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4300 San Mateo Blvd NE, Ste A220

Albuquerque, NM 87110 -1295

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RPPR Final Report
as of 26-Mar-2018

Agency Code:

Proposal Number: 60790ST **Agreement Number: W911NF-12-C-0034**
INVESTIGATOR(S):

Name: James Kainz
Email: jkainz@ara.com
Phone Number: 9195823300
Principal: Y

Name: Michael Shore
Email: mshore@ara.com
Phone Number: 9195823300
Principal: N

Organization: **Applied Research Associates, Inc.-Albuquerque**
Address: 4300 San Mateo Blvd NE, Ste A220, Albuquerque, NM 871101295
Country: USA

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Final Report for Period Beginning 23-Apr-2012 and Ending 22-Apr-2017
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Submitted By: James Kainz Email: jkainz@ara.com
Phone: (919) 582-3300

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STEM Degrees: **STEM Participants:**

Major Goals: This research project was established to find advanced future technologies that would potential impact for Army use. Under this effort, Dr. Michael Shore, worked with academia, non-profits, small businesses, and large businesses to find new and unique technologies with military purpose. Dr. Shore then worked with military organizations such as ARO and USASOC to find willing partners to help foster usage and utility.

Dr. Shore also helped identify and focus STTR and SBIR technologies to help harden and deploy technologies of interest to the military community. Dr. Shore reviewed the utility of these efforts and when necessary provided the conduit for combining these technologies together.

Accomplishments: see attached document

Training Opportunities: Nothing to Report

Results Dissemination: See attached document

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: See attached document

RPPR Final Report
as of 26-Mar-2018

FINAL REPORT
Contract W911NF-12-C-0034; April 2012 to April 2017

Michael J. Shore, PhD

August 2016 Annual Accomplishments

STTR & Basic Research

- The ultrasonic concrete characterization project was funded for Phase II into November 2015. The instruments are providing accurate, repeatable measurements of the unconfined compressive strength of concrete over the range from 3 ksi to 26 ksi. No other instrument can do this. The prototypes are also providing accurate measurements of the thickness of the concrete when slabs are not connected to other structural elements and edges of slabs are visible. Further work is needed to identify the correct thickness from the many resonances observed. The algorithms to locate rebar within the concrete remain problematic. These conclusions were validated during field tests at Ft. Bragg in September 2015 and other sites in October 2015. The customer has identified funding to continue the development effort with award expected in September 2016.

Biosensors Program

- Rhino Horn Detection -- The samples of black and white rhino horn were subjected to chemical analysis and target chemicals were identified that can be used as indicators to tune existing chemical and explosive detectors.
- Ground-based Sensors -- a small, unattended Doppler radar system was used to collect rhino and elephant signatures at the NC Zoo in August 2014. We have demonstrated that this sensor, combined with existing unattended ground sensors, will be able to identify and track threatened animals by species. We are seeking funding to automate and test algorithms for the Doppler radar.
- A new concept to use canines to detect tunneling activity was developed and a white paper was written and submitted to the Army.

International Programs

- Antarctic Research – In response to a request from U.S. Army liaison officers in Santiago, Chile, a joint U.S.-Chilean research initiative was developed to examine earthquake and tsunami threats to Chilean Antarctic research installations, to research ice conditions around the Chilean Base O'Higgins, and to measure isostatic uplift along the northern Antarctic Peninsula. This work was submitted as a new research initiative in collaboration with UNC Chapel Hill and is being coordinated with the Cold Regions Research and Engineering Laboratory and the National Science Foundation. A funded postdoc position was successfully established with NRC support to initiate research in support of this initiative.

Optical Communications

- The required equipment to make environmental measurements and demonstrate optical communications has been assembled. The validation testing of optical communications in the laboratory and in bright sunlight were conducted in October 2015 before funding was exhausted. We continue to seek additional funding for the initiative.

August 2015 Annual Accomplishments

STTR & Basic Research

- The ultrasonic concrete characterization project was funded for Phase II in November 2014. The contractor experienced a serious setback when one of his suppliers delivered boards that did not adequately shield RF interference. Another board manufacturer was brought in to design and manufacture new boards. The problem has been solved and the first two prototypes are being tested at NC State. The instruments are providing accurate, repeatable measurements of the unconfined compressive strength of concrete over the range from 3 ksi to 26 ksi. No other instrument can do this. The prototype is also providing accurate measurements of the thickness of the concrete. The algorithms to locate rebar within the concrete remain in development. We are expecting field tests of the prototype to begin at Ft. Bragg in September 2015 and move to other sites in October 2015. The customer is identifying funding to procure units for operational testing and to continue the development effort.
- Prepared a technical approach to treat trees infected with citrus greening to prolong their productive life.

Biosensors Program

- Rhino Detection -- have black and white horn in hand. Samples have been given to a DoD dog training group to do some analysis on how well the dogs can perform at detecting the horn. Other samples are at NC State along with miscellaneous horns/hoofs that will have similar breakdown products. These samples were subjected to chemical analysis and target chemicals were identified that can be used as indicators to tune existing chemical and explosive detectors.
- Beef Detection in the Field -- a problem exists in some African countries where game meat biltong (jerky) is illegal. When caught, the bad guys claim it is beef and it takes several weeks of lab testing to determine what species it actually is. As a result, most perpetrators are long gone by the time the evidence is processed. We are working with a U.S. company to develop a rapid (~2-hour) field test for beef. The thought is that if we can prove the perpetrator is lying, then the local authorities can be more aggressive on the front end. Various known species-varieties of biltong in Africa have been obtained and passed to the company for development work. Testing is currently underway.
- Ground-based Sensors -- a small, unattended Doppler radar system was used to collect rhino and elephant signatures at the NC Zoo in August 2014. We have demonstrated that this sensor, combined with existing unattended ground sensors, will be able to identify and track threatened animals by species. We are awaiting funding from the World Wildlife Fund to automate and test algorithms for the Doppler radar.

International Programs

- Supported U.S.-sponsored Border Security Symposium in September 2014.
- Antarctic Research – In response to a request from U.S. Army liaison officers in Santiago, Chile, a joint U.S.-Chilean research initiative was developed to examine earthquake and tsunami threats to Chilean Antarctic research installations, to research ice conditions around the Chilean Base O'Higgins, and to measure isostatic uplift along the northern Antarctic Peninsula. The first field work under this program is planned for December 2015.

Optical Communications

- The required equipment to make environmental measurements and demonstrate optical communications has been assembled. The first tests of optical communications in the laboratory and in bright sunlight were successful. Additional testing is planned during late 2015.

July 2014 Annual Accomplishments

Cooling Vests

- Testing program was discussed in September during a visit to the South African Mine Rescue Service.
- South African Mine Rescue Service testing was concluded. It was determined that the vests were too cumbersome for practical use in the mines. However, they believe they might be very useful in other applications.
- The U.S. Company has declined to develop a head cooling system for testing unless and/or until they receive government funding for their amputee cooling device.

STTR

- The battlefield ultrasound proposal was approved for Phase II. However, the contract could not be awarded due to the developer being purchased by a large company.
- The ultrasonic concrete characterization project was funded for Phase II. The contractor is making excellent progress. We are expecting lab tests of the prototype to begin in September 2014 with field test to follow in October through December.
- No new Phase I topics were approved.

Biosensors Program

- Elephant Infrasound – Completed initial analysis of infrasound and seismic data during scent testing. Presented results at African Biosensors Conference in September 2013 in Bela Bela, South Africa. Presented resulted at Bi-Lateral Conference at the Technion, Haifa, Israel.
- Rhino Detection -- have black and white horn in hand. Samples have been given to a DoD dog training group to do some analysis on how well the dogs can perform. Other samples are at NC State along with miscellaneous horns/hoofs that will have similar breakdown products. These

samples are being prepared for chemical analysis that will be done at UNC Chapel Hill. Assuming the testing is positive and we can detect/discriminate rhino horn chemically, we will then take the test results to Army chemical and explosive detection companies to assess which, if any, can be programmed to detect rhino horn.

- Elephant-Human Conflict – supported the successful demonstration in March of an elephant collar conceived to limit human-elephant conflict. The collar was developed by NC State and includes a programmable GPS fence capability. As the elephant approaches the defined GPS boundary, a number of alarms sound on the collar to confuse and startle the elephant. In tests in South Africa, the elephant turned and consistently moved away from the protected area. More development and testing on other elephants will be needed to validate the approach.
- Beef Detection in the Field -- a problem exists in some African countries where game meat biltong (jerky) is illegal. When caught, the bad guys claim it is beef and it takes several weeks of lab testing to determine what species it actually is. As a result, most perpetrators are long gone by the time the evidence is processed. We are working with a U.S. company to develop a rapid (~2-hour) field test for beef. The thought is that if we can prove the perpetrator is lying, then the local authorities can be more aggressive on the front end. If this test platform works, it can then be developed for other applications in endangered species. We have talked with USAID about abalone as a next possibility if the beef test proves useful. Right now we are gathering various known species-varieties of biltong in Africa. We hope to bring those back in September 2014 and hand off to the company for development work. If things work well, we may have a prototype early in 2015.
- Ground-based Sensors -- a small, unattended Doppler radar system was used to collect rhino and elephant signatures at the NC Zoo in August 2014. There is hope that this sensor, combined with existing unattended ground sensors, will be able to identify and track animals hopefully by species, but at least discriminating the larger animals as a minimum. The sensor is used in Afghanistan and can discriminate between pack animals, horses, people, and vehicles. In initial evaluation of the signatures will be conducted in the coming months. If successful, it will prove useful for population studies as well as counter poaching.

International Programs

- Israeli Cooperative Programs – supported ARL Director's visit to Israel for discussions of various technical programs.

Water Research

- Water Research Technical Exchange Group – attended workshop and provided recommendations for future activities.

Interagency Cooperation

- Citrus Research – provided technical support for interchange of information between ARO and Department of Agriculture on mitigation of insect-transmitted citrus disease affecting much of Florida citrus industry. Prepared a summary of heat treatment

July 2013 Annual Accomplishments

Elephant Infrasound

- Received approval to purchase geophones.
- Returned to SA in July 13th to 25th to collect seismic and infrasound during training
- Analysis of July infrasound and seismic data ongoing.
- Present results at conference in September

Mine Rescue Cooling Vests

- Approval to purchase vests received
- Vests purchased and quality assurance tests performed
- Tanks and CO_2 refills purchased in SA
- Vests delivered and testing program underway from July to September with CSIR Mining Institute. Will observe testing during September visit.

STTR

- One battlefield ultrasound and two concrete characterization proposals approved for Phase II
- New Phase I topics being developed with Ft. Bragg. Will re-submit robot/VTOL UAV navigation topics from last year along with 3 new topics: Porticos prosthesis cooling; NC State unimproved landing zone characterization; and UNC-C circular polarized TTL.
- Coordinated visit by Medical commodity lead with Porticos on medical devices

Singapore

- Singapore and PACOM have expressed interest in exercise
- Briefing presented at joint planning meeting in late May
- Follow-up discussions continuing

Animal Trafficking

- Secretary Clinton spoke on subject in November 2012
- AID initiative expanding. Looking for partners, especially military
- Met with AID scientists on May 29th to explore S&T synergy between anti-poaching and Army
- Follow-up meeting in SA in July held with USAID and S&T Advisor to Ambassador
- Several follow-on paths being explored

Canine Heart Rate Variability

- Waiting for new version of Zephyr to be released

Arms Control

- Coordinated visit to Syngenta, UNC GA, and Medicago by DTRA NTV Director
- Attended CTBTO S&T Conference in Vienna, Austria

Reports, Publications, and Presentations

Biryol, C.Berk, Michael J. Shore, Stephen J. Lee, and Jonathan M. Lees. (2016) *S-wave Receiver Functions revealing upper mantle variations near a slab window; A case study from Antarctic Peninsula,* Geochemistry, Geophysics, Geosystems (Projected date for submission to G-Cubed: December 2016).

Biryol, C. Berk, Jonathan M. Lees, Michael J. Shore, and Stephen J. Lee. (2016) *Lithospheric Fragmentation Controlled by Stalled Subduction: P-wave Receiver Functions from Bransfield Strait, NW Antarctic Peninsula*. Bulletin of Seismological Society of America (Manuscript in preparation; Projected date for submission to BSSA: September 2016, Projected date for publication: December 2016).

Shore, Michael J., C. Berk Biryol, Jonathan M. Lees, and Stephen J. Lee. (2016) *Stalled Subduction and Microplates: P-wave Receiver Functions from NW Antarctic Peninsula*, American Geophysical Union, Fall Meeting December 12-16 2016, San Francisco, CA. (Poster Presentation)

Lee, Stephen J., and Michael J. Shore. (2016) *Wildlife Security Convergence with Conservation and Innovation,* Wildlife Security and Conservation Symposium, North Carolina State University, Raleigh, NC, 26 May 2016.

Biryol, C. Berk, Stephen J. Lee, Jonathan M. Lees, Michael J. Shore. (2016) *Lithospheric Structure of an Incipient Rift Basin: Results from Receiver Function Analysis of Bransfield Rift Basin, NW Antarctic Peninsula*, Poster Presentation, Seismological Society of America Annual Meeting, Reno, NV, Seismological Research Letters 87:2B, p. 522. (Poster presentation), Online. Link: http://www.seismosoc.org/members/annual-meeting-presentations/2016-annual-meeting-presentations/presentation/?id=16-454), 21 April 2016.

Miller, Ashadee, Michael Hensman, Sean Hensman, Kip Schultz, Paul Reid, Mike Shore, Jessica Brown, Kenneth Furton, and Stephen Lee. (2015) *African Elephants (Loxodonta africana) can Detect TNT using Olfaction: Implications for Biosensor Application.* Applied Animal Behaviour Science (2015), http://dx.doi.org/10.1016/j.applanim.2015.08.003.

Lee, Stephen, Michael Shore, and Paul Reid. (2014) *United States – South Africa Border Surveillance Technology Cooperation Symposium.* Pretoria, South Africa, September 16, 2014.

Shore, Michael J. (2014) *Elephant Scent Training – Infrasound and Seismic Monitoring.* U.S.-Israel Working Dog Technical Exchange Meeting, Technion – Israel Institute of Technology, Haifa, Israel.

Shore, Michael J. (2014) *Motivation for a High Explosive Testing Program in South Africa.* ARA Technical Report, Raleigh, NC, 18 February 2014.

Shore, Michael J. (2013) *Infrasound and Seismic Monitoring during Scent Training using African Elephants.* South African Indigenous Biosensors Meeting, Bonwa Phala Nature Reserve, Bela Bela, South Africa, 3 September 2013.

Shore, Michael J. (2012) *Future Directions in Arms Control.* Presentation, DTRA, Alexandria, VA.

Shore, Michael J. (2012) *Future Robotics Capabilities for Military Applications.* Tactical Ground Robotics Conference sponsored by U.S. Army Special Operations Command, Fayetteville, NC.