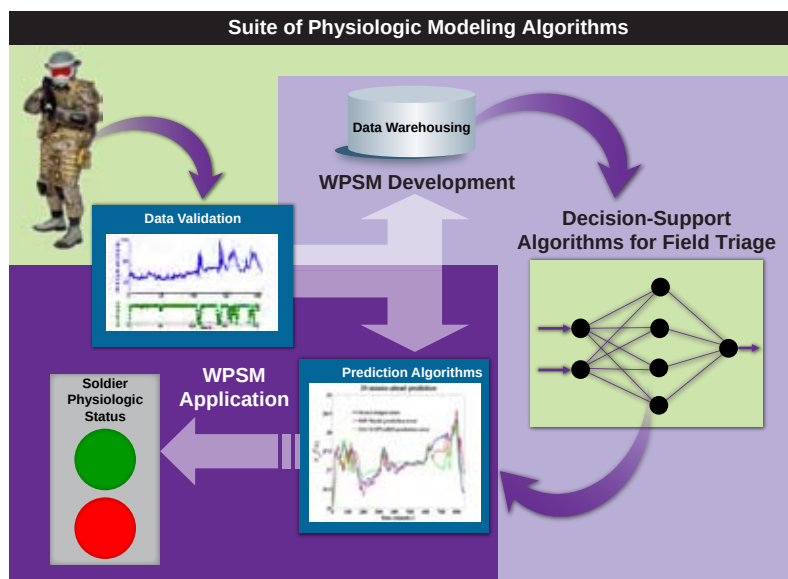
Bioinformatics Cell (BIC)

Researchers in this field developed breakthrough, next-generation biomathematical models, which, for the first time, allow for individual-specific (vs. population-average models), real-time 20-minute ahead predictions of core temperature and glucose readings. The glucose model developed is fivefold more accurate than existing ones.

Some 7,000 patients are admitted annually to DoD hospital Intensive Care Units (ICU) for more than three days, at a cost of \$413 million. Intensive insulin therapy to maintain glucose levels of ICU patients has been shown to reduce stay by 20% and mortality by 50%. Researchers developed data-driven models that predict blood glucose levels with sufficient accuracy and warning time (20 minutes ahead) for appropriate interventions and avoid hypo- and hyper-glycemic states. Results were validated with three separate studies, involving 34 type 1 and type 2 diabetic patients. Timely, proactive therapy for diabetic patients, before glucose levels depart from desired range, will improve the health of Warfighters and their families while reducing health-care cost. In concert with continuous glucose monitors and insulin infusion pumps, such models could lead to closed-loop control in chronic patients.

Modeling Blood Glucose Levels in Diabetic Patients (WRAMC)

Impaired regulation of blood glucose levels causes microvascular and metabolic dysfunctions that result in progressive failure of many organ systems in the body, leading to complications, such as blindness, neuropathy, kidney failure, lower-limb amputations, and cardiovascular disease. TATRC developed the capability, using data-driven autoregressive models, to (1) capture correlations in glucose time-series



The BIC has developed: algorithms to quantify the quality of monitored time-series physiologic data; Web-enabled database management systems for large amounts of time-series physiologic data; algorithms to detect hypovolemia in Warfighters with severe injury; and subject-specific biomathematical predictive algorithms, such as Warfighter's core body temperature during physical activity and soldier's cognitive state after prolonged periods of sleep deprivation.

data, (2) make accurate predictions for clinically useful prediction horizons, and (3) make the model portable from individual to individual without any need for model tuning. Using the autoregressive model, we were able to show that, for a 30-minute prediction horizon, the model provides sufficiently accurate and clinically-acceptable estimates of glucose levels, and should be considered as a modeling engine for predictive modeling of patients with type 1 diabetes mellitus.

Predicting Core Temperature in Advance to Prevent Heat Injuries (USARIEM)

The armed forces suffer thousands of heat injuries each year. Currently, accurate models for real-time, near-future predictions of a Warfighter's core temperature (a determinant of heat injury) do not exist. TATRC research has led to new models that, for the first time, allow for real-time individualized predictions of a Warfighter's core temperature. Retrospective tests showed that the model can predict the onset of an injury (39.5 °C) 20 minutes ahead. The model is being implemented into a computer chip for real-time, prospective testing. This research will reduce preventable heat injuries, minimizing warrior loss of duty time in both training and combat.



TATRC algorithms are being implemented with USARIEM for real-time Warfighter monitoring.

Predicting Status of Casualties during Evacuation (USAISR)

Unattended hemorrhage is a major source of mortality in trauma casualties. Early identification of major hemorrhage could be lifesaving and useful for triage, resource mobilization, and therapeutic decision making. TATRC has developed machine-learning algorithms for use as a decision-assist tool to identify a hypovolemic state in trauma patients. The decision-assist algorithm identifies hemorrhage in patients based on simple vital signs. Using data provided by the US Army Institute of Surgical Research (USAISR), the classifier scored the same as medics (comparing areas-under-the-curve of receiver operating characteristic curves for prediction of mortality and red blood cell transfusion).

Predicting the Effects of Fatigue and Sleep Deprivation (WRAIR)

Although there is no direct physiological measure of fatigue, the conditions leading to fatigue are well known. It is the likely root cause of lapses in attention and vigilance, delayed reactions, operational inefficiencies, and other symptoms. A fatigue model could predict if, and when, fatigue will hinder a person's performance on the job and thus improve operational safety. Combat and training-related incidents resulting in near-misses and fatal casualties could be reduced. The model could be useful in military as well as in civilian

Continued on next page

Computational Biology

situations, such as predicting if an airline pilot is sufficiently alert before flying.

Predicting the effects of sleep-deprivation on an individual using a model based on group averages is highly inaccurate. TATRC has developed a new method using individualized biomathematical models that predicts performance impairment for individuals exposed to total sleep loss. When the individualized models were applied to a sleep study performed at WRAIR, it was up to 75% more accurate than existing group-average models.

Biotechnology HPC Software Applications Institute (BHSAI) Software Tools

The BHSAI has developed and deployed at various DoD HPC centers six software systems to support design of diagnostic assays and identify drug and vaccine candidates:

1) TOFI - identifies short, unique genomic DNA

fingerprints for the design of pathogen diagnostic assays

2) PIPA - predicts protein functions from comparisons of the protein's sequence with similar sequences with known functions

3) PSPP - predicts protein 3D structure based on the primary amino acid sequence

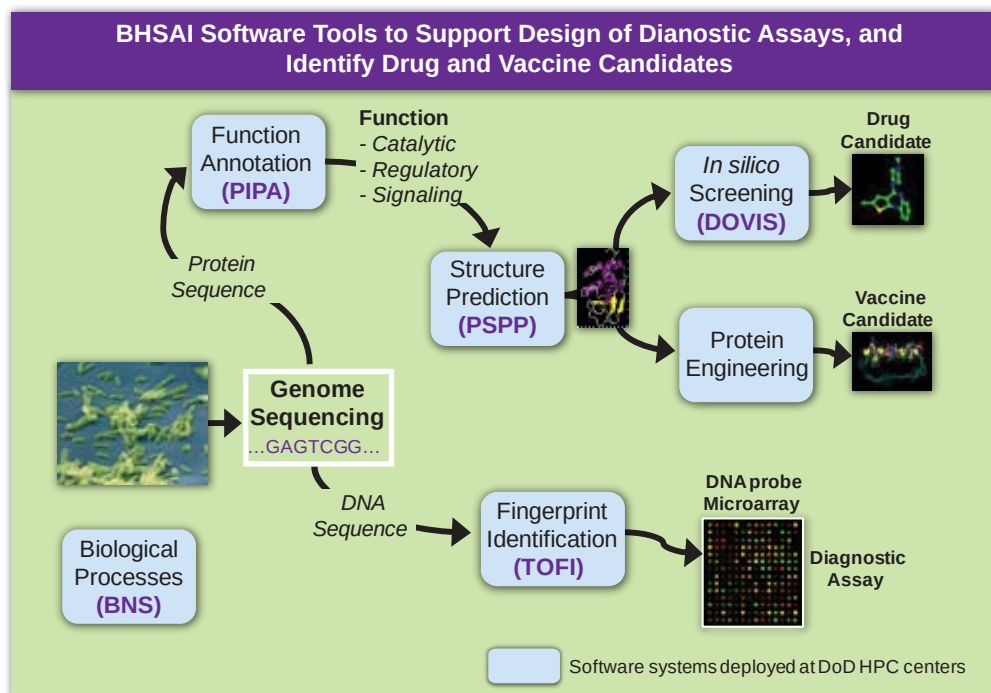
4) DOVIS - performs large-scale *in silico* screening of small, drug-like compounds against protein targets,

5) Protein Engineering - simulates biomolecular systems in atomic detail to help identify vaccine candidates

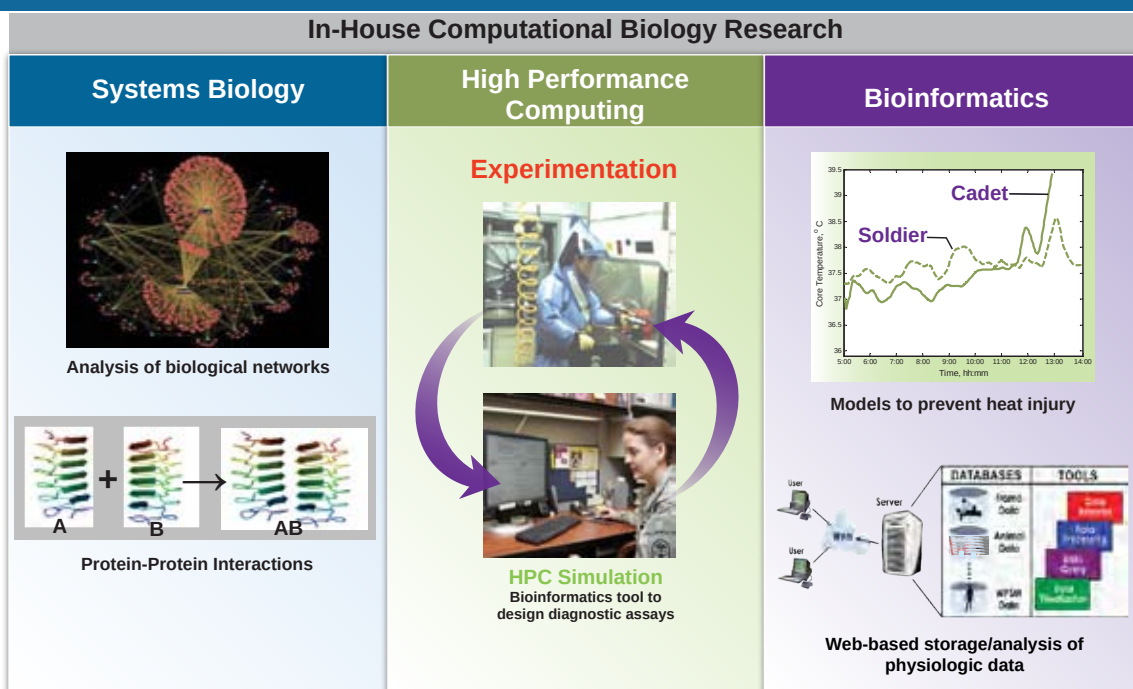
6) BNS - simulates and analyzes coupled biochemical reactions of biological systems.

Army Network Science Initiative

Recent developments in genomic research present both challenges and opportunities for Army scientists to extract knowledge from large amounts of gene and protein data that could lead to early detection of biological threats and emerging infectious diseases, as well as the discovery of new drugs and treatment regimens. There is a critical need to advance the state-of-the-art of computer models and simulations by developing applications capable of analyzing huge quantities of gene and protein data to gain insight into therapy, drug targeting, and diagnosis of biological threats to benefit both the Warfighter on point for the nation and the public at large.



The BHSAI serves as resource to develop HPC applications to accelerate research and development of militarily-relevant medical products for Force Health Protection. To date, users and developers have applied more than 4 million CPU-hours of computational resources, representing 450 years of equivalent 24/7 desktop computing.



Systems biology is an inter-disciplinary field which studies the complex interactions of biological systems, providing leap-ahead advances in health monitoring and protection strategies. Similarly, high performance computing and bioinformatics are modern tools that provide the DoD with huge efficiencies in solving difficult medical problems.

Protein-Protein Interactive Networks

TATRC is analyzing experimentally determined high-throughput data sets, involving tens of thousands of protein-protein interactions (PPIs), to link biological properties of proteins and protein-complex interactions to the topological properties of the network. With these insights, we will develop statistical predictive models to prospectively investigate PPIs that are difficult to study experimentally and to describe the behavior of a pathogen, such as *Yersinia pestis* (the causative agent of plague), within human host cells. We will then compare networks of host-pathogen PPIs of both pathogenic and non-pathogenic organisms to elucidate the underlying causes associated with virulence and disease mechanisms. This knowledge shall lead to novel intervention strategies to more effectively combat infectious diseases.

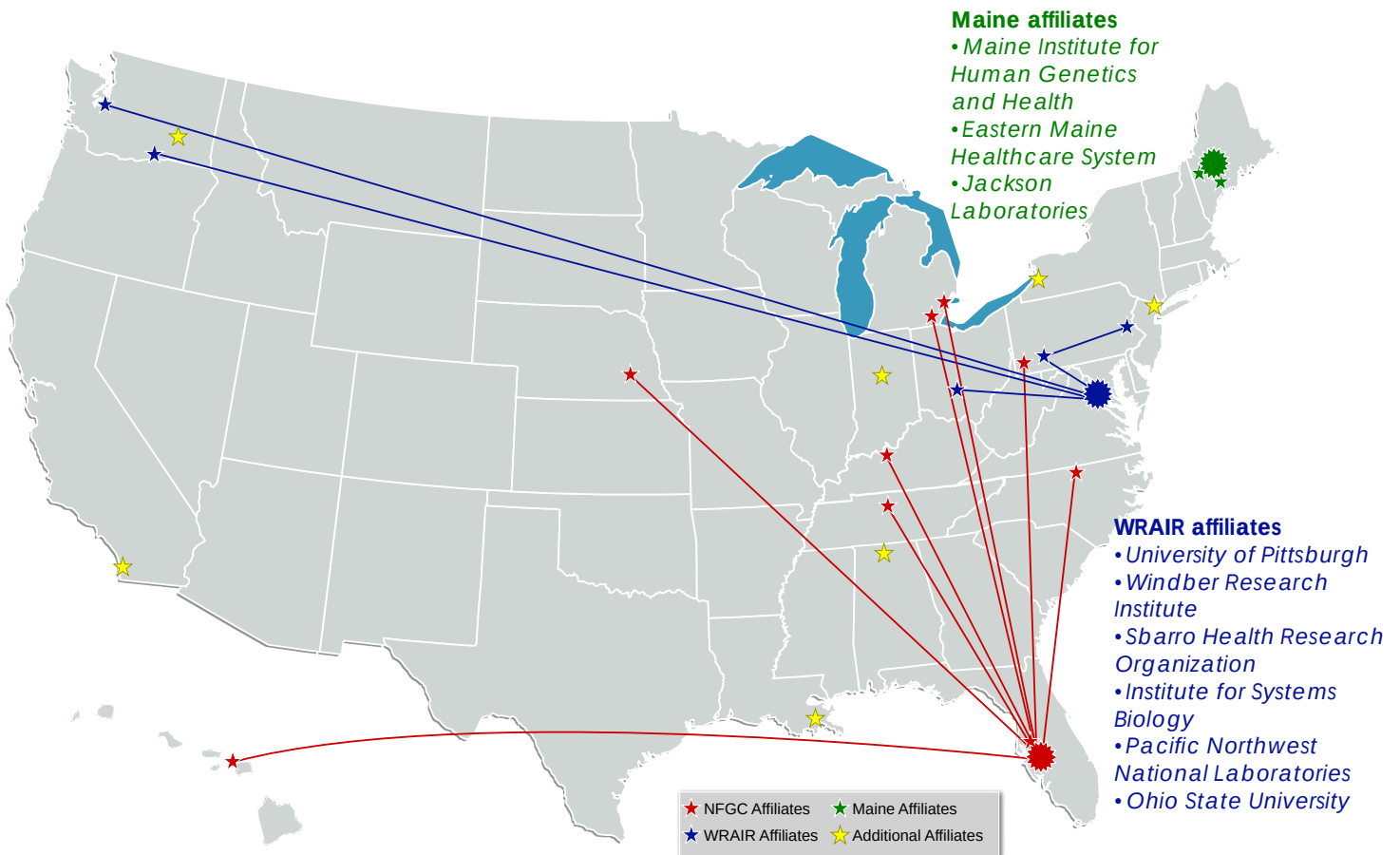
Metabolic Networks

TATRC is developing mathematical models to simulate the effects of inhibiting enzymes in metabolic pathways and monitor the perturbed growth of the pathogen. This systems-biology framework is capable of identifying potential drug targets that selectively affect the growth and the viability of pathogens that reside in human host cells. Using these techniques, we can quantitatively model and predict the effect of selected drug molecules on microbial growth. This work is crucial in proposing new experimental studies by extending, combining, and exploring novel chemical and biological inhibition concepts that are of relevance to the development of countermeasures against military-relevant biological threat agents, such as *Yersinia pestis*, *Francisella tularensis* (the causative agent of tularemia), and other intracellular pathogens.

Genomics / Proteomics

Dr. Anne Westbrook

Genomics and proteomics efforts focused on cancer diagnosis as well as personalized treatment and state-of-the-art care for Warfighters. This disease model created an infrastructure that provides a specific capability that can be applied to future medical threats.



Additional affiliates

- *SUNY - University at Buffalo*
- *University of California, San Diego*
- *New York University*
- *Owensboro Cancer Research Program*
- *Indiana Women's Oncology*
- *Southern University at New Orleans*
- *Louisiana State University Health Sciences Center*
- *Institute for Systems Medicine*
- *Washington State University*

NFGC affiliates

- *University of South Florida*
- *Vanderbilt University Medical Center*
- *University of Hawaii*
- *Southeast Nebraska Cancer Center*
- *University of Michigan*
- *Barbara Ann Karmanos Cancer Institute*
- *University of Pittsburgh Medical Center*
- *University of North Carolina Chapel Hill*

Two female US Army Warfighters relax prior to departing on a mission from Forward Operating Base Hammer in Iraq on May 21, 2007. DoD photo by Staff Sgt. Shawn Weismiller, US Air Force. (Released)

National Functional Genomics Center

The National Functional Genomics Center (NFGC) was created to identify hereditary and environmental influences that can affect our genes and result in cancer. The aim is to design better therapeutic agents through gene expression analysis, proteomics, genetics, and a bioinformatics program that supports the analysis and interpretation of data.

Key discoveries made by the NFGC include:

- Identification of a recurrence signature in colon cancer patients
- Development and external validation of signatures in fresh frozen tissue that predict platinum-response for primary ovarian cancer
- Successful opening of a prospective clinical trial to validate the treatment prediction signature in ovarian cancer patients

The objectives of the NFGC include tracking the genetic changes involved in cancer, allowing for the design of more effective therapeutic agents as well as a better understanding of the hereditary and environmental influences that lead to cancer and unraveling the functional significance of these genes.

Bioinformatics Focus

Most of the research within bioinformatics has focused on cancers, including breast, ovarian, colon, lung cancer, melanoma, lymphoma, and glioma. In addition, the portfolio includes projects in infectious diseases, toxins, heart disease, and PTSD.

Proteomic analyses are being performed to identify markers for early detection of cancer and to identify new therapeutic targets. Bioinformatics plays a pivotal role in ensuring that these discoveries are statistically valid. To this end, specialized software and databases have



been developed, disseminated, and used to manage de-identified patient information and research data. In addition, epigenetic research on the effects of toxins on the Warfighter has been started. TATRC's goals, to support these efforts and to further expand this portfolio into other areas of research, including PTSD, TBI, and heart disease, will have a direct impact on military and ex-military personnel.

Gynecologic Cancer Center (GCC)

The objective of the GCC research activities at WRAMC is to reduce the incidence, morbidity, and mortality of gynecologic diseases among our active duty Warfighters, female dependents and other military health care beneficiaries. The GCC also is a research center that covers a wide range of investigative activities and research projects including three programs managed by TATRC; the Gynecologic Disease Program (GDP), the GCC Health Disparities Program, and the Obesity and Cancer Program.

The GDP led by COL Larry Maxwell, has produced a blood test that can detect both early and advanced stage endometrial cancer with 99% accuracy. The GDP has also developed a blood test that is 88% sensitive and 99% specific in the identification of ovarian cancer. Both of these blood tests are the most accurate screening tests currently reported. GDP research evaluating poor cancer survival among African Americans has been highlighted by NCI and the Society of Gynecologic Oncology and has led to numerous awards.

Medical Modeling and Simulation

Mr. Gene Wiehagen

The DOD's requirement to train more than 100,000 military health care personnel annually, and the national emphasis on reducing medical errors, underpins TATRC's Medical Modeling and Simulation research portfolio. In 2008, TATRC led the research effort to enhance military medical training technologies.

Special Operations Forces Medical Handbook, 2nd Edition (SOFMH2)

Developed as a primary medical information resource and field guide for the Special Operations Command (SOCOM) medics, the Special Operations Forces Medical Handbook now defines the standard of health care delivery under general and adverse field conditions. Treatment protocols are organized according to symptoms, organ systems, specialty areas (such as trauma, infectious disease, and toxicology), operational environments (including altitude, temperature,

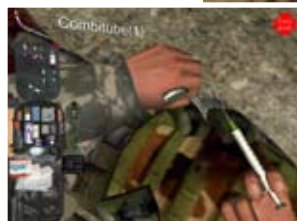
aerospace, and dive medicine), and procedures. It emphasizes acute care in all its forms (gynecology, general medicine, dentistry, infections, etc.), as well as veterinary medicine and sanitation practice under primitive conditions. Compiled with input from more than 80 military and civilian medical specialists, the SOFMH2 serves as the primary reference manual for Special Forces combat medics in all branches of the Armed Forces, as well as civilian emergency response teams, including firefighters and EMTs.

TATRC South contributed to the SOFMH2 by providing the Chief Editor, Style Editor, Production Manager and Medical Illustrators.



Stryker medical elements are conducting Combat Medic Advance Skills Training (CMAST) sustainment training with the Ft. Lewis MSTC. Exercises like these help Warfighters respond more quickly on the battlefield.

During training or “gameplay,” the “floating hand” in the bottom left of the screen is controlled by the trainee. The trainee selects medical items from the treatment kit using a mouse. In the inset example the trainee selects a combitube to prepare an injection for a wounded Warrior. Images courtesy of VRMC.



Institute for Simulation and Interprofessional Studies (ISIS)

The TATRC-NW team partnered with the University of Washington Institute for Simulation and Interprofessional Studies (ISIS), Seattle Science Foundation (SSF) and the Ft. Lewis Traumatic Brain Injury Clinic to leverage web-based virtual reality case management tools to enable case managers at the Fort Lewis Warrior Transition Unit to better communicate with soldiers receiving distant care.

The Virtual Reality Medical Center (VRMC)

The VRMC sought to demonstrate that low-cost, interactive virtual reality training improves combat medic skills performance. The US Marine Corps requested the project be modified for the VRMC to develop scenarios relevant to the Marine Corps.



Realistic training in emergency response scenarios is provided by the Medical Simulation Training Center at Ft. Lewis, WA. Post-training reviews of performance boost a Warfighter's confidence levels on the battlefield, thus reducing morbidity and mortality. (Photos by Harvey Magee)



Simulation and Training for Medics and Surgeons

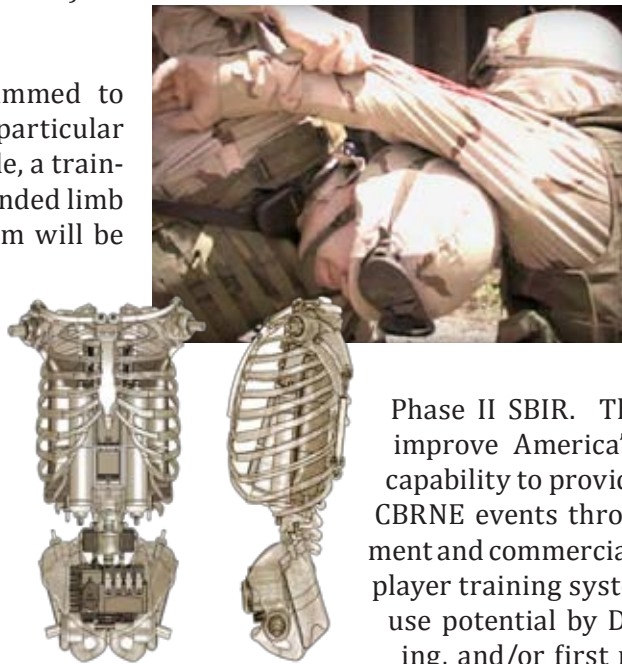
Embedded testing and training using video games, realistic manikins, and virtual environments will soon be commonplace. TATRC partners are rapidly advancing the field so that medics and all levels of health care providers will be more effectively trained, tested, and refreshed using currently available technologies.

Combat Medical Training System (COMETS)

Dr. Steven Dawson, CIMIT Simulation Group, is developing advanced technologies to design, fabricate and test a completely autonomous, highly-realistic prototype casualty simulator that is capable of withstanding harsh field conditions encountered during combat trauma training and chemical, biological, radiological, nuclear and high explosive (CBRNE) exercises.

COMETS will be pre-programmed to exhibit a specific injury for a particular training scenario. For example, a trainer will be able to attach a wounded limb to the manikin and the system will be programmed to automatically recognize the injury and adjust the physiology, such as breathing and heart beat, accordingly.

The system will be programmed to simulate unconsciousness, change stiffness in ball joints in the hips and shoulders, and to simulate a pulse. The torso will hold sufficient fluid that can be programmed to pump simulated blood through synthetic veins and solenoid-controlled valves to an injured limb.



The COMETS manikin is constructed with full body size and proper weight to simulate injured Warfighters for emergency training.

An audio amplifier in the head will produce pre-recorded words and sounds—screams, moans, pleas for help. The manikin will also recognize an RFID tag worn by the individual performing the treatment, triggering an appropriate vocal reaction like “Doc, save me.” A wireless Ethernet system will allow the system to upload the record of treatment and physiology changes as medics move the manikin from the point of injury to higher levels of care and will enable

trainers and trainees to review treatment during the after action review.

CBRNE Training System

Forterra Systems Inc., was selected to receive additional research funding after successfully completing their

Phase II SBIR. Their goal is to expand and improve America’s DoD and private sector capability to provide medical first-response to CBRNE events through the research, development and commercialization of multi-player role player training systems. This system may have use potential by DOD, civilian medical training, and/or first responder organizations to prepare for and rehearse responses to CBRNE events in an immersive simulation as a step between book learning and live drills.

Dr. Skip Rizzo, a USC clinical psychologist at the ICT is a national leader in the development of virtual reality for use in prevention and treatment of PTSD.



Data Driven Optimization of Surgeon Skills for Enhanced Training, Simulation and Assessment

William Beaumont Hospital in Royal Oak, Michigan is funded by TATRC internal funds to address the problem of deterioration of specialty skills of deployed surgeons. Its purpose is to improve patient safety by optimizing individual surgical skills. It will develop a graded set of surgical tasks from basic skills such as knot tying through more complex sub-procedural performance. Through motion tracking, sensor data capture, and built in sensing systems that provide error-tracking capabilities for trainee feedback, automatic data collection methods will be used to define task-specific metrics for each component of a surgical skills task list. A reset training protocol will be designed that could be used by surgeons called to active duty to refine skills prior to deployment, and by surgeons returning to private practice to identify and remediate skills deteriorating after prolonged absence from specialty-specific experience.

Simulation-Based Open Surgical Training System (SOSTS)

SOSTS will develop and demonstrate a PC-based training system for surgeons to obtain higher

quality training opportunities that will improve diagnosis, treatment planning, and procedure rehearsal. This has potential for the DoD and the private care sector to reduce surgical errors, improve patient safety, reduce cost, and improve access to care in fixed medical treatment facilities and improve medical educational training programs. Two companies (SimQuest, Silver Spring, MD; Touch of Life, Aurora, CO) are close to completion of their two-year Phase II efforts.

Virtual Iraq

The University of Southern California Institute for Creative Technologies has created a “Virtual Iraq” environment for use as an exposure therapy PTSD treatment tool and as a system to scientifically study the many issues involved in the susceptibility, maintenance and impact of the PTSD diagnosis. Virtual Iraq’s VR environments are designed to resemble Iraqi city and desert scenes—typical trauma settings for use in VR exposure therapy. In addition to the visual stimuli presented in the VR Head Mounted Display, directional 3D audio, vibrotactile and olfactory stimuli of relevance can be precisely delivered in these simulations as the patient drives a virtual Humvee or walks through them.

The American College of Surgeons (ACS) conducts level III through level V clinical simulation training.



Large Scale Disaster Response

Dr. Kevin Montgomery

TATRC oversees a portfolio of projects in large-scale disaster response and management that are becoming increasingly important at the national and international levels, as the DoD moves to a new era of low-level persistent conflict and stability operations.

Using Evidence-based Best Practices for Explosive Device Incidents

At the Robert Wood Johnson University Hospital (RWJUH) in northern New Jersey, Dr Clifton Lacy is leading a project titled “Evidence-based best practices for explosive/incendiary incidents: translating the Israeli experience for use in the US military and civilian pre-hospital and hospital health care systems.” This project will organize workshops to examine the Israeli mass casualty experience and develop a similar US

plan for civilian and military medical response. The goal is to develop a set of guidelines that could be implemented by any healthcare facility to plan, prepare, and provide an effective response to a mass casualty event, with the initial implementation of these guidelines at RWJUH, should a disaster occur in the New York/New Jersey region.

The Loma Linda University researchers’ CURE model will develop predictors of the number and acuity of patients likely to seek treatment at a hospital after a natural, accidental, or intentional disaster.



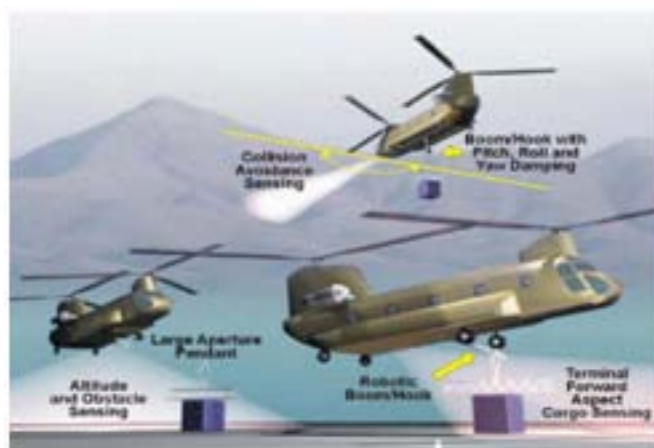
One of CIMERC's efforts at Drexel University involves Unmanned Aerial Systems. These aircraft would autonomously handle large cargo volumes, thus reducing the risk of human exposure to CBRNE toxins after a mass casualty event.

The Bioterrorism Civilian Medical Response Center (CIMERC)

The Bioterrorism Civilian Medical Response Center (CIMERC) at Drexel University in Philadelphia, PA, under the leadership of Dr. Banu Onaral has been developing technologies relevant to emergency medical response, such as non-contact measurement of optical properties of wounds and burns; non-invasive hand-held device to detect and monitor brain edema; and medical command and communications platforms for field medical use. Another project involves developing the handbook for civilian disaster response in rural areas which could be used by any school, healthcare facility, or local government to manage a mass-casualty event.

Convertible Use Rapidly Expandable Model (CURE)

Dr. Elizabeth Lynch at Loma Linda University leads the CURE project to provide research and development of a model for response to disasters and mass casualties. This project created a Multi-Casualty Incident Center with access to state-of-the-art medical and information technologies and can provide cost-effective patient care surge capacity during incidents of natural, accidental, and intentional disasters. The developing model can: provide estimates of the number and acuity of patients that may present to the hospital after a natural, accidental, or intentional disaster; develop and describe the concept of operations for the CURE center as applied to various geographical and hospital settings, including academic centers, community hospitals, and military installations; design a center that meets the requirements defined



above, is cost-effective and multi-purpose, and contains state-of-the-art medical technologies and innovations for disaster surveillance and patient care; demonstrate and evaluate the capabilities and use of the center; and provide a graphic demonstration of the center deployment during various disaster scenarios. These concepts will be transferred to other facilities nationwide.

DISCOVERIES Project's Mobile Telemedicine Vehicle (MTV)

Also at Loma Linda, the DISCOVERIES project has developed a Mobile Telemedicine Vehicle (MTV) which is an off-road vehicle with telemedicine capability that can bring the expertise of a tertiary care facility to the site of a disaster. The vehicle can send TM images, including x-ray, from the vehicle back to the Loma Linda University Medical Center ER. It also has, housed inside it, an ATV that can be deployed to more remote locations, and still connect back to the MTV. It has a robust communications system, including satellite, that would allow it to work independently in an area without a communications infrastructure, and the ability to set up and deploy a communications network in such an area. The MTV has been deployed to multiple venues including NASCAR events and other mass gatherings, as well as participated in drills (including Strong Angel), in an effort to test and improve its capabilities.

Large Scale Disaster Response

The Disaster Relief and Emergency Medical Services (DREAMS™)

The DREAMS™ project is a consortium of scientists, medical professionals, and engineers from The Texas A&M University System and the University of Texas Health Science Center at Houston, under the guidance of Dr Larry Flournoy. The goal of the DREAMS™ project is to improve the diagnosis and treatment of critically ill or injured Warfighters in the field by expediting their access to medical experts at trauma centers or field hospitals.

Digital EMS

Digital EMS is the DREAMS™ component that allows trauma specialists to treat patients more quickly by providing the virtual presence of a physician on the battlefield or at the emergency scene. Digital EMS integrates multiple leading-edge telecommunications technologies, especially video processing, wireless communications and digital signal processing. The Digital EMS ambulance prototype connects emergency medical personnel on the scene with trauma specialists in distant hospitals, allowing physicians to monitor patients using real-time video and vital signs data from a suite of advanced digital medical monitoring equipment. Interpreting this real-time data, the virtual physician may then telementor EMS personnel to extend medical protocols available inside the ambulance or at the trauma scene.



The virtual presence of a physician is provided at the emergency or battlefield site by this prototype digital EMS ambulance vehicle. Trauma specialists in hospitals can monitor patients through real-time video and vital signs data and inform emergency medical technicians as to their treatment.



A MTV can take x-rays of patients and send them to the Loma Linda University ER. A satellite communication system enables the MTV to function in areas lacking a communication infrastructure.

The Combat Online Medical Direction (COMD)

The Combat Online Medical Direction (COMD) AAMTI is being conducted at William Beaumont Medical Center in El Paso, TX to provide teleconsultation for injuries sustained in the field. The ability to communicate the medical needs of a clinician from any location with voice, data,

and video capability would provide for enhanced care as well as provide the ability for other medical personnel to provide consultation and medical regulation to assist in a mass casualty situation. In addition, by reducing the time of practitioner intervention for en-route critical patients it will increase patient survivability rates. The use of a blended communication architecture would enable flexibility for medical providers as well as logistic, command, and control functions during a disaster response and during en-route care.



The views and opinions expressed in this report are those of the author(s) and do not necessarily reflect official policy or position of the US Government.

The TATRC Annual Report represents a collaborative effort involving contributions from many different people across varied organizations. TATRC wishes to gratefully acknowledge the support of each and every partner who participated in the writing of this report.

Some graphs, charts, images, and photographs are for illustration purposes only. Some images courtesy of the US Army.



"We in the Army have lived by a warrior ethos, and part of that ethos is that we do not leave a fallen comrade.

You're seeing that here, exemplified in the work of these great caregivers—throughout the Army medical department and the military health system—every day."

**— The Army Surgeon General
Lieutenant General Eric B. Schoomaker
June 1, 2007**





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TATRC is a subordinate element of the USAMRMC, located at Fort Detrick.

