ARMY RESEARCH LABORATORY

Volume II: Compendium of Abstracts

by ARL Summer Student Research Symposium

ARL-TM-2009a **August 2009**

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of manufacturer's or trade names does not constitute an official endorsement or approval of the use thereof.

Destroy this report when it is no longer needed. Do not return it to the originator.

Army Research Laboratory
Adelphi, MD 20783-1197

ARL-TM-2009a **August 2009**

Volume II: Compendium of Abstracts

ARL Summer Student Research Symposium

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED (From - To)
August 2009	Final	

4. TITLE AND SUBTITLE
Volume II: Compendium of Abstracts

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
ARL Summer Student Research Symposium

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
2800 Powder Mill Road
Adelphi, MD 20783-1197

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TM-2009a

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

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.

All college undergraduate and graduate students receiving research appointments and conducting summer studies at ARL are automatically enrolled in the symposium program. As an integral part of their summer study, all students are required to write a paper on their work which summarizes their major activity and its end product.

The program is conducted on two separate competitive levels: undergraduate and graduate. The format of the paper in both levels is the same. However, the evaluation will take into consideration the difference in the academic level of the students.

All students submitted their research paper for directorate review. Directorate judging panels selected two papers from each competition category for the laboratory-wide competition at the Summer Student Symposium on 6 August 2009.

Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 6 August 2009. At the symposium the students presented their papers to the ARL Director and an ARL Fellows panel.

This volume of the Summer Student Symposium Proceedings contains the abstracts for all papers prepared for the Summer Student Symposium Program.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Vallen Emery
Unclassified	Unclassified	Unclassified	UU	104	19b. TELEPHONE NUMBER (*Include area code*) 301-394-3585

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

Director's Foreword

The U.S. Army Research Laboratory (ARL) mission is to "Provide innovative science, technology, and analyses to enable full spectrum operations." As the Army's corporate laboratory we provide the technological underpinnings critical to providing capabilities required by our current and future Soldiers.

Our nation is projected to experience a shortage of scientists and engineers. ARL recognizes the criticality of intellectual capital in generating capabilities for the Army. As the Army's corporate laboratory, addressing the projected shortfall is a key responsibility for us. We have therefore identified the nation's next generation of scientists and engineers as a key community of interest and have generated a robust educational outreach program to strengthen and support them. We have achieved many successes with this community, and believe that the breadth and depth of our outreach programs will have a significant positive effect on the participants, facilitating their journey toward becoming this Nation's next generation of scientists and engineers.

A fundamental component of our outreach program is to provide research experiences at ARL to students. During the summer of 2009, we supported research experiences at ARL for over 100 undergraduate and graduate students. Each of these students was required to write a paper describing the results of the work they performed while at ARL. All of the papers were of high quality, but only a select few could be presented at our student symposium. The abstracts for all papers prepared this summer are contained in this volume of the proceedings and they indicate that there were many excellent research projects with outstanding results. It is unfortunate that there was not enough time for us to have all of the papers presented. We would have enjoyed hearing them all.

We are very pleased to have hosted this outstanding group of students for the summer. It is our hope that they will continue their pursuit of technical degrees and will someday assist us in providing critical technologies for our Soldiers.

Introduction

The ARL Summer Student Research Symposium is an ARL Director's Award Program for all the students participating in various summer scholarship and contract activities across ARL. The goal of the program is to recognize and publicize exceptional achievements made by the students and their mentors in the support of Army science.

All college undergraduate and graduate students receiving research appointments and conducting summer studies at ARL are automatically enrolled in the symposium program. As an integral part of their summer study, all students are required to write a paper on their work which summarizes their major activity and its end product.

The program is conducted on two separate competitive levels: undergraduate and graduate. The format of the paper in both levels is the same. However, the evaluation will take into consideration the difference in the academic level of the students.

All students submitted their research paper for directorate review. Directorate judging panels selected one or two papers from each competition category for the laboratory-wide competition at the Summer Student Symposium on 6 August 2009.

Students selected by their directorate for competition participated in the one-day Summer Student Symposium on 6 August 2009. At the symposium the students presented their papers to the ARL Director and an ARL Fellows panel.

This volume of the Summer Student Symposium Proceedings contains the abstracts for all papers prepared for the Summer Student Symposium Program.

Bio-inspired Wireless Sensor Network Architecture: Event Detection and Localization in a Fault Tolerant Wireless Sensor Network

Alayev, Yosef

One can think of the human body as a sensory network. In particular, skin has several ways to sense, such as touch with different sensitivity and neurons for communicating the sensory signals to the brain. Even though skin might occasionally experience some lacerations, it performs remarkably well (is fault tolerant) to the failure of some sensors. One of the challenges in collaborative wireless sensor networks (WSNs) is fault tolerant detection and localization of targets. In this paper, my mentor and I present a biologically inspired architecture model for a WSN. The diagnosis of sensors in this WSN is derived from the concept of the immune system, and the architecture of the WSN for detection and localization of targets is inspired by the human nervous system. We show that the advantages of such bio-inspired networks are reduced data for communication, self diagnosis to detect faulty sensors in real time, and an ability to localize events.

The author wishes to acknowledge the mentorship of Thyagaraju Damarla.

Aluminum Nitride Direct Bond Copper Microchannel Substrates for Integrated Power Electronics Cooling

Armenteros, Roberto

Silicon Carbide (SiC) is a semiconductor material that is capable of operating at high temperatures and high power levels. Aluminum Nitride (AlN) is a packaging material used in power electronics that is very efficient due to its stability under high temperatures, high thermal conductivity, and electrical isolation. In order for the power electronic devices to function properly, they need a way to be cooled effectively and rapidly, as well as a thick layer of metal for the high current levels. A direct bond copper (DBC) AlN substrate is an ideal material due to the thick (typically 12 μm) layers of copper. The thickness of the copper traces allows it to be capable of handling the large amounts of current used in high power electronics. Furthermore, microchannels can be formed in the AlN to allow the devices to be cooled more directly through the reduction of the thermal stack and increased surface area. To investigate the effectiveness of integrated power electronics cooling using a DBC AlN substrate, a circuit design was patterned on the topside of the substrate, as well as two parallel spaces etched on the backside. The tests detailed in this report also measured the characteristics of cooling at different flow rates.

The author wishes to acknowledge the mentorship of Dimeji Ibitayo.

Fundamental Studies and On-Chip Integration of Nanoporous Energetic Silicon

Becker, Collin

Porous silicon (PS) combined with a solid oxidizer is a promising new energetic material for on-chip integration with microelectromechanical systems (MEMS) or electronics. Currently, the correlation between PS morphology and energy release rate is unclear. Here we characterize the structure of the PS prior to ignition, using Fourier transform infrared spectroscopy, Raman Spectroscopy, and Scanning Electron Microscopy. This characterization is coupled with bomb calorimetry data and pressure measurements to show that by modifying the hydrogen surface termination of the porous silicon, the quantity of gas generated can be tuned without affecting the total energy released. This new discovery will be an important tool for optimization of the material for different applications—for instance, thrusters (maximize gas output) and heat generation (minimize gas output). Finally, as a means to yield high-performing energetic PS on-chip, a galvanic corrosion process is demonstrated. This is a major advancement for energetic PS, offering a more flexible approach to integration than previous work using electrochemical etching. The new galvanic process has no requirement for electrical connection to the wafer during pore formation and is compatible with many more materials than the electrochemical etch process.

The author wishes to acknowledge the mentorship of Luke Currano.

Catalytic Combustion of Alcohols for Microburner Applications

Behrens, Douglas A.

The combustion of energy dense liquid fuels in a catalytic micro-combustor is an attractive alternative to cumbersome batteries. To miniaturize the reactor, I developed an evaporation model to calculate the minimum distance required for complete droplet vaporization. By increasing the ambient temperature from 298 K to 325 K, the distance required for complete evaporation of a 12 micron droplet decreases from 12 to 3 cm. A platinum mesh acted as a baseline measurement and demonstrated 75% conversion of ethanol. I then selected a more active rhodium-coated alumina foam with a larger surface area and attained 100% conversion of ethanol and 95% conversion of butanol under fuel lean conditions. Effluent post-combustion gas analysis showed that varying the equivalence ratio results in two distinct regimes. A regime of high carbon selectivity for CO_2 occurs at low equivalence ratios and corresponds to complete combustion with a typical temperature of 775 K that is ideal for PbTe thermoelectric devices. Conversely, for equivalence ratios greater than 1, carbon selectivity for CO_2 decreases and hydrogen production increases. By tuning the equivalence ratio, I have shown that a single device can combust completely for thermoelectric applications, or operate as a fuel reformer to produce hydrogen gas for fuel cells.

The author wishes to acknowledge the mentorship of Dr. Ivan C. Lee.

Ballistic Testing of Eyewear

Bender, Jesse

The eyewear worn by Soldiers is essential for their protection. A blinded Soldier can do little to defend himself or his comrades; therefore, every effort must be made to protect his vision. Previously, safety glasses issued to Army personnel protected them against spall (fragments blasted off of objects by a ballistic projectile), but did not ensure protection against lasers, which are is becoming much more prevalent on the battlefield. Recently, new safety glasses have been developed that claim to protect against certain lasers while still providing the same protection against ballistic spall. The objective of the test was to determine if the new glasses maintained the military specifications for spall protection by Soldier eyewear. The glasses (Frame 35 type and Frame 38 type) were tested according to section 4.4.1.1 of performance specification MIL-PRF-31013 for a total of 40 hits per eyewear type. Results were obtained through pre- and post-photographs, as well as high-speed video of each shot. All of the shots conducted according to the MIL-SPEC passed; however, a few hits at velocities below the specification produced cracked or perforated lenses. Additionally, many of the shots resulted in irreparable damage to the frames or hinges, rendering the glasses useless after one hit. Although there are some issues with the practical performance, the eyewear passed the official specification and thus can be implemented as a replacement for the current design.

The author wishes to acknowledge the mentorship of Robert Kinsler.

Characterization of Transmission Lines for Nonlinear High Power Microwaves

Betancourt, Allison

The purpose of the project is to characterize the material in transmission lines, specifically Barium Strontium Titanate or BST, a ceramic nonlinear material. The materials dimensions are 25mm x 8mm x 0.5mm. Three different experiments will help find the Capacitance-Voltage (CV) measurement, the breakdown point, and the time constant of BST.

The first test will help to calculate the CV. How the capacitance changes as the high voltage changes will be calculated with an LCR meter. The problem is that there is no commercial set-up for measuring the high voltage in excess of 15 kV, so a protective circuit must be made to protect the LCR meter from the high voltage, as well as an AC voltage applied to the circuit. This is done with the help of capacitors and a diode bridge. The second test will calculate the time constant of the BST. A high voltage IRCO pulsar ranging from 2 kV to 25 kV will be used and the circuit will be measured by an oscilloscope. The oscilloscope will measure the rise and fall time of the pulse into a high impedance load. The third test is the high voltage breakdown test. Silver epoxy will be used to attach the leads of the voltage source to the BST material itself. High voltage will then be run across the material. The source will signify when the material has broken down by measuring if there is a current across the circuit. The current indicates that the material is broken down.

This project is still in the set-up stages.

The author wishes to acknowledge the mentorship of Marc Litz.

Compton Diode Measurements of Ionizing Radiation from Linear Accelerators

Bilenky, Aaron

The U.S. Army Research Laboratory operates two linear accelerators with maximum energies of 2 and 6 MeV. Confirmation of radiation characteristics of the accelerators are made with Compton diodes. Compton diodes are most efficient above 3 MeV. In this effort, I explore the use of Compton diode structure and extend the use down to 1 MeV. I then describe and discuss the measured results.

The author wishes to acknowledge the mentorship of George Merkel.

Angular and Axial Dosimetry

Brent II, Jim

The U.S. Army Research Laboratory operates 2 MeV and 6 MeV linear accelerators as x-ray sources. The radiation intensity and spectrum differs with angle and distance from the tungsten converter. I measured the dose (energy deposited) as a function of angle and distance from the sources. The radiation intensity falls off as ~1/r^2. The angular distribution of the dose can be calculated in large part from the collimators used after the converter. The predicted angular distributions compare well with the measured results. I will test the angular radiation intensity in an area of 100° in front of and around the output of the 2 MeV linear accelerator x-ray source. I will measure angular radiation intensity in an area of 180 degrees from the output of the 6 MeV linear accelerator. Both the axial measurements will be taken to up to 1 m from both the linear accelerators.

The author wishes to acknowledge the mentorship of Marc Litz.

High Sensitivity Gamma Detection with HPGe Detectors

Burns, David

Isomers are energetic materials that can be stimulated for enhanced decay. Photon cross-section for stimulated decay must be measured in order to develop these materials as power sources. The cross sections are small and require very sensitive measurement techniques. An high-purity germanium (HPGe) detector system has been improved with several kinds of shielding to increase the sensitivity of these measurements. An enclosure consisting of a lead brick layer, a tantalum layer, and a copper layer—also filled with nitrogen gas—serves to reduce the natural background radiation that is normally present in an HPGe detector setup. Total noise reduction of 400 times was observed.

The author wishes to acknowledge the mentorship of Marc Litz.

Investigation of Structure/Transport Property Correlations in Nanocomposite Polymer Gel Electrolytes

Capaldo, Brian

For this effort, I made gel electrolytes with varying amounts of silica to determine their ability to serve as structural electrochemical energy storage elements. Fumed silica nanoparticles with a surface area of 200 m^2/g were added to polymer electrolyte matrices in quantities of 2.5% and 5% by mass. The polymer electrolyte matrices consisted of a mixture of either (1) Epon 828 epoxy resin cured with para-amino cyclohexyl methane (PACM) or (2) Sartomer SR 209 or SR 494 vinyl ester resin with a liquid electrolyte comprising 1-M of lithium salt in either propylene carbonate or poly(ethylene glycol) (PEG) 200. The samples were mixed under anhydrous conditions, cured at room temperature, and post-cured at 70 °C for 1 h. The mechanical properties were evaluated using dynamic mechanical analysis, and the ion transport was evaluated using electrochemical impedance analysis.

The author wishes to acknowledge the mentorship of Dr. James Snyder, Ph.D.

Multi-Functional Carbon Nanotube Metal Matrix Composites

Carey, Brent J.

The material demands of advanced weapons technologies have pushed the limits of available metals and alloys, emphasizing the need for next-generation lightweight, multi-functional materials. Carbon nanotubes (CNTs), whose tensile strength and thermal and electrical conductivity along their axis exceedingly surpass virtually all known materials, have been shown to provide marked increases in the mechanical strength and hardness of metal matrix composites (MMCs); conversely, their influence on bulk thermal and electrical conductivity has been largely overlooked. Here, we explore the improvement of these three fundamental properties for two novel CNT MMC architectures: (1) a vertically-aligned array (forest) of CNTs infiltrated with molten aluminum to achieve an anisotropic, continuous fiber composite, and (2) a CNT-reinforced surface coating applied through cold spraying. The application of a 1 μm sputter-coated layer of aluminum on the CNTs resulted in the encapsulation of all exposed nanotubes, a promising result which strongly suggests an affinity between the two materials and efficient interfacial interaction. Preliminary data also highlights the viability of non-destructively impregnating the CNT forests with aluminum via capillary action, a technique demonstrated previously with a polymer matrix. These composites should significantly improve upon already-existing materials for applications where greater structural integrity, thermal diffusivity, and high electrical conductance are desired.

The author wishes to acknowledge the mentorship of Jerome Tzeng, Ph.D., and Shashi Karna, Ph.D.

Low Noise Amplifier RF Direct Injection Experiment

Chase, Robert M.

A low-noise amplifier (LNA) is commonly used in the front end of radio frequency (RF) receiver circuits that are used in a wide variety of military and commercial applications. Understanding the strengths, vulnerabilities, and characteristics of these components is vital to the development of dependable communications and other products that will eventually be deployed in support of the warfighter. I conducted tests to measure the RF power/energy required to produce upset/damage to both gallium arsenide (GaAs) and gallium nitride (GaN) based LNAs (i.e., RF effects and susceptibility levels). Since the effect level for the LNA can depend upon the frequency and modulation of the RF energy, I measured its susceptibility to various frequencies and modulation schemes. To determine if there was an effect as a result of the interfering RF pulses, I used a known reference signal for the LNA's input and monitored the output before, during, and after the RF interference pulses were introduced. The plan is to use the data to compare the relative susceptibility levels of GaAs with GaN devices to see if one technology is more robust than the other against RF pulse interference. Data is currently being gathered manually, but a MATLab program is being developed to automate the data collection and analysis to ensure consistent and accurate results.

The author wishes to acknowledge the mentorship of Andre Witcher.

Analysis and Design of a Processing Frame to Control Gap Width and Variability in Ceramic Tile Arrays

Cohen, Brian

The need for reproducible dimension tolerances is critical in ceramic armor tile arrays. A common tile array uses hexagonal ceramic tiles assembled into a tightly spaced pattern. The free space between tiles is filled with composite graphite/epoxy inserts on the order of 20 mils (0.020 in.) in thickness. During processing, this armor strikeface is thermally cycled and the tiles will shift if not properly held together. In order to maintain uniform spacing, a mechanical fixture was designed and constructed. This paper explores the design process, including rudimentary modeling and tradeoff analysis for such a fixture. Ultimately, computer-aided design (CAD) models are provided for an appropriate steel frame to constrain the tile array during the process heat cycle. If successful, this approach will be transferred to BAE Systems, Inc., for insertion into an armor manufacturing line.

The author wishes to acknowledge the mentorship of Seth Ghiorse.

X-ray Fluorescence

Cornell, Zachary

Inducing the decay of radioisotopes is a strategy for generating higher power output levels from isotopes. In this way, isotopes can be transported in a low power decay state, and then decay can be accelerated (power increased) as demanded in the field. This type of power source would be useful in developing compact low-power for sensors. Measuring the changes in the decaying states of atoms can be performed through x-ray fluorescence. I describe techniques to make accurate and sensitive measurements of x-ray fluorescence. Numerical models based on Monte Carlo simulations have been developed to predict experimental results. I discuss comparisons between measurement and modeling. Preliminary comparisons show that new energy levels predicted from scattering events are also measured in the experiments.

The author wishes to acknowledge the mentorship of Marc Litz.

Blast Venting and Quasi-Static Pressure Study

Daly, Anthony

The objectives of the blast venting study was to improve upon preexisting software analysis models to allow for a more complete understanding of the quasi-static pressure build up within an enclosed space. The U.S. Army Research Laboratory (ARL) Two Room Blast Structure (2RB) was used to conduct a group of tests using varying charge sizes and areas of ventilation to determine a relationship between those two parameters. All explosive charges were statically detonated from the geometric center of the room and the pressure information was gathered using an array of eight pressure gauges. The software, WaveMetrics Igor Pro, was then used to analyze and graph the pressure over time, and the graphs were then compared to the current software models to begin to develop a more accurate program.

The author wishes to acknowledge the mentorship of Brendan McAndrew.

Understanding Optical Properties of Novel Ceramics and Single Crystals for Future Lasers

Damiano, Michael

This report documents the work performed in the summer of 2009 under the STEP Program in the Electro-Optics and Photonics Division of the Sensors and Electron Devices Directorate (SEDD) at the U.S. Army Research Laboratory in Adelphi, MD. I studied single crystals and novel ceramics, and then I conducted experiments to help shed light on innovative ways in which the military can exploit their properties in future lasers.

The author wishes to acknowledge the mentorship of Larry D. Merkle.

The Effect of Ceramic Surface Texture on Measured Dielectric Properties

Denault, Kristin A.

This project uses an in-house dielectric measurement system to study the effect of surface roughness on the measured dielectric constant of ceramics. Two varieties of silicon carbide (SiC) tile were analyzed, SiC-N and SiC-X1. Three groups of surface treatments were used: as-received factory finished tiles, tiles subjected to successive amounts of grit blasting, and tiles subjected to various amounts of indents. The in-house dielectric measurement system was used to index all the SiC tiles used and provided a method to identify cracks and voids. Reference tiles were also studied in order to assess the sensitivity of the in-house method. The results illustrate that for the SiC-N and SiC-X1 reference tiles, the average coefficient of variation for the measured dielectric constant recorded over 10 days was 5.46% and 3.83%, respectively. The results also show that after 240 s of grit blasting, the average surface roughness increased by about 550% for the SiC-N and SiC-X1 tiles and the measured dielectric constant decreased by about 28% and 14% for the SiC-N and SiC-X1 tiles, respectively. Data from the tiles indented with up to a maximum of 0.14% surface area removed from contact with the electrode showed no effect on the measured dielectric constant.

The author wishes to acknowledge the mentorship of Todd Jessen.

Novel Organic Metal Electrodes and Fabrication of Thin Film Transistors for Flexible, Organic Applications

Douglas, Erica

Organic-based electronics research began in the 1940s, when the first commercial organic electronics device was a photoreceptor imaging plate for analog photocopiers (Xerox). With the success of this commercial technology, organic electronics subsequently expanded to more complex device architectures, such organic light emitting diodes (OLED), organic thin film transistors (OTFT), and organic based photovoltaics. The current mobility for OTFTs, now approaches or even exceeds that of amorphous silicon TFTs, the current enabling technology for commercial liquid crystal displays. As the applications increase, OTFTs remain three orders of magnitude less than single crystal transistors. However, organic semiconductors exhibit many promising characteristics, such as low temperature processing, mechanical flexibility, and low cost processing. Demand for transparent flexible displays, however, now becomes increasingly imperative, especially for military applications, where present glass liquid crystal displays do not meet the durability, low weight, and low power consumption requirements for Soldiers on the battlefield. The ability to fabricate high performance OTFTs and OLEDs at low temperatures on flexible substrates would allow for the fielding of various useful applications, such as wearable health-sensor arrays, electronic paper, and energy harvesting. To accomplish this, OTFTs need additional research to improve the mobility of the active channel, while reducing both the contact resistance at the source and the electrode drain, while improving operating stability. Further, sensor applications will ultimately demand complimentary transistor devices (CMOS), where OTFTs are the PMOS and devices such as a-Si and mixed-oxide TFTs are the NMOS. This paper, therefore, reports on the fabrication and characterization of active layer organic transistor materials, as well as novel materials towards improved conductances for the electrode.

The author wishes to acknowledge the mentorship of Eric Forsythe and Sanchao Liu.

Micro-Torque Measurement using a Flywheel

Etchison, Joshua

Micro-robotic applications exist in many areas, including surveillance and miniature simulators. These applications range from micro-aerial vehicles (MAV) to an air-speed simulator. To increase development of micro-robotics, it is imperative that the performance of the relevant micro-rotary motors is known. Having a device that can measure the performance of different micro-rotary motors is essential to increasing prototyping in the field of micro-robotics. One approach to this is a micro-dynamometer using a flywheel. The micro-dynamometer design presented spins a flywheel using a micro-rotary motor to calculate the torque, which can be calculated if the moment of inertia and angular acceleration are found. The micro-dynamometer is able to measure the performance of micro-scale motors quickly and easily to determine the use of a motor for a particular application.

The author wishes to acknowledge the mentorship of Harris Edge.

Very Affordable Precision Projectile State Estimation Using Kalman Filtering

Fairfax, Luisa

The U.S. Army Research Laboratory (ARL) has been designing and testing a Very Affordable Precision Projectile (VAPP), which uses canard deflections in order to guide to target or range. In the case of a global positioning system (GPS) jam, the projectile must still measure and estimate its states in order to control and navigate to target. There are two methods for finding states: using an inertial navigation system (INS), which may incorporate accelerometers, gyroscopes and magnetometers, which are subject to sensor drift and noise; or using a model of the system, such as a simple dynamic model of the system like a point mass model. Using both INS and a point mass model, a Kalman filter can accurately propagate projectile states forward in time, and thus can be used to guide the projectile in the event of a GPS jam and help to hot-start the GPS. This paper will show that when GPS is intermittent or absent, a Kalman filter implementing the point mass model along with an INS system can track projectile states, improve precision, and guide the projectile to target.

The author wishes to acknowledge the mentorship of Dr. Frank Fresconi.

2.4 GHz High Voltage/High Power Amplifier Implementation with SiGe HBTs

Farmer, Thomas

A two- and three-stage High Voltage/High Power (HiVP) Power Amplifier has been designed, implemented, and measured using a 0.12 um silicon germanium (SiGe) Heterojunction Bipolar Transistors HBT process. The purpose of this work is to discuss the first ever HiVP device implementation using SiGe HBTs at gigahertz frequencies. The HiVP configuration allows for very large output voltage swings leading to high output power. The intent of this paper is (1) to provide a practical framework for simulation of a HiVP in silicon based technologies, and (2) to show the results of a 0.12 um SiGe HBT implementation of the HiVP at 2.4 GHz.

The author wishes to acknowledge the mentorship of Ed Viveiros.

Detection Optimization of the First Peptide-Derived Handheld Assay

Faulkner, Kasey

The rapidly emerging and evolving landscape of biological hazards requires new technology to develop detection methods against emerging threats. It is essential for the Army to be able to identify biologically hazardous material in food, water, the environment, and the battlefield. Currently, researchers are working to use peptide libraries to rapidly determine affinity reagents within one week rather than the current method of producing monoclonal antibodies in living animals, which can take months. The affinity reagents developed from peptide libraries can then be combined into a compact handheld device that uses a lateral flow assay to detect hazardous biological materials. The selection and design of the lateral flow assay materials must facilitate proper binding between various peptides and their targets in order to give an accurate and rapid response.

The author wishes to acknowledge the mentorship of Dr. Joshua Kogot.

Exploring Photonic Upconversion for Development of a Cryogenic High Energy Laser

Fick, Alexander B.

The military has long valued High Energy Laser (HEL) technology because of the wide variety of HEL applications which potentially can make significant contributions. However, thus far, only chemical lasers have been capable of providing the required multi-kW energy output at desired wavelengths, and they suffer from high logistical costs and lack of portability. In order to make HEL systems more practical for today's Soldiers, solid-state laser systems are currently being developed in hopes of scaling up their output power. One solid-state material which showed promise was erbium-doped yttrium aluminium garnate (Er:YAG). However, it suffers from Cooperative Pair Upconversion (CPU) which can cripple the laser's output energy. I studied this upconversion phenomenon to investigate the limitations it places on increasing the output power from Er:YAG to a high energy system, as well as the benefits of operating at cryogenic temperatures. Results provide a quantitative description of how upconversion will affect a given Er:YAG system, and show that, although data has not yet been analyzed for cryogenic experiments, low temperatures should allow significant gains in output power of an Er:YAG laser.

The author wishes to acknowledge the mentorship of Dr. Jeffrey O. White.

Fretting Fatigue Investigation of CH-47 Chinook Engine/Transmission Materials

Fudger, Sean J.

The objective of this research was to evaluate the performance of materials associated with CH-47 Chinook engine/transmission (E/T) gears that have experienced a fretting fatigue based failure mechanism in service. Boeing was tasked by the U.S. Army Cargo Program Management Office (PM Cargo) and the U.S. Army Aviation and Missile Command (AMCOM) Safety, Airworthiness Authority and Combat Developer to undertake a risk reduction program in conjunction with the U.S. Army Research Laboratory (ARL). As part of the program, ARL developed a unique fretting fatigue machine to reproduce the failure mechanism observed on the materials within the E/T systems. ARL has produced S-N curves to compare and contrast the performance of various material couples, carburization levels, coatings, surface enhancing processes, and lubricants as a possible solution to further evaluate the issue at hand. To determine how the carburization process has affected the materials fatigue strength, specimens were produced in three distinct carbide levels: low, medium, and a level that represents the currently fielded gear average (production). In this paper, I discuss the fretting fatigue performance of the various material couples and the typical fractography observed.

The author wishes to acknowledge the mentorship of Scott M. Grendahl.

Development of a Biomimetic MEMS Directional Microphone

Gee, Danny

Sound localization is a critical asset to the Soldier, providing the necessary situational awareness for threat detection and target acquisition. In this work, a microelectromechanical systems (MEMS) directional microphone is presented that is inspired by the auditory sensory organ of a parasitoid fly, *Ormia ochracea*. The directional microphone amplifies the interaural time difference (ITD) between two adjacent silicon membranes with a coupling beam. Using a laser Doppler vibrometer to detect the mechanical response, an ITD of 34.96 μs is detected. This first-generation MEMS directional microphone is 35 times smaller than a similarly designed machined microphone and generates a time delay amplification factor of 10, which is more than double previously reported values. The ideal amplification factor of the *Ormia ochracea* is ~45. The corresponding directional sensitivity of the fabricated microphones is .39 μs per degree of incident angle. Preliminary data from a parametric study shows a compelling relationship between the central pivoting anchor and the measured acoustic cues. The results of this work provide a foundation for realizing an accurate biomimetic MEMS directional microphone.

The author wishes to acknowledge the mentorship of Luke Currano.

Investigation of Separator Materials for Structural Composite Supercapacitor Applications

Geinger, Edwin

Development of efficient multifunctional structures is of interest for mass reduction in a variety of Army platforms. Structural batteries and supercapacitors are of particular interest for their ability to provide energy storage in load-bearing materials. Electrical separation of the electrode materials is required to prevent shorting and reduce self-discharge of the energy storage component. Polymer-based separator materials are typically used in traditional energy storage devices. For multifunctional composite applications, this separator must also facilitate interlaminar bonding while maintaining chemical and physical compatibility. In this study, a series of inter-electrode separator materials were investigated for adhesion, resistance, and lap shear strength. Vacuum-assisted resin transfer processing setups were used to fabricate composite-based supercapacitors. Throughout processing, resistance through the cells was monitored using a multimeter, and trends in resistance and overall resistivity were determined. Lap shear tests were conducted to better understand the effect each materials would have on system strength as well as the separators' adhesion to the resin matrix and carbon fabric electrodes. The mode of failure for each material was also determined. The results of the experiments are instrumental in determining the proper electrical separator to use in structural energy storage devices.

The author wishes to acknowledge the mentorship of James Snyder.

Surface Engineering of Materials by iCVD, Sputtering and Plasma Processes

Geist, Peter

This paper describes the current progress and future initiatives being made at the U.S. Army Research Laboratory (ARL) in the area of creating functionalized surfaces. In this effort, polymer surfaces and silica microspheres were treated using fluidized bed sputtering of atmospheric and low pressure plasmas to modify the surface of the material. During sputtering, glass spheres are agitated at a certain frequency under vacuum and placed under a magnetron sputtering head, which deposits metal on the particles. Low pressure plasma treatments done in a vacuum chamber can be used for plasma-enhanced chemical vapor deposition (CVD), nanotube growth, or preparation of surfaces for subsequent chemical treatments. When using atmospheric plasma, bulk material is exposed to a high-speed radio frequency (RF) arc that discharges outside of a vacuum system for etching or cleaning. ARL is also beginning to study the use of iCVD, a technique in which glass spheres (d =10−100 micrometers) are placed in a rotating flask under vacuum, cooled in a water bath, and exposed to heated a monomer for the deposition of polymeric coatings. All of these techniques can functionalize surfaces in various ways, such as adding free radicals, etching, cleaning, and depositing coating. Applications of these functionalized materials include optical devices, self-healing materials, vehicle armor, body armor, and nanoparticles for tailored mechanical interaction.

The author wishes to acknowledge the mentorship of Derek Demaree.

Dimensional Analysis of Impulse Delivered from a Shallow Buried Explosive

Glomski, Patrick

The impulse delivered to an armor plate from a shallow buried explosive (SBE) blast is directly proportional to the plate's dynamic and permanent deflections. Thus, determining the impulse delivered to a vehicle underbody from an SBE is of prime importance in hardening vehicle structures against SBE blasts. However, full-scale SBE experiments require a large amount of manpower and time, and are expensive. Scaled experiments would allow for a more rapid investigation of structural hardening concepts and materials needed to mitigate SBE blasts as well as an examination of variables such as moisture and soil type that affect the output of SBEs. In this effort, SBE impulse data from several sources are compiled and dimensional analysis is used to formulate a functional relationship between soil, explosive, air, and target properties and the total impulse imparted to the target. Using this developed functional relationship, preliminary results indicate the viability of scaling SBE blast experiments, which would enable ARL to rapidly screen materials, structural concepts, and soil parameters at reduced cost.

The author wishes to acknowledge the mentorship of Dr. Bryan Cheeseman.

Structure and Properties of Carbon-filled Physically Associating Gels

Gold, Christopher

For this effort, a study was conducted on physically associating triblock copolymer gels to determine the effect of filler geometry and concentration on mechanical properties. The material used was a poly[styrene-b-(ethylene-co-butylene)-b-styrene] (SEBS) triblock copolymer, which had been swelled with mineral oil to form a non-aqueous thermoplastic elastomer gel (TPEG). The mechanical properties studied were Young's modulus (E), both in tension and compression, and the shear modulus (G), in oscillatory (torsional) shear. The effect of the fillers on moduli and maximum strain was minimal, generally affecting the modulus by only a few percent. The carbon black fillers and carbon nanotubes typically showed no change or a slight increase in modulus. Ongoing studies will be aimed at determining whether this effect is due to poor filler dispersion, size or agglomeration, chemical incompatibility, or other factors.

The author wishes to acknowledge the mentorship of K. E. Strawhecker.

The Effects of Calcium Doping on Transparent Magnesium Aluminate Spinel ($MgAl_2O_4$)

Green, Matthew

This study is a continuation of previous work conducted by Sutorik et al. in an effort to assess commercially available starting powders for the production of transparent magnesium aluminate spinel ($MgAl_2O_4$). Particularly, this effort aims to understand what levels of calcium impurity become detrimental to the functionality of $MgAl_2O_4$ as a transparent armor system, and what levels could be acceptable in starting powders for large-scale manufacture. As of now, the cost of producing transparent $MgAl_2O_4$ for large-scale transparent armor applications is impractical. One possible way to minimize the costs of transparent $MgAl_2O_4$ armor would be to use less-refined starting powders with higher levels of elemental impurities. A constituent used in the production of $MgAl_2O_4$ that will be examined is magnesium oxide (MgO). The effects of an impure MgO source will be tested by doping samples of $MgAl_2O_4$ with various levels of calcium carbonate ($CaCO_3$), and determining the effects it has on selected properties and characteristics of the spinel system (i.e., electromagnetic [EM] transmission, elastic modulus, hardness, etc.).

The author wishes to acknowledge the mentorship of Dr. Anthony C. Sutorik.

Synthesis of a Novel Bio-Based Styrene Replacement

Greer, Sylvester

In recent years the Department of Defense (DoD) has begun heavily using composites. Unfortunately, the creation of composites involves hazardous air pollutants (HAP) and volatile organic compounds (VOC). One of the most ubiquitous of these pollutants is styrene, and one solution to styrene pollution is to replace it. This paper details efforts to create a bio-based, nonvolatile replacement for styrene for use as a vinyl ester or unsaturated polyester monomer. The proposed replacement monomer was designed as a product of furoic acid (naturally derived) and glycidyl methacrylate, whereby the furoic acid carboxylic acid ring opens and adds to the epoxide of glycidyl methacrylate. Regrettably, the produced monomer proved nonviable due to its viscosity. It was concluded that the chemical reaction associated with the production of a styrene replacement monomer was plagued by side products.

The author wishes to acknowledge the mentorship of Dr. John LaScala.

Extended Kalman Filter Implementation and Analysis on Man-portable Autonomous Robots

Gregory, Jason

Accurate position estimation is a vital factor for precision autonomous navigation and becomes even more important when applied to man-portable robots. Due to physical and atmospheric interference, global positioning system (GPS) data is often unreliable. Similarly, magnetic compass and odometry data can be inaccurate and prone to measurement drift. However, when combined with compass and odometry data, noise present in GPS data can be removed from the raw data by using an extended Kalman filter (EKF). This allows for consistent and accurate position estimations to be made, resulting in more precise navigation. The U.S. Army Research Laboratory's (ARL) Computational and Information Sciences Directorate (CISD) has a semi-autonomous man-portable robotic platform called the PackBot that is capable of GPS waypoint following. As with most small robots, the PackBot has limited processing resources. With autonomy software consuming much of these resources, providing accurate position estimation must be done in a computationally efficient manner. This paper will evaluate the performance of an efficient EKF implementation that provides state estimation on the CISD PackBot's organic processor. Further, the paper will explore alternate solutions to the state estimation problem, namely the unscented Kalman filter.

The author wishes to acknowledge the mentorship of Barry O'Brien.

Transport Phenomena in the Alkaline Anion Exchange Membrane Fuel Cell

Grew, Kyle N.

The U.S. Army depends upon its Soldiers' technological advantage to ensure mission effectiveness. Sustaining this advantage requires the development of safe and reliable power sources for the technologies they depend upon (e.g., sensors, communications, and surveillance). Proton exchange membrane (PEM) based direct methanol fuel cells (DMFCs) have been the primary focus for Soldier portable power; however, these systems require expensive noble metal catalysts, which are subject to degradation and crossover depolarization. An alkaline alternative, known for its favorable kinetics with non-noble metal catalysts, could serve as an enabling technology. This paper takes a computational approach to examine recent demonstrations of alkaline anion exchange membranes in fuel cell (AEMFC) applications. These demonstrations have shown substantial resistive losses and activation losses. A framework for understanding the opportunities, limitations, and technical barriers associated with AEMFCs is being developed. This approach focuses on the transport phenomena to elucidate the underpinnings of the conductive transport, the role of water transport, and their coupled effect on activation processes. The studies are validated with published experimental data and comparisons to the PEM literature.

The author wishes to acknowledge the mentorship of Dr. Deryn Chu.

Dielectric Characterization of Composite Materials: An Exploration of Composition

Hamblin, Stacey

A high void volume in a composite material generally lowers the performance of the composite, which makes it an important property to consider. In this study, an in-house characterization method for determining imperfections such as void volume within composite materials was evaluated. The dielectric constant was calculated using capacitance measurements measured in a parallel plate capacitor geometry at a frequency of 1 MHz, and then the correlation between void volume and dielectric constant was investigated. Once this relationship is established, it is proposed that, to within a certain degree, the fraction of air in a given sample can be predicted from the measured capacitance. The objective is to determine the validity of this nondestructive test method so that it can be used as a way to test for panel uniformity over the entire panel.

The author wishes to acknowledge the mentorship of Todd Jessen.

Reynolds Number Matching for Scale Insect Wings

Harrington, Aaron

Reynolds number matching is necessary for aerodynamicists when scaling designs for testing. Whether scaling larger aircraft down to models that will fit in wind tunnels or scaling insect wings up to a larger size, it is important that the ratio of inertial to viscous forces experienced by the fluid be kept as close to the actual vehicle as possible. This paper outlines the methodology for creating a tank used for Reynolds number matching of scaled insect wings so that aerodynamic forces and moments, as well as the flow around the wings, can be better understood. The challenges of scaling insect flapping motion require the use of computer controlled motors to reproduce both the flapping motion, as well as the pitching motion of the wing at each end of the flap. Digital shaft encoders are used to accurately track this motion by monitoring the speed and position of the motor. A custom force balance is also used to measure the forces created by the wing via strain gages in a Wheatstone bridge. This paper will cover these processes of controlling the motors, tracking the flapping motion, and measuring the wing forces for a Reynolds number-matched insect wing in an oil tank.

The author wishes to acknowledge the mentorship of Drew Wilkerson.

Stress Driven Surface Instabilities In Ionic Solids With Charged Point Defects

Henke, Steven F.

Oxides exhibit a wide range of functional characteristics that make them suitable for many technological applications, including electronic devices, sensors, solid-state lighting, and catalysis. In many of these applications, the oxides phases form epitaxial systems with the underlying support structure, giving rise to internal stresses that affect mass transport within the system. Stress-Driven Rearrangement Instability (SDRI) theory postulates that diffusion in stressed solids can lead to surface morphological instability, an effect that is currently believed to be important for elevated-temperature deposition or annealing of thin films. Building upon previous works, we present a continuum reformulation of the SDRI theory, with surface diffusion and bulk point defect distributions. In oxides, however, vacancies are charged, and their distribution is influenced by space-charge formation and the associated internal electrostatic fields. Our model considers such electrostatic effects, coupled with elasticity, in modeling point defects within the bulk. The present theory will enable us to understand the coupled electric, elastic, and chemical interactions in ionic thin film systems, as well as the impact of these interactions on the thin film morphology changes during film deposition and annealing.

The author wishes to acknowledge the mentorship of Peter W. Chung.

Surface Engineering of Ceramics Under Atmospheric Plasmas: A New Alternative Method to Promote Adhesion in Composites

Ho, Christine

In this work, I report on the surface modification of ceramic materials due to helium, helium-oxygen, and helium-nitrogen dielectric barrier discharge (DBD) exposure operating under atmospheric pressure. The ceramic material studied was alumina (Al_2O_3). As-received alumina samples were compared to samples that were grit blasted and samples that were treated under various plasmas conditions. After the samples were treated, surface characterization techniques were used to study the impact of processing on the surface properties for the treated alumina. Wettability, x-ray photoelectron spectroscopy (XPS), and atomic force microscopy (AFM) results revealed that plasma processing is a promising alternative method to modifying the surface. Wettability tests revealed improvement of the hydrophilic character of the surface as the water contact angle measured after the plasma treatment significantly decreased by 24% with He-O_2 plasma for 0.85 s. These experimental results are attributed to the presence of oxygen-containing groups that exist on the surface due to plasma treatment and grit blasting, as confirmed by XPS analysis. AFM revealed the surface roughness of each treatment method. The control sample surface roughness was found to be 136.8 nm; whereas, the grit-blasted and plasma-treated samples were 205.5 nm and 176.4 nm, respectively.

The author wishes to acknowledge the mentorship of Daphne Pappas.

Characterization of PbSe Uncooled Infrared Sensor Material

Hood, Demere

Uncooled lead selenide (PbSe) infrared sensors have a state-of-the-art performance, but the physics of how they work is not fully understood. In order to gain a better understanding, we studied samples of PbSe infrared material in this work. The Hall effect was used to measure the mobility and carriers type (holes and electrons). X-ray photoelectron spectroscopy (XPS) was used to characterize the surface chemistry. The major surface species is a mixture of lead oxide (PbO) + selenium dioxide (SeO_2) with overall average composition $PbSeO_3$. Electron microscopy and the Mean Linear Intercept method were used to obtain the average grain size measurement of 1.4198 μm.

The author wishes to acknowledge the mentorship of Patrick J. Taylor.

Development of Novel Characterization Methods to Obtain Loading Rate Effects of Protective Materials

Huang, Jamie

Two research projects attempted to test the failure properties of protective materials under high- and low-rate testing: (1) the stress-strain response of single polyethylene fibers as a function of strain rate and (2) the flexural strength of a ceramic material as a function of loading rate. In the first project, single polyethylene fibers were tensile tested to determine their material response as a function of strain rate. Preliminary low-rate tests concluded the current NanoUTM test machine (with a maximum loading limit of 500 mN) was insufficient to cause single fiber failure. A modified split Hopkinson pressure bar (SHPB) for high-rate testing has been developed. The second project tested an armor ceramic material under various loading rates to determine its maximum flexure stress. The four-point bending method (ASTM-C-1161-02c standard) was chosen to test the material, using a modified SHPB for high rate loading and an Instron test machine for low rate loading. Preliminary testing at both rates showed high statistical variations due to loading misalignment. The standard deviation was approximately 36% of the average for high loading rates and 49% for low loading rates. Equipment for both methods is being refined to obtain more consistent results.

The author wishes to acknowledge the mentorship of Tusit Weerasooriya.

Flexible Client-Server Architecture Designed for Testing Optimized Link State Routing (OLSRv2) for Component-Based Routing (CBR)

James, Justin

This paper discusses client-server architecture designed for testing the Optimized Link State Routing (OLSRv2) protocol for Component-based Routing (CBR) implementation. The client-server application was devised to combine maximum performance flexibility with minimal structural ambiguity. The proposed client-server architecture is tremendously adaptable and permits the user to specify any number of parameters related to information exchange. This client-server architecture is necessary because conventional studies have shown that the performance of a routing protocol in a Mobile Ad-hoc Network (MANET) is stoutly reliant on the network environment and/or desired result(s). Consequently, to accomplish the most favorable routing performance in a dynamic network atmosphere, the routing procedure, itself, should be dynamic. One proposed resolution is CBR. In CBR, researchers use a compilation of fundamental component modules from existing routing protocols merged together to construct a distinctive, best possible, on-demand protocol for any set of network circumstances. Consequently, this obliges the implementation of flexible client-server architecture. Since the network constantly changes, the client-server needs constantly change. Flexible client-server architecture ensures maximum compatibility between the client-server information exchanges. The client-server application produced will be used to test the performance of the component modules and overall routing system of OLSRv2. The results of the performance test will be used to implement CBR more effectively.

The author wishes to acknowledge the mentorship of Lisa Scott and Rommie Hardy.

Universal ATV Test Platform

Jaworski, Joseph

I performed research to modify a commercial All Terrain Vehicle (ATV) to meet specific demands. A larger, higher-speed multi-purpose test platform was needed to test autopilot systems and various sensors. Modifications included mounting a servo and designing a linkage so that steering could be autonomously (or remotely) controlled. A servo saver was also designed to protect the servo from shock. A safety brake was also designed so that in the event of a system failure, the ATV would automatically stop. The ATV is to be controlled by a propeller micro-processing chip, which will allow the steering, speed, and braking to be controlled autonomously or by radio. The chip will also provide a simple interface for lab computers to work with. The eventual goal of this test platform is to create a gas-electric hybrid motor. Manipulator arms are also an envisioned goal.

The author wishes to acknowledge the mentorship of Raymond VonWahlde.

Detection and Localization Sensor Assignment with Exact and Fuzzy Locations

Johnson, Matthew P.

Sensor networks introduce new resource allocation problems in which sensors need to be assigned to the tasks they best help. Such problems have been previously studied in simplified models in which utility from multiple sensors is assumed to combine additively. In this paper, we study more complex utility models, focusing on two particular applications: event detection and target localization. We develop distributed algorithms to assign directional sensors of different types to multiple simultaneous tasks using exact location information. We extend our algorithms by introducing the concept of fuzzy location, which may be desirable to reduce computational overhead and/or to preserve location privacy. We show that our schemes perform well using either exact or fuzzy location information.

The author wishes to acknowledge the mentorship of Lance Kaplan and his co-authors Hosam Rowaihy, Diego Pizzocaro, Amotz Bar-Noy, Lance Kaplan, Thomas La Porta1, and Alun Preece.

Investigation of Spin-Yaw Resonance for Maneuvering a Finned Projectile

Jones, Paul

The U.S. Army Research Laboratory (ARL) is designing a guided weapon called the Very Affordable Precision Projectile (VAPP). The VAPP projectile uses two canard actuators (movable fins) to maneuver through the air. While canard actuation is well known for guidance, a less conventional method using roll-yaw resonance (also know as spin-yaw resonance) has significant potential. A recent ARL-sponsored 120-mm projectile test unexpectedly demonstrated a course change of 10°. From unpublished ARL data, it is speculated the projectile encountered roll-yaw resonance. This work examines the exploitation of roll-yaw resonance on the VAPP projectile and numerically demonstrates course changes of up to 22°.

The author wishes to acknowledge the mentorship of Mr. Bernard Guidos.

Spectrograph for use with Lasers

Karrfalt, Karlene

In this experiment we have constructed a spectrograph with a resolution of 0.3 nm/pixel and a detection range of 1–3 μm. We used commercially available components for the detector and spectrometer. A simple lens system was used to couple the detector and the spectrometer. Our preliminary results indicate that we can achieve an accurate measure of wavelength with a maximum resolution of 0.24 nm/pixel, which exceeds our goal of 0.3 nm/pixel.

The author wishes to acknowledge the mentorship of Alex Newburgh.

Characterization of PiezoMEMS Shunt Switches to Enable Improved Phase Shifter Performance for ARL's Compact Radar Program

Keaney, Ken

Piezomicroelectromechanical (MEMS) shunt switches are currently being developed to provide MEMS phase shifters to enable compact radar systems. The scope of this project assesses which of these shunt switches best fits the requirements of the phase shifters. Testing of the devices is ongoing using a SUSS-automated probing station. Each switch is characterized based upon the measured S-parameters via an Agilent E861A PNA Network Analyzer at a frequency range from 10 MHz to 40 GHz, and a series of different measured values including contact resistance, leakage current, isolation, and insertion loss. To determine the value of each design, the yield is analyzed after the devices are finished with testing. In joint operation with the shunt switch evaluations, we are also performing reliability testing of caged devices (precursor to hermetically sealed switches). This system required the construction of an adequate C++ program that properly displays and records the lifetime characteristics of several switch designs. Each design is cycled to failure and the mean output voltage is logged. The results of these testing efforts are expected to dramatically improve the reproducibility and repeatability of switches and phase shifters for use in the compact radar Army Technical Objective (ATO).

The author wishes to acknowledge the mentorship of Dr. Joe Qiu.

Procedurally Generated Human Models using BRL-CAD

Kennedy, Stephen

Existing vulnerability and lethality Ballistic Research Laboratory (BRL)-Computer-Aided Design (CAD) vehicle models often include human models for ballistic analysis. Current methods for positioning human models are cumbersome and time consuming. Most geometric human models placed into target descriptions are created to fit a specific purpose and are not necessarily physically accurate or uniformly applicable to most vulnerability and lethality analysis. My goal over the summer was to write software for the BRL-CAD modeling package that generates an easily posed and positioned human model. The human model's geometric primitives are generated and positioned in my program using anthropomorphic data based on human anatomy and ranges of motion. This procedurally generated human model conforms to human proportionality data gathered from such sources as the 1988 Anthropometric Survey. In this model, the limbs and body are oriented to a specified range of motion for the human body. These parameters allow the generated human model to sit, stand, or lie in the prone position, with each limb being independently oriented. Now, using my program, BRL-CAD human models can be created easily and accurately, thus increasing the benefit of vulnerability and lethality analysis generated using them.

The author wishes to acknowledge the mentorship of Edwin Davisson.

Targeting of *Pseudomonas aeruginosa* Biofilms with Lectins

Kim, Elizabeth

Biofilms are bacterial communities embedded in a network of extracellular filaments, which serve to protect bacteria from environmental challenges. It is important to develop methods for detecting and treating biofilms, as their presence in hospitals and in food production presents significant challenges. Current methods for biofilm detection are not sensitive enough, and treatment with antibiotics is not always effective. Here, the utility of the lectins *Marasmium oreades* agglutinin (MOA) and *Hippeastrum hybrid* (HHA) for targeting biofilms from *Pseudomonas aeruginosa* is explored. Additionally, one of the lectins is linked to silver nanoparticles to explore the possibilities of using nanoparticles to provide sufficient release of ionic silver for bacterial killing or as scaffolds for attachment of bioactive molecules. Our results show that both MOA and HHA bind to the extracellular filaments of biofilms from *P. aeruginosa*. The interior of the biofilms is accessible for both the labeled lectins and the labeled avidin, which binds to biotinylated HHA. This is a work in progress, and the biotin-conjugated silver nanoparticles process is currently being developed to be linked to the HHA-bound avidin.

The author wishes to acknowledge the mentorship of Dr. Paul Pellegrino.

Synthesis of Monodisperse Au Nanorods for Fluorescence Sensing

King, Nathan

Toxins in both water and food supplies are an extreme threat to U.S. Soldiers; the need for a fast, accurate sensor of these toxins is obligatory. Our research aims to solve this problem by synthesizing near–infrared (IR) emitting "green" bio-nanosensors capable of detecting biological agents using luminescence. Lanthanide-doped oxide molecules have shown promising efficiency in undergoing the necessary luminescence quenching for the sensing application when coupled with gold (Au) nanorods. With the application of a reliable nanorod synthesis and the application of a peptide-binding scheme for this specific dye molecule, a rapid, sensitive near-IR bio-nanosensor can be developed.

The author wishes to acknowledge the mentorship of Dr. Joshua Kogot.

Fast Curing Underwater Adhesives

Klankowski, Steven

Current adhesive technology performs very poorly in high moisture or underwater areas, suffering from dramatic reductions in adhesion quality and overall strength with a significant increase in cure time. Research has focused primarily on improving two adhesive attributes of existing adhesive compounds: the surface wetting and the speed of cure in aqueous environments. Using Sartomer M Cure 400 and modifying currently available epoxy and acrylate-based adhesives, a much faster curing adhesive can be obtained. Current results show a two-fold increase in cure speed with as little as a 4% addition of M Cure 400 monomer, when used with Devcon 1 Minute Epoxy or 3M DP805 acrylic adhesives in dry condition. When placed in wet conditions, the cure time and bond quality is significantly affected.

The author wishes to acknowledge the mentorship of Dr. John LaScala.

Development and Implementation of a Toolkit to Aid in the Review of Data for Prognostic Algorithms

Klein, Brittany

The development of diagnostic algorithms that can gauge the health of a mechanical system, and prognostic algorithms that predict its remaining useful life, is critical to implementing the practice of condition-based maintenance on the Army's vehicles. This allows for potential failures to be repaired before they occur, and for extended use of healthy parts instead of replacing them strictly by maintenance schedules. Seeded-fault testing is a methodology that is used to determine fault progression signatures leading up to part failure. To create effective diagnostic and prognostic algorithms, a significant amount of data must be acquired and processed. A toolkit in MATLAB has been created to streamline the process of initial data examination. The toolkit can process multiple files at once, and display raw data, histograms, and both fast and short-time Fourier transforms, along with basic statistics, to aid the end-user in determining at a glance what data files may be of primary interest for developing algorithms. More advanced algorithms developed to detect bearing and gear faults were also implemented. A description of this toolkit, as well as the results of its analysis on seeded fault data obtained from a bearing fault simulator, are detailed in this report.

The author wishes to acknowledge the mentorship of Kwok Tom.

Novel Impact Testing of Composite Laminates

Lawrence, Bradley

While most composite structures are designed such that loads are aligned with the fiber direction of the material, certain situations will subject such structures to high loadings, causing them to sustain damage. The aerospace industry has done extensive work involving the damage tolerance of composite materials. A new research program at the U.S. Army Research Laboratory (ARL) aims to expand upon this work and to apply it to thicker, heavier-duty structures. The goal of this research is to develop a test method for determining durability and to quickly rank and develop novel Army composites in applications involving multiple impacts. In this work, samples of three resin matrices reinforced with eight plies of S2 glass were impacted as per the test method specified in American Society for Testing and Materials (ASTM) standard D 7136. We used three analysis methods to assess the extent of impact damage present in the samples, and we used digital image correlation (DIC) to measure sample displacement and to validate a finite element model of the impact process.

The author wishes to acknowledge the mentorship of Travis Bogetti.

Analytical Prediction of Lower Leg Injury in Vehicular Mine Blast Events

Li, Justine

Modeling the effects of anti-vehicular mines on the lower human body through both experiments and finite element models is expensive. The objective of this project is to produce accurate predictions of maximum axial tibia loads through the development and verification of a one-dimensional (1-D) analytical model. In this effort, a 1-D analytical model of the lower leg was created and evaluated for its accuracy in predicting the maximum tibia force given a displacement over a period of time. The calculated forces were compared to the experimental data presented in Bir (2006). The analysis shows that the model, which uses only springs, leads to convergence of the calculated maximum tibia force. The ideal number of springs to use in the analytical model is determined by the numerical integration method. The calculated maximum force is approximately twice the experimental maximum force. Using a simple spring-mass system of a variable number of elements, I found that using the two-step Runge-Kutta numerical integration method with 50 springs and a factor of 0.5 is accurate with the experimental data presented for the Hybrid-III 50% dummy in Bir (2006). Further verification using more experimental data is necessary to confirm the validity of the model.

The author wishes to acknowledge the mentorship of Rahul Gupta.

Optimization of the Sinterability of Lutetium(III) Oxide Using Microspheroid Powder Derived From Wet Chemical Processing

Lidie, Ashley

We synthesized lutetium oxide (Lu_2O_3) powders using a wet chemical process with ammonium hydroxide (NH_4OH) precipitant. We then compared the processed powders to the initial starting powder in an effort to determine the effect of the wet chemical processing on the sinterability of the powder. With Brunauer-Emmett-Teller (BET) analysis, we determined the specific surface of the two powders, and Field Emission Scanning Electron Microscopy (FESEM) images were used to observe the morphology throughout the processing. The wet processed powder exhibited a unique microspheroid geometry on the order of 15μm. The powder was calcined and analyzed with X-ray diffraction and thermogravimetric analysis to confirm the chemistry of the titrated powder and the reactions that generate Lu_2O_3 during calcination. After sintering and hot isostatic pressing, the densities of the two different samples were measured. We observed that the starting powder had a non-uniform morphology with minimal surface area for solid state reactions that led to significant porosity throughout the sample. As such, the samples derived from wet processed powder achieved 99.99% of theoretical density, while the as-received powder only achieved 99.4% of theoretical density. As a result, the light transmission through the samples was determined to greatly improve with the powders derived from wet chemical processing.

The author wishes to acknowledge the mentorship of Gary Gilde.

Testing of the IDVRN

Lowry, Selena; Tiffany Hayes

As part of the testing effort within the Integrated Distributed Virtual Research Network (IDVRN), we modeled our effort after statistician/educator W. Edwards Deming's idea that "networking is a system of interdependent components that work together to try to accomplish the aim of the system. A system must have an aim. Without the aim, there is no system." Thus, our aim is to (1) build a small replica of network at the Adelphi Laboratory Center (ALC), MD and (2) test the connectivity between our network and an onsite IDVRN, or "enclave." To accomplish our goal, we will need to design and configure a network, understand how a network works, and obtain a better understanding of what networking is. Our plan is to create two enclaves, one with our replica in it and the other with a source device for the testing.

The authors wish to acknowledge the mentorship of Colleen Adams.

Integrating a CFD Code with the EnSight Visualization Software Package

Mack, Roland

This report presents work performed in support of the overall project to advance the state-of-the-art in parachute modeling and simulation (including the fluid-structure interaction), which is part of a multi-year effort by Jackson State University (JSU), the U.S. Army Research Laboratory (ARL), and the U.S. Army Natick Soldier Research, Development, and Engineering Center (NSRDEC). The work focuses on integrating output from a JSU-designed computational fluid dynamics (CFD) code with the Computational Engineering International (CEI) visualization software, EnSight, which is a graphics package used to display results such as velocity, pressure, and temperature. The JSU code uses modern numerical techniques to solve a range of fluids problems, including incompressible flow. The first step in this effort was to perform a sample calculation using the JSU code and display the results to validate and verify (V&V) its capability. We used the standard NSRDEC problem of a disk in a water tunnel for this V&V calculation. The result of this work is a software package that can be used to translate a JSU code mesh and output files into the EnSight data format. Prior to this internship, the JSU code did not support the EnSight format.

The author wishes to acknowledge the mentorship of Jerry Clarke.

Metabolite Analysis of *Clostridium acetobutylicum* Microbial Fuel Cells

Mackie, Tim

The anaerobe *Clostridium acetobutylicum* has shown promise as an active organism in mediator-less, whole-organism, microbial fuel cells. Such cells typically experience two voltage peaks over a week-long incubation period. This paper will demonstrate that these voltage peaks correspond to oscillating acidogenic and solventogenic phases in the metabolic output of *C. acetobutylicum*. We found that voltage peaks correlated to rapid generation of short chain organic acids, while subsequent periods of declining potential correlated to the reduction of these acids to their corresponding alcohols.

The author wishes to acknowledge the mentorship of Dr. James Sumner.

Nanoscale Piezoelectric Energy Harvesting

Mason, Ashley

To expand the scale of piezoelectric research within the Sensors and Electron Devices Directorate (SEDD), I, in conjunction with my mentors, began an investigation around nanoscale harvesting elements. Zinc oxide (ZnO) nanowires were transferred from their original growth substrate to a flexible substrate, which could be used as a platform for straining a wire. The mechanical deformation imposed on the nanowire should be translated into a piezoelectric potential. Since the nanowires are smaller than microwires used in other experiments, I plan to study the dependence of the piezoelectric output on the size of the element used for harvesting. If the individual peaks seen from discrete actuation are not large enough to characterize using electrical characterization equipment, the integration of a storage element may be necessary. Larger scale piezoelectrics have been used to charge nickel metal hydride batteries. During the summer at U.S. Army Research Laboratory (ARL) in Adelphi, I plan to optimize device fabrication and characterization to evaluate the efficiency of a single-wire nanogenerator. The results gleaned from my experiments can aid in the search for a viable power option for nanoscaled devices such as Soldier or vehicular borne sensors.

The author wishes to acknowledge the mentorship of Dr. Stephen Kilpatrick and Dr. Christopher Anton.

Calibration of an Instrumented Treadmill: Instrumented Pole and Protocol Design

McBride, Michaela

Force plates are used to measure ground reaction forces during gait analysis. Instrumented treadmills are built on or around force plates to collect kinetic data for successive gait cycles. To ensure the accuracy of these instrumented treadmills, frequent and thorough calibration is necessary. One tool used for force plate and instrumented treadmill calibration is an instrumented pole, which is a pole equipped with reflective markers and a load cell to measure force. This paper describes the design of an instrumented pole used for calibration and the protocol that will be used to validate an instrumented treadmill that will be installed in the Human Research Engineering Directorate's (HRED) new Soldier Performance and Equipment Advanced Research (SPEAR) Facility. Data collected during this procedure will be used to determine the validity and reliability of the instrumented treadmill, and for calibration of the treadmill.

The author wishes to acknowledge the mentorship of Phillip Crowell.

Booster Chip Characterization

McKnight, Ken

We have characterized the U.S. Army Research Laboratory (ARL)-designed Booster chip for enhancing commercial off-the-shelf (COTS) transceivers in the L and S bands. The booster chips consist of a Low Noise Amplifier, a Power Amplifier, a Binary Phase Shift Keying (BPSK) modulator, and a Transmit Receive switch. Each design had a 450 MHz, 900 MHz, and 2.4 GHz version. The characterization plan consisted of S-parameter and radio frequency (RF) power measurements at each of the aforementioned frequencies. The test setup consisted of an 8510 HP Network Analyzer, an 8565E HP Spectrum Analyzer, a 438A HP PowerMeter, an 8340A HP Synthesizer Sweeper, and a probe station. The results showed an excellent agreement with advanced design system (ADS) simulations.

The author wishes to acknowledge the mentorship of John Penn.

Optimization of the Mini-CHAD to Generate Sub-critical Damage in Transparent and Opaque Armors

McQuaid, Patrick

This report provides an overview of the design and capabilities of the Mini-compressed air Horizontal Accelerating Device (MINI-CHAD), which has the ability to shoot an object, such as a rock or Right Conical Tipped Circular Cylinder (RCTCC), ranging between 1.27 and 3.81 cm (0.5−1.5 in) in diameter at a velocity between 11.176 and 44.704 m/s (25−100 mph). The MINI-CHAD is designed to simulate debris launched from the tire treads of a High Mobility Multi-purpose Wheeled Vehicle (HMMWV) at a nominal operating speed. The possibilities for the use of the MINI-CHAD to simulate launched debris are only limited by the velocity and size of the object to be tested.

The author wishes to acknowledge the mentorship of Pete Dehmer.

Visual Multidimensional Scaling (VMDS) Tool for Determination of High Value Individuals (HVIs)

McVey, Michelle C.; Slocum, Christine

An information fusion tool is required for determining the military value of individuals encountered during high tempo operations. Large amounts of parallel, asynchronous, unreliable, sparse data are difficult for a field intelligence analyst to accurately process in a limited amount of time during critical battle conditions. The Visual Multidimensional Scaling (VMDS) tool combines the multidimensional scaling (MDS) statistical capabilities of the R language/environment with the interactive GGobi visualization program to aid in identifying high value individuals (HVIs) from such data. VMDS provides a simple graphical interface that allows an intelligence analyst to easily load data files, select MDS input parameters, choose display options, and interact with MDS solutions in a three-dimensional (3-D) space. The VMDS tool generates a similarity-based map of persons and groups of interest within the relevant population. The analyst can take screenshots of displayed data and annotate the captured images in real time. These images and annotations are incorporated into "Run Profiles" that are intended to aid in collaboration and provide a means by which discovered visible phenomenon can be expressed and preserved. The analyst can then identify resemblance of subjects to key groups or individuals, thus indicating their likelihood of being HVIs.

The authors wish to acknowledge the mentorship of Ann Bornstein.

Structures of Fatty Acid Esters and their Effects on Fuel Properties

Melick, Cory

JP-8 is military grade diesel used in many U.S. Army vehicles. Currently, JP-8 is a product of oil refinement. There is interest in trying to find a bio-based resource that can be used to produce military grade diesel. Esters derived from plant oils are currently being used as biodiesel for commercial vehicles. This study examined how the structure of free fatty acids and their respective esters affected fuel properties such as freezing temperature, heat of combustion, viscosity, and heat of fusion. Four classes of fatty acids were examined—saturated fatty acids, unsaturated fatty acids, di-acids, and branched fatty acids. Most of the results for the esters are currently unavailable, though it is predicted that a branched fatty acid or long chain (>20 carbons) polyunsaturated fatty acid is going to be the most promising bio-feedstock. These bio-fuels must meet JP-8 specifications, which include a freezing temperature of −47 °C and a heat of combustion of 42.8 kJ/g. Currently, the two best candidates are methyl linoleate and methyl 2-butyl octanoate. Linoleic acid has a heat of combustion of 39.12 kJ/g and a freezing temperature of −29.7 °C, while 2-propyl octanoic acid has a heat of combustion of 36.91 kJ/g and freezing temperature below −80 °C.

The author wishes to acknowledge the mentorship of Dr. John LaScala.

Fabrication and Testing of Carbon Nanotube Supercapacitor Electrodes

Miller, Benjamin

Carbon nanotube (CNT) films have a high surface area as well as outstanding physical and chemical stability. When used in creating a supercapacitor electrode, CNTs can result in a greatly increased specific capacitance and a lower electrolytic resistance relative to current activated carbon electrodes. The result will be a supercapacitor with increased energy density, making supercapacitors better suited for a variety of Army specific applications. This paper reports on the design, fabrication, and testing of a supercapacitor made from single-walled carbon nanotube (SWCNT) electrodes, where the CNTs were deposited on the substrate using a spray deposition technique. The CNTs were suspended in acetone prior to being sprayed onto the substrate with an Aztec Ultimate Metal Airbrush Set. A Keithley 4200 Semiconductor Characterization System was used to take capacitance readings, as well as to determine the energy density of the supercapacitor. Other factors are analyzed in the report, including which electrolyte to use as well as the most effective method for spraying the SWCNTs onto a conductive substrate.

The author wishes to acknowledge the mentorship of Dr. Matthew Ervin and Dr. Christopher Anton.

Mechanical Testing and Evaluation of S2 Glass Composites

Miller, David

This report describes the manufacture and mechanical testing of S2 glass composite materials, as well as the evaluation of mechanical properties of S2 glass composites for the creation of a database of the mechanical properties of composite materials. It will also provide a comparison to the legacy S2 glass/ SC-15 epoxy composite system currently being investigated by the military. Two types of mechanical tests were carried out on various composite systems to determine the flexural and short-beam shear properties of the material. This testing results in the short-beam strength, flexural strength, modulus of elasticity, and flexure failure strain of the composites in question. Though some of the composite systems were capable of exceeding the SC-15 legacy composite's performance for specific properties, no single composite system was capable of exceeding SC-15's performance in all of the properties that were tested. Further testing will include tension, compression, end notch flexure, drop tower impact, and izod impact.

The author wishes to acknowledge the mentorship of Steven E. Boyd, Jason J. Cain, and Todd Jessen.

Compact Scintillator Investigation

Monahan, James

Sodium iodide (NaI) coupled to photomultiplier tubes (PMT)s are some of the most sensitive, conventionally used gamma detectors. In the last five years, a number of more luminous scintillators have been developed. I compare the recombination rates, the rise time, and the luminosity of lanthanum halide ($LaBr_3$:Ce), cesium iodide (CsI), cesium fluoride (CsF), CdS:Te, and LaI_3:Ce pilot-B plastic scintillating materials. I will make comparisons to NaI, and I will also evaluate solid-state detectors.

The author wishes to acknowledge the mentorship of Dr. Tom Podlesak.

Molecular Dynamics Calculations of RDX Material Properties

Munday, Lynn

This paper presents results from molecular dynamic simulations of the energetic molecular crystal, hexahydro-1,3,5-trinitro-1,3,5-s-trazine (RDX), using a flexible molecular potential. In the past, determining material properties through molecular dynamics simulations was not feasible due to computational constraints on the molecular potential function being used. Through high performance computing, we show that correct RDX molecular conformations and lattice structure, as well material properties such as the coefficients of thermal expansion, melting temperature, shock Hugoniot data, and constants of elasticity, can be predicted from a recently published model for octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX). Although this potential has been used to model RDX in literature, the success with which this potential reproduces the experimental results of RDX has not been quantified before. The model of RDX permits for a fully flexible molecule, which is important for future Army investigations exploring the transfer of vibrational energy from the crystal lattice to the internal vibrational modes of the molecule to study the events leading to initiation. Such effects may also be amplified in the vicinity of crystal defects.

The author wishes to acknowledge the mentorship of Dr. Peter W. Chung.

Silicon Ion Implant Assisted Ohmic Contacts for GaN

Nguyen, Cuong B.

In this study, the method of using silicon (Si) implanted in a shallow layer to ~10^{20} cm^{-3} under the contact pad for n-type gallium nitride (GaN) was demonstrated to be effective in minimizing the contact resistance. I used Hall effect measurements to measure the carrier concentration and mobility, and the transfer length method (TLM) to determine the sheet and contact resistance. The lowest contact resistance found was 2.66 x 10^{-8} $\Omega \cdot cm^2$, which was achieved under an annealing temperature of 1200 °C and an annealing time of 10 min. An annealing cap was required to achieve this extremely low contact resistance. In addition, analysis with a scanning electron microscopy (SEM) showed the annealing cap was able to protect the GaN film from deteriorating up to an annealing temperature of 1250 °C. From the analysis with an atomic force microscope (AFM), the root mean squared (RMS) roughness of implanted GaN was recorded as 3.196 nm after a 1250 °C anneal for 10 min, while the RMS roughness for sample that was not implanted and annealed under the same conditions was 5.357 nm.

The author wishes to acknowledge the mentorship of Dr. Kenneth A. Jones.

Microstructural Analysis of Friction Stir Welded Tri-modal Metal-Matrix Composite

Patterson, Travis

The objective of this effort was to evaluate microstructural characteristics of friction stir welded (FSW) cryomilled tri-modal aluminum (Al) boron carbide (B4C) reinforced metal matrix composites. Two FSW samples were used—(1) M4 "hot and slow" tool rotational and travel speed were 250 rpm and 1.5in/min, respectively; and (2) M5 "slow and fast" had a tool rotational and travel speed of 150 rpm and 10in/min, respectively. Microstructure evaluation was conducted using optical, scanning electron, and transmission electron microscopy techniques. Measurements of B4C size and distribution were evaluated, showing that increased tool rotational speed may breakup B4C in the weld zone. Further, ultra-fine grained Al size and distribution was also examined as a function of position in the weld zone, showing that M4 and M5 FSWs show very similar levels of grain growth in the weld zone. Also, it was shown that coarse grain Al, due to mechanical deformation during the FSW process, may be broken down into finer grains during welding.

The author wishes to acknowledge the mentorship of Kyu Cho.

Part I: Residual Catalyst Removal from Polymers Prepared by Ring Opening Metathesis Polymerization

Part II: Synthesis of Polydimethylsiloxane Star Polymers via Thiol-Ene Click Chemistry

Pederson, Samuel J.

This report will focus on two different areas of study: residual catalyst removal from polymers prepared by ring opening metathesis polymerization (Project I) and synthesis of polydimethylsiloxane star polymers via thiol-ene click chemistry (Project II).

Heterogeneous metal scavengers and solubility modifying agents were explored as possible methods of removing residual ruthenium (Ru) catalyst from polymers made by ring-opening metathesis polymerization. Qualitative observations suggest that a number of the techniques are removing significant amounts of residual catalyst from the polymer. Samples have been submitted for quantitative analysis via inductively coupled plasma mass spectroscopy (ICP-MS). Further research will continue in attempts to optimize the best results from this project to construct the most efficient approach to removing residual Ru.

The use of thio-ene "click" chemistry was investigated as a viable technique for synthesizing polydimethylsiloxane star polymers. Variables such as types of initiator, initiator content, and reaction conditions were tested. Verification of the reaction was tracked using gel permeation chromatography (GPC), Fourier transform infrared spectroscopy (FT-IR), and nuclear magnetic resonance (NMR). The current characterization of the thiol-ene reaction suggests that the reaction is proceeding with high fidelity and has significant potential for further development. Future outlook consists of better characterization of successful reactions and optimization for scaled-up production.

The author wishes to acknowledge the mentorship of Dr. Robert H. Lambeth.

Laser Dimensioning System for Measuring Ceramic Tiles

Peeples, William

This paper discusses a system developed for automating the dimensioning of ceramic tiles used in armor panels. The system incorporates a high-accuracy laser, a rotary stage, a personal computer (PC), and a power supply. A convenient graphical user interface (GUI) was written controls all the components of the system. Parametric studies were conducted to determine the system's repeatability given different inputs such as sampling rate, step-size, noise, and degrees of measurement. The system was optimized to give the most accurate measurements of ceramic tiles in the shortest amount of time. Through different methods, processing time has been reduced from 20 min to 3.5 min per tile. This laser dimensioning system will later be incorporated into a larger system to facilitate the automatic dimensioning of a large set of tiles. This data will help armor panel fabricators to consider machining tolerances of the manufacturer.

The author wishes to acknowledge the mentorship of Dr. Matthew Bratcher.

Analysis of the Abrasive Resistance of Various Transparent Polymer Surfaces

Perticone, Andrea

Transparent materials technology is a rapidly growing business area allowing for new advances in the materials field. Among the ongoing technical developments in the materials environment is commercial development of new polymers with high transparency. The opportunity for new armor solutions to arise from these new materials remains to be discovered and validated. Measurements of the optical properties, such as transmittance, haze, and clarity, of various polymers before and after abrasion testing are compared in order to evaluate their use as potential effective transparent armor. Abrasive resistance testing methods include the Bayer Abrasion Test, the Falling Sand Test, and the Taber Abrasion Test. Various coatings are also examined to determine whether the degree of abrasive resistance on the polymer's surface can be increased. In addition, the mechanical properties of these materials are evaluated. Calculation of the glass transition temperature and Young's modulus are performed in preparation for ballistic performance testing. Comparisons of these properties and their impact on a coating's abrasive resistance, as well as overall polymer performance, are analyzed.

The author wishes to acknowledge the mentorship of James Sands.

SMART, APG Site—Diffusion Barriers for Adatoms in Growth of Quantum Dots

Ramsey, James J.

In order to study the effects of additional adatoms on diffusion barriers for adatom hopping, I attempted to reproduce a published result from *ab initio* calculations by Rosini et al. (*Physical Review B*, 2008) for a diffusion barrier of an isolated indium (In) adatom on an InAs(001)-β2(2×4) layer over a GaAs(001) substrate. For an adatom hopping to and from the binding sites, I calculated the diffusion barrier as 0.149 eV, which differs from the 0.083 eV value reported by Rosini et al. This appears to result from a difference between the compressive strain from lattice mismatch in my simulations (7.6%) and the simulations done by Rosini et al. (5.3%). This difference in lattice mismatch is due to the difference in the pseudopotentials used, and it is consistent with the literature, where for semiconductors, the diffusion barrier decreases as the compressive misfit strain decreases. I also attempted iterative *ab initio* relaxation calculations with more than one adatom, and the preliminary results from them suggest that the presence of an additional adatom changes the available binding sites for other adatoms.

The author wishes to acknowledge the mentorship of Dr. Peter W. Chung.

Synthesis of Hydantoin-Boltorn Polymers for Antimicrobial Surfaces

Ratzlaff, Samuel

The objective of this research is to synthesize a hydantoin-Boltorn H20 polymer to create a polymer surface with antimicrobial properties. The synthesis of this polymer can be achieved via two different synthetic routes. One route binds an acetyl group on Boltorn H20, where the hydantoin group can then be added. The second route involves the reaction of methyl chloroacetate with the potassium salt derivative of 5,5-dimethylhydantoin, followed by the addition to the Boltorn H20 polymer. Afterwards, the product will be added to solutions of estane, polystyrene, and poly (methyl methacrylate) (PMMA) in order to cast films. The films that were successfully cast will be chlorinated with bleach. The resulting films will then undergo XPS, contact angle, and antimicrobial tests.

The author wishes to acknowledge the mentorship of Dr. Andre' Williams.

Development of an Interactive Ray Trace Display for MGED

Reed, Nicholas

While the Ballistic Research Laboratory's (BRL) Computer-Aided Design (CAD) Multi-Device Geometry Editor (MGED) offers an interactive display that shows geometry in a wireframe representation, many programs also can provide interactive shaded displays for geometry. In recent years, shaded displays for general geometry have been a frequent request of target modelers and vulnerability analysts who view target models in MGED. Their common problem of being able to quickly identify and understand the construction of a model would be alleviated by a shaded display, which provides a more natural representation of three-dimensional (3-D) models that is much easier to interpret. This report describes the results of my work to create an interactive shaded display for MGED that will work with standard (constructive solid) geometry as well as triangle mesh geometry. The resulting prototype makes use of BRL-CAD's existing ray tracing functionality to render geometry. This is a more accurate and computationally intensive approach compared to the various approximation methods used in other modeling software. For this reason, developing strategies for high performance is a top priority of future work on the prototype.

The author wishes to acknowledge the mentorship of Edwin O. Davisson.

Fidelity Evaluation of Physics Engines for Manipulation

Rice, Joseph B.; Smith, Daniel C.

Robotic simulations have become increasingly popular due to their low cost, rapid deployment, and safety. From the computer, roboticists can now test and evaluate behaviors and hardware without the use of expensive field testing. The primary limiting factor in the fidelity of modern simulations lies within its physics engine. In this paper, multiple physics engines are reviewed and rated with a focus on manipulation. An extensive literature review is conducted and three engines are chosen through the use of weighted selection. The three physics engines are then evaluated more extensively and a further evaluation is done.

The authors wish to acknowledge the mentorship of Dr. MaryAnne Fields and Chad Kessens.

X-ray Detectors on a ZigBee Network

Russo, John

The ability to use small, low-power, x-ray sensors is a battlefield awareness objective for the Army. In this project, I will develop techniques to test and evaluate effective x-ray detectors. A variety of scintillators (e.g., BaF2, CsI, and plastics) will be evaluated and compared for their luminosity, rise-time and recombination time. The Linacs at the U.S. Army Research Laboratory provides greater than 10^(13) photon/second. I will use these sources to evaluate materials in order to provide lower-power, compact, efficient x-ray sensors. These sensors are expected to provide greater sensitivity than commercial products. The main purpose of the experiment is to examine the effectiveness, sensitivity, and simplicity of these various sensors. ZigBee Drop-in Networking will be used to bring together all of the data and results measured during the experiment, and broadcast wireless to local computers.

The author wishes to acknowledge the mentorship of Bill Allmon.

Shear Properties of S-2 Fiberglass Composites

Salvatore, Steven

In an effort to find an alternative to the current S-2 glass/SC-15 epoxy composite combination, we are evaluating a number of different S-2 glass/resin combinations for possible integration of composite materials in the field. We are building a database of the mechanical properties of the candidate resins to further our knowledge of them. This report describes the process in which some of the candidate resins are been evaluated to determine certain mechanical properties. This effort describes the shear property test, one of many that are to be performed on the candidate resin composites. From these tests, we have generated mechanical property data for each S-2 glass/resin composite that includes ultimate shear strength and shear stiffness. Based on the results from tests done in the past, improvements over the legacy matrix are expected to be observed in several of the candidate resins, although it is unclear if there is a single candidate resin that possesses the desired properties needed to replace the legacy matrix. Future testing will include more tensile property testing, as well as compression testing.

The author wishes to acknowledge the mentorship of Todd Jessen.

Examining the Feasibility of a Tripwire Detection Method using Acoustics

Sanchez, Kevin

A major objective in developing tools and weapons for military use has always been ensuring the safety of Soldiers and actively making them aware of hazards in their environment. One such hazard is tripwires hidden in the field. Current research is investigating a method of detecting trip wires using an air flow aimed at a wire to generate sound that can then be detected using a microphone. This paper examines the effect of varying tension, distance, nozzle type, and air flow rate on the generated sound. Should this technique prove viable, the equipment's size would permit usage on small robots. Furthermore, this technique, when coupled with other sensors in a multi-modality approach, could increase the probability of detection of tripwires.

The author wishes to acknowledge the mentorship of Pam Clark.

Indentation Response of Several Tough Ceramics to Sharp and Blunt Diamond Indenters

Shanholtz, Eugene

This research investigates the indentation response of three commercially available tough ceramic variants—silicon aluminum oxynitride (SiAlON), silicon carbide (SiC), and tungsten carbide (WC). The respective variants are SiAlON abC (Kennametal, Inc.), SiC-N (BAE Advanced Ceramics Division), and PAD WC. The indentation responses of these materials were investigated using Knoop and Hertzian indentation tests. We performed Knoop indentation tests between loads of 3−200 N to determine hardness values for each ceramic variant. Hertzian indentation tests paired with acoustic emission capability were conducted between 500−1500 N to produce load-displacement curves and estimate the load at which ring/cone cracks initiate in the given material. The Knoop and Hertzian indents were then examined using optical and scanning electron microscopy to determine the microstructures and deformation mechanisms present. Results and experimental procedures will be presented.

The author wishes to acknowledge the mentorship of Jerry LaSalvia.

The Effect of Various Sample Preparation Techniques on the Tensile Strength of Nextel 610 Reinforced Aluminum

Smith, Alexander D.

In this report, the effect of sample preparation on Nextel 610-reinforced aluminum is investigated as part of an ongoing study being conducted to determine the effect of different sample preparation techniques on its tensile strength. This report contains an explanation of the sample preparation process before the plate is sectioned and an explanation of the sample preparation technique used after the plate has been sectioned. It also provides results for three tensile tests using as-sectioned water jet specimens and contains a discussion of future tests using various sample preparation techniques during and after sectioning.

The author wishes to acknowledge the mentorship of Dr. Robert Carter.

Client/Server Implementation Modeled With Rational Rhapsody

Sorrells, Calynna

This paper examines the purpose, innovation, implementation, and results of an adaptable client/server system. Client/server systems have become widely used within the last decade. Client/server architecture has been developed to send a string of Transmission Control Protocol (TCP) or User Datagram Protocol (UDP) messages from client to server. This client/server program uses the Windows Sockets Interface as the communications protocol and was implemented to allow for two-way communication between client and server. This architecture is innovative because it will serve as a versatile prototype according to user specifications. This model will be integrated into the Component-based Routing (CBR) framework developed in Rational Rhapsody for the performance evaluation of an Optimized Link State Routing (OLSR) protocol. From my research, a client/server program has been implemented in other component-based platforms, such as JavaBeans and Common Object Request Broker Architecture (CORBA), but has not been implemented in the Rational Rhapsody platform. Using Rational Rhapsody allowed for the development of the client/server program in Microsoft Visual C and for the subsequent implementation in Rational Rhapsody. It would be difficult to measure the performance of OLSR within the CBR structure without this program.

The author wishes to acknowledge the mentorship of Rommie Hardy.

Functionally Graded Adhesives

Stabler, Christopher B.

The goal of this project was to increase rubber to metal adhesion in Army materials using the concept of functionally graded interfaces as observed in squid beaks. Through application of adhesive as a graded interface with layers of varying rigidity, exceptional adhesion can be accomplished. 3M Scotch-Weld 847 was chosen as the adhesive because of its flexibility and potential for use on Army weapons platforms, and because it contains no hazardous air pollutants. We added talc, silica, and calcium carbonate fillers at various loading levels to increase the rigidity of the adhesive. Various methods were employed to optimize the dispersion of the filler in the adhesive. Testing with 5, 10, and 12.5 lb loads illustrated that a graded interface at various percentages provides superior adhesion over a non-graded system or the neat baseline adhesive.

The author wishes to acknowledge the mentorship of Faye R. Toulan and Dr. John LaScala.

HAP Free Adhesive Replacement for UH-60 Nose Door Seal and HGU-56/P Aviation Helmets

Stewart, Daniel

I conducted a demonstration/validation where a silicone rubber and composite were adhered. The demonstration used one applied coat to each substrate. The possible hazardous air pollutant (HAP)-free replacement, 3M-847, as well as the baselines, 3M-1357 for the UH-60 nose door seal and Clifton E-1293 for the HGU-56/P aviation helmets, failed. I hypothesized the reason for this failure was absorption of the adhesive into the porous composite and rubber substrates. Thus, strip adhesion tests were conducted in the laboratory to show that applying two coats of adhesive to each substrate would provide better performance relative to one coat of adhesive. Neoprene Rubber on epoxy/glass composite was the first strip adhesion test and showed that two coats of adhesive to both substrates performed better than one coat to each substrate. The baseline Clifton E-1293 actually failed the test for one coat, further demonstrating that one coat of adhesive is not sufficient. When using the ZZ-R 765 class B grade 50 silicone rubber on epoxy/glass composite, the 3M-847 again performed as well as the baseline adhesives. Thus, the HAP-free 3M-847 is an environmentally friendly alternative to the baseline adhesives for both Army applications.

The author wishes to acknowledge the mentorship of Faye R. Toulan and Dr. John J. LaScala.

Second Phase Toughening of Epoxy Resins with Nanosilica and Rubber Modifiers

Tertin, William

Toughened thermosetting resins are the basis for many important structural adhesive and composite systems that enable lightweight military structures. The overall goal of this work was to use liquid rubber modifiers to improve the fracture toughness of a diglycidyl ether of bisphenol F (DGEBF)-based epoxy without reducing properties associated with strength, such as Tg and modulus. This work presents three variables involving this form of toughening. The first variable considered changing the rubber solubility in the matrix through varying the acrylonitrile content in the acrylonitrile-butadiene backbone of the rubber. The second variable entailed altering the rubber reactivity with the matrix by changing the end-group reactivity of the rubber from carboxyl to epoxy termination. Finally, nanosilica was added to the formulation to mimic a toughening synergy with the rubber that has been shown to work for anhydride-cured epoxies. For each variable investigated, the fracture toughness, network properties, cure kinetics, cloud point, and rubber phase morphology were evaluated to elucidate behavior that occurs during cure that leads to the formation of varying phase compositions and differences in fracture toughness and other resin properties. I found that adding more soluble rubber modifiers led to morphologies displaying smaller rubber particles and enhances the fracture toughness of the system. When comparing the reactivity of the rubber modifier, I observed that the more reactive rubber modifiers altered cure kinetics and second phase morphology, but ultimately led to tougher resin systems. Finally, the addition of nanosilica exhibited no toughening synergy, and in the cases of more reactive rubber modifiers, actually had a detrimental effect on toughness properties.

The author wishes to acknowledge the mentorship of Jason Robinette.

Bacterial Native Fluorescence

Tsai, Michael

The native fluorescence of inorganic and organic environmental substances is being considered for the detection of biohazards. Compared to other bio-sensing methods, the detection of native fluorescence is relatively fast and easy to use, as it does not require the use of specific binding agents. Here we explore the utility of native fluorescence for distinguishing between live and dead planktonic bacteria, and dry films made of either live or dead planktonic bacteria. We also consider the native fluorescence of bacterial biofilms and of culture media after bacterial growth. We used excitation emission matrices (EEMs) for distinguishing the native fluorescences of the aforementioned samples. Our data shows that native fluorescence provides limited utility for distinguishing between live and dead planktonic bacteria or between different bacterial species. The EEMs of planktonic bacteria, dried bacteria, bacterial biofilms, and growth media from bacterial cultures, however, were significantly different from each other, demonstrating that native fluorescence is useful for distinguishing between biomaterials derived from bacteria at different environmental conditions.

The author wishes to acknowledge the mentorship of Dontcho Jelev.

A Case Study of Automated Exploitation of Trust between Nodes of a Social Network

Walsh, Ashley

The recent increase in the Government's use of social networking Web sites, commonly referred to as "Gov 2.0", has increased the overall use of social networking sites in the workplace. "Social networking sites, sometimes referred to as "friend-of-a-friend" sites, build upon the concept of traditional social networks where you are connected to new people through people you already know" (US-CERT). *OPORD 09-14,* however, argues that although "the intent of senior Army leaders to leverage social media as a medium to allow soldiers to 'tell the Army story' and to facilitate the dissemination of strategic, unclassified information...", the use of social networking sites still produces a serious security risk. This paper will analyze the social networking malware Koobface, which spread through sites such as Facebook and Twitter, and its impact on the warfighter.

The author wishes to acknowledge the mentorship of Tony Pressley.

Materials Characterization of High Temperature Epoxy Resins: SC-79 and SC-15/SC-79 blend

Wang, Michael L.

The relatively low glass transition (Tg) temperature of the SC-15 epoxy resin system necessitates study into suitable alternative resins capable of better high temperature performance for Army applications. This work investigates two of those alternative resins, SC-79, and CCMFCS2, both manufactured by Applied Poleramic Inc. (Benicia, CA). Several different curing cycles were tested for each resin in an effort to find the best process for Army applications. I found that under the right cure conditions, both SC-79 and CCMFCS2, are able to achieve higher Tg's and outperform SC-15 in flexural testing. However, more work is planned in order to more fully determine the properties of these alternative resins and their suitability to the Army.

The author wishes to acknowledge the mentorship of Dr. John LaScala.

Scaling Geometry in Operational Requirement-based Casualty Assessment (ORCA) using Transformation Matrices

Weaver, Eric

Operational Requirement-based Casualty Assessment (ORCA) is a computer tool used by the U.S. Army Research Laboratory's (ARL) Survivability/Lethality Analysis Directorate (SLAD) to simulate and report the effect of different insults on a Soldier in the field. The model allows the user to insert a number of different parameters into the program such as fragment size, material, velocity, and location on the body that is hit. Given these parameters, ORCA will output injuries sustained by the Soldier, tissues hit, and different incapacitations experienced by the Soldier. The geometry of the modeled Soldier is programmed using a number of three-dimensional coordinates and 4x4 matrices that facilitate the translations and transformations of these points. This report discusses how these matrices can be used to scale the geometry of the three-dimensional anatomical representation when given the desired scaling factors. As the model is scaled, the same fragment will have different effects on different-sized anatomies and result in different injuries.

The author wishes to acknowledge the mentorship of Timothy Myers.

Examination of the Simulated Performance of the Improved Outer Tactical Vest Performance against Behind Armor Debris

Weaver, Kate

Experimental ballistic data has been generalized in order to predict the residual velocity of various fragments after striking different types of protective materiel. The predictions are a function of the initial striking velocity of the fragment and the A/M ratio of the fragment, where A represents the average cross-sectional area of the fragment along its trajectory and M represents the weight of the fragment striking the protective material. Historical experimental data is available for the Improved Outer Tactical Vest (IOTV) using 2, 4, 16, and 64 grain right circular cylinders (RCCs) at two impact obliquities, 0° and 45°. Generalizations have been made from experimental observations of this data. This study will combine recently obtained behind-armor debris (BAD) fragment penetration data collected from recent tests on the IOTV with the historical experimental ballistic data. Graphs of the striking velocities versus estimated residual velocities from test and simulated using a mathematical model will be created and examined. The mathematical model consists of two empirical equations known as the Johnson equations. The ultimate goal is to determine if it is necessary to refit the body armor penetration coefficients to support BAD fragments.

The author wishes to acknowledge the mentorship of Patrick Gillich.

Anthropometric Measurements for Computer Geometry Models Representative of Human Diversity and Joint Articulation to be used for Ballistic Analysis

Weaver, Stephanie

The U.S. Army Research Laboratory (ARL) uses computer geometric models of humans within the Operational Requirement-based Casualty Assessment (ORCA) and the Modular Unixed-based Vulnerability Estimation Suite (MUVES-S2) when evaluating survivability to ballistic penetration. These human models are limited in their representation for a variety of reasons. Human models do not have anthropometrically valid dimensions, are missing joint properties, and only represent the male anatomy. The ability to demonstrate diverse yet precise characteristics for all significant body parts as well as the creation of a female model will benefit the accuracy of the survivability evaluations and provide more realistic results for analytical purposes. This summer, I researched anthropometric proportions for all imperative body parts and created a database of this information. This research is being used by fellow summer student, Stephen Kennedy.

The author wishes to acknowledge the mentorship of Ed Davisson.

Development of Ferroelectric/Dielectric Nanocomposite Thin Films

Weiss, Claire

We propose a method for fabrication of composite thin films of barium titanate nanoparticles (a ferroelectric material) in a strontium titanate matrix (a dielectric material) by using a modified metalorganic solution deposition (MOSD) technique and spin-coating. The precursor solution and thin film will be characterized by ultra-violet/visual (UV-VIS) spectrometry, as well as optical and electron microscopy, in order to determine the appropriate chemical dispersants and observe the distribution of the nanoparticles within the matrix. The thin films would then be characterized using a field emission scanning electron microscope (FESEM), an atomic force microscope (AFM), x-ray diffraction (XRD), and dielectric and electrical measurements using an impedance analyzer. These results will be compared to single-phase dielectric thin films. At this time, due to lab safety shut-downs, no films have been successfully fabricated or tested. The hope is that the obtained results would indicate that ferroelectric/dielectric nanocomposite thin films may be promising candidates for use in next-generation electronic devices.

The author wishes to acknowledge the mentorship of Melanie Cole.

Entrainment of Neural Activity in the Cortex Provides New Information on Individual Differences in Brain Activity: A Proof-Of-Concept for Future Neuroscience Research in the Army

Whitaker, Keith W.

This report outlines a new methodology for pre-processing and analyzing electroencephalography (EEG) recordings that uses novel metrics to describe individual differences in brain function. A repetitive background tone entrains cortical neurons while the participant focuses on one of three forced-choice discrimination tasks. Using data from two representative participants, I worked to achieve three aims: (1) identify individual differences in neural processing; (2) perform trial-by-trial analysis of brain activity in response to a repetitive tone for a given individual; and (3) localize cortical areas involved with processing sensory information with patterns of activity that differ within and between participants. I provide proof-of-concept that the first two aims are feasible, but no conclusions can be drawn about the third aim at this time. A novel metric of phase-shifted entrainment can be used to address inter- and intra-individual differences and could be implemented on a trial-by-trial basis. Determination of specific aspects of the EEG recording will require a much greater sample size. Future brain scanning technology may be able to use frequent, repetitive stimuli, such as beeps and tones, to elicit patterns of brain activity to assay mental state without requiring the directed attention of the Soldier.

The author wishes to acknowledge the mentorship of Kaleb McDowell.

Comparison of Exothermic Reactions in Nickel-Aluminum and Titanium-Aluminum Foils: Interim Progress Report

Wingate, Nathan R.

I studied exothermic reactions of physical vapor deposition (PVD), cold-rolled nickel-aluminum (Ni-Al) foils and cold-rolled titanium-aluminum (Ti-Al) foils. The foils were analyzed in a differential scanning calorimeter (DSC) with a controlled heating rate to determine the evolution of intermetallic phases between the two reacting elements, with a focus on noting the effect of different material systems and fabrication methods. Typically two to three exothermic peaks were present in the DSC thermograms of the three foil types. I further examined the reacted PVD and cold-rolled foils using a scanning electron microscope (SEM) equipped with an energy dispersive X-ray spectroscopy analyzer (EDS) to more accurately determine the intermetallic chemical compounds corresponding to each of the DSC peaks.

The author wishes to acknowledge the mentorship of Laszlo J. Kecskes.

Automated Technique for Ultrashort Pulse Measurements

Word-Daniels, Akil

The development of efficient, eye-safe lasers is a priority in multiple defense applications. To assist in the characterization of doped rare earth materials for efficient lasing mediums, the High Energy Laser (HEL) team at the U.S. Army Research Laboratory obtained a Tsunami Ti: sapphire Model 3950. The Tsunami is mode-locked laser capable of producing 10–80 ps pulses with a tunable bandwidth of 410 nm. A permanent, automated system to assist in monitoring and adjusting pulse durations was developed. This paper discusses the general functionality of mode-locked lasers and the use of autocorrelation as a permanent solution for temporal pulse measurements.

The author wishes to acknowledge the mentorship of Larry D. Merkle.

Formation of Multiple Micro-Scale Features in Bulk Metallic Glass Using a Heated Press

Yow, Caleb

The objective of this project was to produce a device to heat metallic glass above its glass transition temperature and force it into a silicon die to produce micro-scale features for further testing. This report addresses the design and implementation of the device, as well as theoretical background, final outcomes, and future advances. The press itself needed to fit inside an Instron 4301 to use the compressive force from the frame to force the heated glass into micro scale features approximately 50 μm in diameter and 100 μm deep or smaller. These features were designed to be used in Micro Compression Testing, under the research of Dr. Brian Schuster to evaluate the materials' strength and failure characteristics on the micro scale. Thus, the device needed to be able to achieve very high resolution and repeatability to ensure consistency in the subsequent tests (1).

References

1. Schuster, B., personal communication, ARL-WMRD, Aberdeen, Md. March 2009

The author wishes to acknowledge the mentorship of Brian Schuster.

The Cognitive and Neural Signatures of Extended Multisensory Exposure: A Proposed Study

Yu, Alfred

Despite the extensive literature on learning, there has been relatively little focus on learning within complex operational environments, such as military crewstations. In more realistic environments, an operator will be exposed to regularities both within and across sensory modalities. Take the example of an aircraft with warning signals. A pilot putting the vehicle into a steep descending attitude might first see the rapid approach of the ground, followed shortly by a visual alert, and then perhaps by an audible warning tone. There is no doubt that these temporal contingencies can be learned quickly by humans. However, the specific cognitive and neural mechanisms associated with the learning of cross-modal associations are less clear. The proposed study will serve to investigate changes in multisensory processing, over an extended period of three weeks. These changes will be related to neural signatures afforded by the electroencephalogram (EEG), which will provide useful metrics for real-time assessment of the cognitive state of an individual within a complex, multisensory environment.

The author wishes to acknowledge the mentorship of Kaleb McDowell.

ADMNSTR
DEFNS TECHL INFO CTR
ATTN DTIC OCP (ELECTRONIC COPY)
8725 JOHN J KINGMAN RD STE 0944
FT BELVOIR VA 22060-6218

US ARMY RSRCH LAB
ATTN RDRL CIM G TECHL LIB T LANDFRIED
BLDG 4600
ABERDEEN PROVING GROUND MD 21005-5066

DIRECTOR
US ARMY RSRCH LAB
ATTN AMSRD ARL RO EV W D BACH
PO BOX 12211
RESEARCH TRIANGLE PARK NC 27709

US ARMY RSRCH LAB
ATTN RDRL CIM P TECHL PUB
ATTN RDRL CIM L TECHL LIB
ATTN RDRL D J M MILLER
ATTN IMNE ALC HRR MAIL & RECORDS MGMT