S&T

Perspective

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Science and Technology at Strategic Analysis, Inc.

Driving Advancement in the Field of Prosthetics

Throughout human history, war has served as one of the strongest driving forces for advances in prosthetics. In modern times, the response of medical sciences to battlefield casualties has provided significant technological progress in the field. For example, the American Orthotic and Prosthetic Association, formed as a result of the post-WWII leadership of Dr. Normal Kirk, Surgeon General of the Army, helped launch the modern era of prosthetic research in the United States. The war on terror, including operations in Iraq and Afghanistan, presents a major impetus for development of more functionally advanced prosthetics. While advanced body armor and an efficient combat casualty care system are improving survival on the battlefield, many injured soldiers are experiencing extremity injuries that often result in or necessitate amputation.

The field of prosthetics likely depends on the most diverse array of disciplines out of any field in the medical sciences. Prosthetic advances are driven by work in material sciences/nanoengineering, robotics, surgery, artificial muscles, power supplies, sensors and neural communication. This range of disciplines is no surprise considering the goal of prosthetics is generally defined as *the*

design, manufacture, and fitting of an artificial replacement for a lost limb. The highly evolved tissues of a limb, composed of bone, muscle, connective tissue, nerves, and sensory cells are capable of complex movements around numerous degrees of freedom. Our limbs literally define the human condition from provision of weight bearing and locomotion by the lower extremities to grasping and communication by the upper extremities.

Continued on next page...

Corrosion Control

Corrosion of materiel and infrastructure is a significant problem to the Department of Defense (DoD). Not only are millions of maintenance dollars needed to combat the problem, the readiness of military forces is negatively impacted by inability of equipment to function due to corrosion.

Recently, Congress has taken interest in corrosion-related matters. In July 2003, the General Accounting Office published a report entitled "Opportunities to Reduce Corrosion Costs and Increase Readiness," which evaluated corrosion impacts on cost, readiness, and safety. The U.S. Air Force's interest in acquiring new aerial refueling tankers examples the costs of corrosion, both to acquisition and to maintenance budgets. The KC-135 tanker, originally produced in the 1950s, is suffering from significant corrosion, particularly the E models resulting in a large investment to fight this corrosion. The B-52 was built in the same era, but does not have the same level of corrosion because the B-52 was built with longevity in mind. Corrosion resistant materials were used, unlike the KC-135E tanker. Maintainers of ships are also caught in a constant fight against the environment in which they operate. If corrosion on any equipment gets too severe, safety is likely to be threatened.

Not simply a maintenance or acquisition issue, corrosion risk also impacts product design. By investing in controlling the effects of corrosion early in the design of weapons systems or infrastructure, significant cost savings in operations and maintenance can be experienced long term. The issue of corrosion is an important concern for the Office of the Secretary of Defense for Acquisition, Technology, and Logistics, and efforts are being made to create a strategy and policy for handling this issue from the beginning of development of a new product through the entire life cycle of that product. This "cradle-to-grave" approach is an ideal way of managing the potentially crippling effects of corrosion on DoD weapons systems and infrastructure.

Corrosion should be regarded broadly as a policy issue due to the preventative measures needed throughout the entire life of these systems. The prevalent maintenance-oriented attempts to control the corrosion problem cost the DoD millions of dollars each year. This cost could be eliminated if the investment had been made at inception.

For more information about Corrosion Control, please contact Stacie Smith at 703-527-5410 or smiths@sainc.com.

New Faces at SA

Anna Cole: Anna Cole is currently working at the Naval Research Lab supporting the Virtual Reality Training Environment program. She achieved her Master of Electrical Engineering and Bachelor of Biomedical Engineering at The Catholic University of America. Before joining SA, Ms. Cole was a Research Engineer & Laboratory Manager at the Rehabilitation Engineering Research Center on Telerehabilitation at The Catholic University of America where she developed and implemented software algorithms that collect radio frequency signals in real-time for unobtrusive activity monitoring in the home environment and formulated algorithms based on principles of artificial intelligence, particularly fuzzy logic and possibility theory. **acole@sainc.com**

Scott Roberson, PhD: Dr. Scott Roberson is SA's technical lead for projects in DARPA TTO and IXO as well as Joint Forces Command (JFCOM). Dr. Roberson accomplished his Ph.D in Materials Science & Engineering at North Carolina State University and his B.S. in Materials Engineering, Auburn University, Magna Cum Laude. His extensive engineering background includes serving as a Senior Science and Technology Engineer - AF S&E Functional Management Team at the Air Force Research Laboratory (AFRL) & SAF/AQR, and prior to that as Team Leader, Intelligent Fuzing-Air Force Research Lab (AFRL), Fuzes Managerial, Branch, Eglin AFB, FL (AFRL/MNMF). **sroberson@sainc.com**

Erik Lucas, PhD: Dr. Lucas performs as a Scientific Advisor with the Advanced Research Projects Agency at the Department of Homeland Security. His primary efforts are to help evaluate chemical agent countermeasures programs. Dr. Lucas received his doctoral degree in Inorganic Chemistry at Kansas State University, his M.S. in Chemistry at Northern Arizona University, and his B.A. at University of Arizona. For the three years prior to SA, Dr. Lucas was a Postdoctoral Fellow at National Research Council Resident Research Associate; U.S. Naval Research Laboratory where he focused on nanoparticles and sol-gels as high surface area catalysts and reaction platforms. Dr. Lucas has had eleven years lab experience. **elucas@sainc.com**

Prosthetics

continued from front page

In a time of unparalleled advances in the fields of medicine, material sciences, and biotechnology, significant advances for prosthetics will continue. Improvements will be seen in residual limb functionality as progress is made in surgical procedures for skin, bone, and nerve tissue transfer and healing. A number of enabling technologies, such as advanced power supplies (e.g., fuel cells), has the potential to impact prosthetics from improved bio-implantable materials to advanced actuators to serve as artificial skeletal muscle. Development of neural communication with the prosthesis seems possible through application of microelectromechanical approaches for sensor production combined with implantable, wireless electrodes for communication with the central and peripheral nervous systems. This would provide a motor control-sensory "closed loop" use of the prosthetic device.

Virtual reality environments may find use in rehabilitation and prosthesis training to allow "virtual" use of advanced prosthetics while an amputation site is still healing. Computer-based rehabilitation approaches may be capable of addressing phantom limb pain and may also prevent brain plasticity that can occur from lack of neural input from the lost limb.

Implementing such advancements into rugged, waterproof prosthetic devices that can stand the rigors of daily use, particularly in a military setting, is a daunting challenge. Yet, such advancements will dramatically impact the quality of life and societal engagement of amputees. To further that, development of such technologies would have other medical applications including improved therapies for neural damage and paralysis, chronic pain and improved joint replacement options.

For more information about the field of prosthetics, please contact Jon Mogford at 703-797-4583 or jmogford@sainc.com.

Joint Battle Management Command and Control (JBMC2) Roadmap

The Joint Battle Management Command and Control (JBMC2) roadmap is expected to be implemented this summer after a senior leadership panel review in early August. The roadmap prescribes how legacy JBMC2 programs will be made interoperable, convergent or phased out by 2008, sets milestones for key JBMC2 programs and lays out a strategy for Doctrine, Organization, Training, Material, Leadership, Personnel and Facilities (DOTMLPF) relating to JBMC2. The objective of the roadmap is to provide an executable plan for integrating JBMC2 capabilities to enable a fully networked and interoperable joint force that will be able to share real-time situational awareness, act on fused, precise intelligence and targeting information, possess decision superiority, and be able to conduct coherent, distributed and dispersed operations.

The roadmap is being developed by U.S. Joint Forces Command (USJFCOM) and by the Office of the Under Secretary of Defense (OUSD) Acquisition, Technology and Logistics (AT&L) in cooperation with senior representatives from industry. Strategic Analysis, Inc. is one of seven organizations - and the only non-FFRDC - supporting the development of the JBMC2 roadmap. Strategic Analysis Inc. has been tasked with assessing the impact and potential contributions of technology and experimentation to the development and integration of JBMC2 capabilities. This involves identifying emerging technologies that could help bridge interoperability shortfalls as well as assessing gaps between requirements and currently available technologies. In keeping with JBMC2 integration priorities, Strategic Analysis, Inc. is focusing on emerging technologies that may benefit critical Joint Mission Threads being developed by USJFCOM. At present these mission threads include: Joint Close Air Support (JCAS), Time Sensitive Targeting, Joint Command and Control, Integrated Air Missile Defense (IAMD), Joint Ground Maneuver, Joint Integrated Fires and Joint Focused Logistics.

A broader challenge, however is identifying ways to better-align the efforts of the S&T and Experimentation communities with the development of JBMC2 capabilities to ensure that interoperability requirements are articulated, understood and taken into account early on in the development process. This task is complicated by the mix of organizations and initiatives that play a role in collecting interoperability requirements and in identifying and transferring technologies to the warfighter. The existence of multiple organizations and initiatives seeking to address interoperability shortfalls and transfer technology solutions can even be counterproductive if no mechanism is in place to ensure that solutions developed to address one problem are interoperable with those developed to address another.

Addressing this broader alignment challenge will be a critical factor in ensuring interoperable technology solutions are transferred to the warfighter. In this respect, establishing processes to bridge the gap between warfighter requirements and emerging technological opportunities will be as important as the development of the technology solutions themselves.

For more information about Joint Forces, please contact Evelyn Dahm at 703-797-4531 or edahm@sainc.com

New Publications by SA Staff

"Platelet-Derived Growth Factor B, but Not Fibroblast Growth Factor 2 Plasmid DNA Improves Survival of Ischemia Myocutaneous Flaps". American Medical Association, arch surg/ vol. 139 p.142 Feb 2004. John Hijjawi, MD; **Jon E. Mogford**, PhD; Lois A Chandler, PhD; Kevin J. Cross, MD; Hakim Said, MD; Barbara A. Sosnowski, PhD; Thomas A. Mustoe, MD.

"Biocybernetics to Superior Aviation: A Historical Perspective on Cognition Maximizing Research for the Aviator". Proceedings of the Aerospace Medical Association AsMA Annual Scientific Meeting: Frontiers in Aerospace Medicine. May 2004. **Colby Raley**, D. Schmorrow.

"Impact of Aging on Gene Expression in a Rat Model of Ischemic Cutaneous Wound Healing". Journal of Surgical Research vol. 118, no. 2, p.190-196, 2004. **Jon E. Mogford**, Mark Sisco, Steve R. Bonomo, Alan M. Robinson, Thomas A. Mustoe.

"A Novel Murine Model of Cyclical Cutaneous Ischemia - Reperfusion Injury". Journal of Surgical Research vol.116, p. 172-180, 2004. Russell R. Reid, MD, PhD; Alan C. Suel, BS; **Jon E. Mogford**, PhD; Nakshatra Roy, PhD; Thomas A. Mustoe, MD.

"InfoBionics: Nano-Enhanced Information Performance". Proceedings of the Sixth International Conference on Integrated Nano/Micro/Biotechnology for Space and Medical Applications. August 2003. D. Schmorrow, **Colby Raley**, J. Cohn, **Roy Stripling**.

"Use of Hypoxia-inducible Factor Signal Transduction Pathway to Measure O2 Levels and Modulate Growth Factor pathways". Wound Repair and Regeneration vol. 11, no.6, pl496-503, Nov-Dec 2003. **Jon E. Mogford**, PhD; Nakshatra K. Roy, PhD; Kevin J. Cross, MD; Thomas A. Mustoe, MD.

"Inhibition of Prolyl 4-Hydroxylase Reduces Scar Hypertrophy in a Rabbit Model of Cutaneous Scarring". Wound Repair and Regeneration, vol.11, pl 368-372, Sept-Oct 2003. Injoong Kim, MD, PhD; **Jon E. Mogford**, PhD; Claudia Witschi, PhD; Mehdi NaFissi, PhD; Thomas A. Mustoe, MD.

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