ARMY SBIR

ARMY SMALL BUSINESS INNOVATION RESEARCH

The United States of America and our allies confront growing, continuous national and international security challenges. To stay ahead of these threats, we need an energized and aggressive culture of innovation throughout our technical and research institutions at all levels. The Army Small Business Innovation Research (SBIR) and Small Business Technology Transfer Programs (STTR) provide access to the creative minds in today's small businesses and labs.

Federal funding through the SBIR and STTR Programs provide the opportunity for small businesses to research and develop technologies needed for our Soldiers. The long term goal for these projects is to identify, develop and demonstrate highly innovative technologies, with strong commercialization potential to satisfy Department of Defense (DOD) and private industry needs.

Since the inception of these programs in 1982, SBIR and STTR have become the nation's largest source of funding for small business technology advancement. SBIR and STTR-developed technologies have allowed us to better equip and protect our Soldiers so that they can continue to dominate the virtual and physical battlespace.

The increasingly complicated and dangerous world demands the best technology possible for our Soldiers and our nation. The technologies showcased in this brochure show a small sampling of the outstanding collaborative efforts of our dynamic small businesses and their Army partners. Read these success stories and appreciate the benefits of small business innovation to our Soldiers and our nation.

On behalf of the Army Leadership and our honorable and brave Soldiers, I thank the members of the SBIR and STTR communities along with their supporters for their dedication and contributions to our vital mission.

Very respectfully,

Dr. Thomas P. Russell

THE SBIR AND STTR PROGRAMS

Congress established the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs to provide opportunities to participate in government sponsored research and development (R&D).

The goals of the SBIR and STTR Programs are to:

1) Stimulate technological innovation

2) Use small business to meet federal R&D needs

3) Foster and encourage participation in technological innovation by socially and economically disadvantaged small business (SDBs), and/or 51 percent owned and controlled by women

4) Increase private sector commercialization of innovations derived from federal R&D; thereby increasing competition, productivity and economic growth

While STTR has the same objectives as SBIR regarding the involvement of small businesses in federal R&D and the commercialization of their innovative technologies, the STTR Program requires participation by universities, federally funded research and development centers (FFRDCs) and other non-profit research institutions.

Both the SBIR and STTR Programs use a three-phase program structure that reflects the technical risk involved in developing and commercializing cutting-edge technologies.

1) Phase I is a feasibility study that determines the scientific, technical and commercial merit and feasibility of selected concepts. Phase I projects are competitively selected from proposals submitted against solicitation topics seeking specific solutions to stated government needs.

2) Phase II represents a major R&D effort, culminating in a well-defined deliverable prototype (i.e., a technology, product or service).

3) Phase III expects the small business or research institute to obtain funding from the private sector and/or non-SBIR/STTR government sources to develop the prototype into a viable product or service for sale in government or private sector markets.

	SBIR	STTR
Phase I	6 months; $100,000 max	6 months; $150,000 max
Phase I (Option)	4 month option (government's discretion); $50,000 max, to fund Interim Phase II efforts	No option
Phase II	2 years; $1,000,000 max	2 years; $1,000,000 max
Phase II Enhancement	Extends Phase II contract for up to 1 year (government's discretion); matches up to $500,000	No enhancement
Phase III	Unlimited time; non-SBIR funding	Unlimited time; non-STTR funding

SBIR AND STTR ELIGIBILITY REQUIREMENTS

To qualify for the SBIR and STTR Programs, a firm must meet the following criteria:

1) An organized for-profit, with a place of business located in the United States, which operates primarily within the United States or which makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor.

2) In the legal form of an individual proprietorship, partnership, limited liability company, corporation, joint venture, association, trust or cooperative (except where the form is a joint venture), there can be no more than 49 percent participation by business entities in the joint venture.

3) At least 51 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States; or it must be a for-profit business concern that is at least 51 percent owned and controlled by another for-profit business concern that is at least 51 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States — (except in the case of a joint venture).

4) Has, including its affiliates, no more than 500 employees. The small business may subcontract a portion of its work, as long as the small business "prime" performs at least two-thirds of the Phase I work and half of the Phase II work. For the purposes of determining compliance, percent of work is usually measured by both direct and indirect costs; however, the actual method of measurement will be verified during contract negotiations.

The STTR Program is open to any team consisting of a small business and a research institution. The research institution may be any U.S.-based nonprofit research institution, federally funded research and development center (FFRDC), or university or college. The small business must perform at least 40 percent of the Phase I and Phase II work. The research institution must perform at least 30 percent of the Phase I and Phase II work. Any part of the remaining 30 percent of the work may be subcontracted.

For the SBIR Program Phase I and II efforts, the primary employment of the principal investigator must be with the small business at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. For the STTR Program Phase I and II efforts, the principal investigator may be primarily employed with either the small business or the research institution.

In both programs, the Phase I and Phase II work must be performed in the United States, to include the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands and the District of Columbia.

PHASE III AND COMMERCIALIZATION

A goal of the SBIR and STTR Programs is to increase private sector commercialization of innovations derived from federal R&D, thereby increasing competition, productivity and economic growth.

The Army has instituted several programs to facilitate the transition of Phase II projects to Phase III. The following pages discuss each of these in detail:

1) Technical Assistance

2) Transition Support

Phase III represents the successful culmination of an SBIR/STTR project. SBIR Phase III refers to work that derives from, extends or logically concludes efforts performed under prior SBIR funding agreements, but is funded by sources other than the SBIR Program. Phase III work is typically oriented toward commercialization of SBIR/STTR-developed research or technology.

While Phase II success is measured by whether the prototype, product or service developed by the small business can meet an Army need, Phase III success can be indicated by the marketing and selling of the products or services outside the SBIR/STTR Programs. Sales can include cash revenue from the government, private sale of new products or non-R&D services embodying the specific technology and/or spin-off technology. Commercialization can include additional investments in activities that further the development and/or commercialization of the specific technology.

> "Increase private sector commercialization of innovations"

TECHNICAL ASSISTANCE

> **"Benefit the nation through stimulated technological innovation"**

In accordance with the SBIR Reauthorization Act of 2000, Public Law 106-554; and the National Defense Authorization Act of 2012, Public Law 112-81, of the Small Business Act (15 U.S.C 638); the Army provides technical assistance services to small businesses engaged in SBIR projects through a network of scientists and engineers working in a wide range of technologies. The objective is to increase Army SBIR technology transition and commercialization success; thereby accelerating the fielding of capabilities to Soldiers and to benefit the nation through stimulated technological innovation, improved manufacturing capability, increased competition, productivity and economic growth. The Army SBIR Program has strategically placed Technical Assistance Advocates (TAAs) across the Army to provide technical assistance to small businesses that have Phase I and Phase II projects.

EACH TAA PROVIDES:

Expert advice and analysis to SBIR awardees to assist the firm with:

1) Improving technical decisions
2) Solving technical problems that arise during the performance on a project
3) Minimizing technical risks associated with the project
4) Developing and commercializing new commercial products and processes resulting from the project

Expert advice and analysis to the government regarding:

1) Technology transition planning and development of technology integration roadmaps through participation in Program Executive Office (PEO) requirements development
2) Technology assessment
3) Technology transition planning and management activities that facilitate relevant and timely technical advice to support small business concerns regarding integration of SBIR-derived technologies into DOD programs

In coordination with the government research manager, SBIR awardee and any potential stakeholders, the TAA assists in formulating Phase III plans for Phase II projects. The Phase III plan must document the strategy, requirements and resources to transition the SBIR project to Phase III and into an acquisition program, larger science and technology effort or a stand-alone product or service.

TRANSITION **SUPPORT**

Army SBIR currently provides transition support to companies awarded with Phase II funding to Phase III through the Phase II Enhancement Program.

The Army is currently structuring a permanent SBIR Commercialization Readiness Program (CRP) to incorporate best practices from the past seven years under the Commercialization Pilot Program, and to address Congressional intent as defined by the SBIR Reauthorization language. Once implemented, the Army SBIR Program will administer the CRP to increase SBIR technology transition and commercialization success. The CRP is still in transition, so Phase II companies interested in securing additional support and funding for transition of their technology during this transition period should follow the process established for Phase II Enhancements. Companies interested in pursuing Phase II Enhancement funding are encouraged to contact their Contracting Officer's Representative (COR) or their Technical Assistance Advocate (TAA) for additional information and assistance.

PHASE II ENHANCEMENT:

The Army SBIR Phase II Enhancement Program provides funding to small businesses that require additional funding during their Phase II contract period. Instances where more funding may be required during Phase II should initially be identified by the project's COR. The COR, in conjunction with the TAA and the organization's SBIR Program Coordinator (PC) will compile the needed documentation and forward it to the Army SBIR Program Management Office (PMO) no later than six months prior to the end of the Phase II period of performance. The PMO will review and adjudicate all transition funding requests. Businesses that graduate from the SBIR small business definition or are acquired by a larger business that would not qualify during their Phase II contract will not be considered for Phase II Enhancement funding. SBIR Phase II Enhancement and CRP combined funding will not exceed $500,000 per request and is provided depending upon availability and is subject to a deliberate approval process. Small businesses interested in Phase II Enhancements and CRP should contact their COR.

SUCCESS STORIES

SBIR SUCCESS STORIES

ULTRA-WIDEBAND (UWB) SECURE WIRELESS COMMUNICATIONS FOR EN ROUTE COMBAT CASUALTY CARE

Starix Technology Inc. | www.starixtech.com
U.S. Army Medical Research and Materiel Command (USAMRMC)

Currently, a Ground Medic is unable to communicate with an approaching MEDEVAC Medic until the patient is being loaded. During this brief and vital time, patient information should be communicated between the two Medics. However, given extreme time constraints and loud ambient noise, valuable information can be lost.

Starix Technology has developed a product using Ultra-Wideband (UWB) technology to establish a communication link between the two Medics' end user devices (EUD) to exchange patient Medical data and voice communications prior to the MEDEVAC Medic's arrival. With patient information electronically captured, a more accurate conversation can occur. A pulse oximeter, measuring oxygen levels in the blood, equipped with an UWB adapter will provide the Medic with alerts on the patient's decompensation, or level of blood loss, in order to identify life threatening issues before they occur. The predictive algorithm may provide the Medic 15–20 minutes to react to these life threatening alerts to save the patient.

Starix demonstrated research on three capabilities using UWB at the Communications-Electronics Research, Development and Engineering Center's Ground Activity (CGA) 2016 evaluation at Joint Base McGuire-Dix-Lakehurst:

1) Range extension of the current UWB from 200 meters, out to a target range of 1 kilometer to enable a Ground Medic to transmit Medical data to an approaching helicopter or Ambulance Medic

2) Intercom capability via UWB enables the two Medics to have voice capability without interfering with tactical radio networks

3) Continued UWB-based pulse oximeter development transmission of photoplethysmogram (PPG) waveform — the waveform of optically obtained volumetric measurements of an organ — to an EUD, enabling software that analyzes the PPG to measure patient decompensation with predictive algorithms. In the image shown, Starix used a 3M Peltor headset to perform voice to text input. Then used UWB to transfer the Tactical Combat Casualty Care (TCCC) encounter from the Platoon Medic to the Ambulance Medic.

TECHNOLOGY TRANSITION:

The Starix UWB effort possesses advantages in security, connectivity (point-to-point, point-to-multipoint) and performance (data rates, user density, and simultaneous connections), that are ideal for TCCC applications. In order to facilitate and accelerate the integration of Starix's UWB technology into existing and new products, Starix is launching a secure UWB developer toolkit with a set of pilot products and applications software to illustrate its use. These include physiological sensors, smartphones and Medical equipment and supporting military Medical applications, including TCCC store and forward, vitals monitoring, telemonitoring and autonomous operations. Starix has received Phase III investment to date of $2.7M, including funding from multiple DOD components.

HUMAN-COMPUTER INTERFACES AND COMMAND AND CONTROL (HCI AND C2) FOR AUTONOMOUS AIR EVACUATION OF CASUALTIES

Neya Systems LLC | www.neyasystems.com
U.S. Army Medical Research and Materiel Command (USAMRMC)

In today's battlefield, unmanned systems are mostly limited to niche roles, and have been optimized for missions that are characterized as dull, dirty or dangerous. With rapidly increasing levels of autonomy, future unmanned systems will transition from filling niche roles to providing multi-functional uses, potentially including emergency Medical resupply and casualty evacuation (CASEVAC). Unmanned Aerial Systems (UAS) could be used for future CASEVAC and Medical resupply missions in situations where manned aircraft are denied access. The need to develop CASEVAC and Medical resupply capabilities for unmanned assets has become increasingly important, but requires new methods for Human-Computer Interfaces (HCI). A pure HCI development effort is not sufficient to enable a Medic or untrained operator to interact with a wide range of existing and emerging unmanned CASEVAC/Resupply Vertical Take-Off and Landing (VTOL) missions. A robust command and control (C2) infrastructure is needed so that the proposed HCI can operate at a task and goal level, rather than through teleoperation or indirect requests from a remote ground control station.

To address this U.S. Army Medical Research and Material Command (USAMRMC) SBIR topic, Neya Systems developed VERTI: A Vertical Takeoff and Landing (VTOL) Evacuation and Resupply Tactical Interface. VERTI

is an application on a handheld device, such as an Android-Based Nett Warrior End User Device, intended to provide the HCI capability to a ground Medic with little or no training in a VTOL operation. This Medic could then interact with unmanned assets at the task and goal level to plan and execute unmanned CASEVAC and Medical resupply missions. VERTI provides an easy to use command and control interface, and is compliant with existing military programs for controlling UAS assets for expedited CASEVAC and resupply, with reduced man-power requirements.

TECHNOLOGY TRANSITION:

Neya Systems was awarded a Phase III contract of $1.6M by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics to provide a Software Development Kit compatible with the latest model specifications of the UAS Control Segment open reference architecture. Additional funding was received from the Naval Air Systems Command of $313K and $286K from the Army. Combined, Neya has been awarded over $2.2M in DOD Phase III investments. With the funding provided, Neya Systems hardened their prototype and successfully tested it with a live flight CASEVAC demonstration using an unmanned Lockheed Martin K-MAX platform in March 2015. Neya Systems received additional commercialization funding through the U.S. Army Medical Material Agency Project Management Office, Medical Evacuation Package to extend Neya's VERTI capabilities, adding a transport telemedicine function by streaming patient vital signs and other information through the tactical radio network while en route. This capability was demonstrated in August 2016 at Joint Base McGuire-Dix-Lakehurst during a field exercise of a CASEVAC mission, using the unmanned K-MAX platform and a remotely controlled Unmanned Ground Vehicle for patient transport. Neya Systems also demonstrated sending command data to the Office of Naval Research Autonomous Aerial Cargo Utility System (AACUS) using VERTI to demonstrate system interoperability with platforms beyond K-MAX. While there is no hard timeframe for full Army fielding; Kevin Westfall, director of unmanned solutions for Lockheed Martin Mission Systems and Training, told Combat & Casualty Care magazine, "This collaborative demonstration signifies how using multiple unmanned systems can address critical needs such as medical casualty response and resupply without endangering additional lives." (Lundquist, Spring 2016)[1]

[1] Lundquist, E. (Spring 2016). MED Response via Vertical Lift. Combat & Casualty Care, 20-23.

SPEAR® AUTOMATIC SPEECH RECOGNITION SYSTEM FOR HANDS-FREE COMBAT MEDIC MEDICAL ENCOUNTER DOCUMENTATION

Think-a-Move Ltd. | tamrd.com
U.S. Army Medical Research and Materiel Command (USAMRMC)

Combat Medics are faced with the challenge of viewing electronic health records (EHR) and documenting quality procedural notes while providing effective and accurate care to the injured Soldier. A standard mobile and hands-free telemedicine platform that provides real-time Medical data and documentation tools does not currently exist. With this type of device connected to the tactical internet a Medic can exchange text, imagery and other data with others on the battlefield. Think-A-Move's (TAM's) speech recognition solution enables a Medic to complete a Tactical Combat Casualty Care (TCCC)/DD1380 card hands-free, through the Android-based NETT Warrior End User Device (EUD).

TAM developed a system enabling a Medic to complete the DD1380 Medical encounter using narration and integration of speech-to-text capability together with the Medical Communications for Combat Casualty Care Product Management Office (PM MC4) TCCC application through an expanded language model. This system was subsequently integrated with Ultra-Wideband (UWB) technology for wireless use in the field. Medics will use speech to enter data hands-free about the injured into a DD1380 encounter, including free-form progress notes. After the Medics complete the encounter, the digital report is signed and sent. The Nett Warrior EUD is connected to a Rifleman Radio to transmit the encounter over the tactical network to a server with the Armed Forces Health Longitudinal Technology Application – Theater AHLTA-T installed to upload the encounter into the patient's permanent electronic health record (EHR). Once the encounter is uploaded, it can now be viewed at the next level of care, such as a Battalion Aid Station (BAS). TAM also created a unique 64K Medical word vocabulary for this system. This vocabulary connects the system into a network with capabilities for telemonitoring, providing the ability to share a common operating picture (COP) of both casualty evacuation and patient movement; capturing, processing and disseminating Medical information electronically in real time.

To obtain better accuracy across a wider spectrum while the Medic is using the application, robust live adaptation of voice recognition in a noisy environment was required. TAM has incorporated continuous transcription, which will allow the Combat Medic instant speech-to-text feedback. Automatic parsing and continuous transcription allows the Medic to freely speak during the combat scenario, and at the end of the scenario, to be able to fill out a more complete patient care form with less manual voice and tactile data entry.

TECHNOLOGY TRANSITION:

Through a Phase II Enhancement, TAM has created an SDK Toolkit that will allow development teams the ability to voice-enable other patient care forms within the Medical community. TAM is also working to implement personal voice assistance capabilities into the Automatic Speech Recognition (ASR) system. Medics will be able to ask questions on previous treatments and receive a response.

Think-A-Move has received Phase III commercialization investment to date of over $1M including funding from multiple DOD components; as well as a related Phase III project with the National Oceanic and Atmospheric Administration to incorporate SPEAR into the Alaska Fisheries' "Fish Specimen Collection" application for scientists on board fishing vessels.

RAPID DETECTION ASSAYS TARGETING CHIKUNGUNYA (CHIKV) AND ZIKA VIRUS (ZIKV) IN MOSQUITOES

VecTOR Test Systems Inc. | www.vectortest.com
U.S. Army Medical Research and Materiel Command (USAMRMC)

Outbreaks of infectious diseases transmitted by mosquitoes and other arthropod insects in operational environments pose a threat to combat readiness, impacting the Army's ability to execute world-wide missions. This makes prevention and preparedness critical to the protection of Defense (DOD) military personnel and civilians stationed in U.S. installations or on foreign soil. Surveillance and control are the main operational methods for the detection and prevention of debilitating arthropod-borne diseases. Determining the risks of arthropod-borne diseases in the field requires practical and accurate detection methods. CHIKV has regularly appeared in 23 countries and analysis of viral sequences identified three distinct clades, or groups of viruses having a common ancestor, separated primarily by geography. Since 2004, several million indigenous cases of CHIKV disease have been reported. CHIKV is a debilitating and prolonged syndrome primarily affecting the peripheral small joints resulting in a form of joint pain known as arthralgia. ZIKV is another arthropod-borne disease that needed an antigen assay for outbreak prevention. ZIKV is a virus causing fever, rash, joint pain and conjunctivitis. ZIKV has been reported in 56 countries and territories, U.S. included, according to the Centers for Disease Control and Prevention (CDC). While mostly non-lethal, birth defects have occurred in those infected and pregnant (CDC). These control methods require effective targeting of interventions, which rely on the detection of the pathogen in the vector.

Traditional methods of detecting viruses in the arthropod vectors include Enzyme-linked Immunosorbent Assays (ELISA), Viral Culture and Real-Time Reverse-Transcriptase Polymerase Chain Reaction (RT-PCR). These methods require specialized equipment, refrigeration and freezing of reagents, and highly trained personnel to perform and interpret results. U.S. Army Medical Research and Materiel Command (USAMRMC) sought an alternative: a portable, inexpensive and rapid field test able to indicate the threat of arthropod vector-borne diseases. Through a Phase II Enhancement with matching funding from The U.S. Army Medical Materiel Activity (USAMMDA), CHIKV was added to the assays produced under this VecTOR Test Systems (VTS) Phase II contract. In a separate Army SBIR effort, VTS created a multiplex assay to quickly and accurately detect medically relevant viruses called alphaviruses and flaviviruses in arthropods collected during military deployments. This project received Phase II Enhancement matching funds for final testing from the Joint Project Management Office for Medical Countermeasure Systems (JPM MCS). Through additional Defense Health Program Phase III funding, this multiplex assay is currently being expanded to include a high-accuracy ZIKV assay.

TECHNOLOGY TRANSITION:

The Armed Forces Pest Management Board (AFPMB) is working with the appropriate organizations to have the CHIKV and ZIKV assays incorporated into appropriated "sets, kits and outfits" used by deployed Preventive Medicine Units. Current kits include: Dengue Fever (DENV), Malaria (MAL) and Leishmania (LEI) antigen assays developed by VTS under the Army SBIR Program. The DENV kit resulted from the same base project that has now yielded the CHIKV assay. A Rift Valley Fever (RVF) assay was also developed under that project.

Additionally, these and other assays previously developed by VTS, are currently available for non-military purposes. They are used in pest management control efforts undertaken by commercial entities and other non-governmental organizations (NGOs). These efforts take place in the U.S. and other areas of the world where arthropod-borne pathogens are endemic. With the increased presence of CHIKV and ZIKV in the United States, rapid detection devices have become critical in the fight against disease transmission by arthropod vectors. The CHIKV and ZIKV mosquito antigen assays are currently undergoing field evaluation and upon completion will be reviewed in order to be assigned National Stock Numbers (NSN). The CHIKV assay is expected to be available for field purchase in the 2017–2018 timeframe and the ZIKV assay will follow approximately one year later. CHIKV is waiting for final testing and approval from AFPMB.

The SBIR efforts resulting in new CHIKV and ZIKV assays have Government combined Phase III investments totaling $2.1M with commercialized sales of approximately $20K for the CHIKV commercial product. Combined, these projects have received over $2M in Phase III funding.

MELIAN II SEARCH AND RECOVERY SYSTEM

Daniel H. Wagner Associates Inc. | www.wagner.com
U.S. Army Space and Missile Defense Command (USASMDC)

Wagner Associates developed the state-of-the-art MELIAN II underwater search system in response to the topic "Search and Recovery of Reentry Vehicles at Kwajalein Atoll (KA)" in 1991. MELIAN II supports all the elements of search planning and execution and runs on a Linux laptop, with optional National Marine Electronics Association (NMEA) connections to GPS, depth and speed sensors and on autopilot. MELIAN II produces target probability maps from combinations of position clues, recommends optimal search areas and patterns, navigates the search platform automatically through the patterns and collects and evaluates sensor input in real-time.

After the completion of the Army Phase II contract in 1994, the company offered MELIAN II to government and commercial customers for mine warfare and search, salvage and recreational diving. The MELIAN II search evaluation algorithms accurately compute the effectiveness of both mine hunting and mine sweeping operations by multiple sensors, sweeps and platforms. MELIAN II based algorithms are used to optimize mine hunting and mine sweeping operations and to support the evaluation of risk to multiple transistors from multiple mine types along a transit route or patrol area.

TECHNOLOGY TRANSITION:

MELIAN II algorithms and software provide the core functionality of the Evaluation, Optimization and Risk Assessment modules used in the U.S. Navy's Mine Warfare and Environmental Decision Aids Library (MEDAL), a Global Command and Control System-Maritime (GCCS-M) Segment, used by all Mine Countermeasures units and their staff as a primary planning and evaluation tool. The cumulative MELIAN II related MEDAL funding has amounted to over $5.6M in Phase III funding.

MELIAN II has been sold to multiple commercial underwater search customers, most recently Northrop Grumman Undersea Systems. Other commercial sales include: NASA/JPL, Phoenix Search, Marex, Oceaneering Technologies, Fugro Pelagos, etc. Cumulative commercial sales and investment have amounted to $767,143.00. In June 1994, Oceaneering Technologies, using a MELIAN II generated search plan, found the wreck of the DERBYSHIRE, the largest British vessel ever lost at sea. The huge bulk carrier went down in the typhoon off Okinawa in 1980 with the loss of its entire British crew of 44, and had been considered unfindable by experts. The MELIAN II search plan called for less than half the effort the search contractor had planned, and the shipwreck was located on the first full sonar search leg.
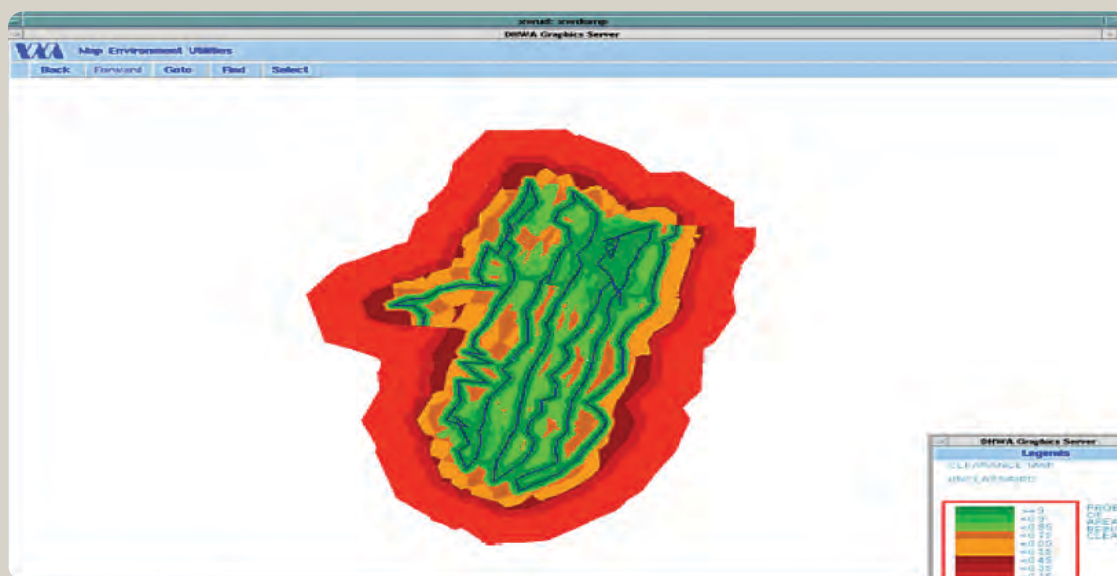
Example Side-Scan Search Effectiveness Map
(Note: Dark Green shows ≥ 0.90 cumulative detection probability (CDP), Medium Green shows CDP < 0.90 and ≥ 0.80, etc.)

BIOMIMETIC CONTROL OF FLYING ROBOTS – INSTANTEYE®
SMALL UNMANNED AERIAL SYSTEMS

Physical Sciences Inc. | www.psitactical.com
U.S. Army Research Laboratory (ARL)

Physical Sciences' InstantEye® team focuses on creating small, low-cost tactical robots for the Warfighter and first responders. The individual Warfighter requires a small, low-cost, airborne intelligence, surveillance and reconnaissance (ISR) sensor to provide on-demand situational awareness. Through U.S. Army SBIR funding, the InstantEye® team first developed a highly agile, reflexive autopilot based on insect flight, navigation and collision studies. This biomimetic, reflexive autopilot became the core of the InstantEye® small unmanned aerial system able to operate in cluttered environments and in all weather conditions. InstantEye® is a miniature, all-weather, high-performance, low-cost aerial system. The vehicle can be easily stowed and deployed on-the-fly for examining roof tops, looking around corners, identifying IEDs or clearing mountain caves. Its quadrotor design provides an adept, hovering platform; ideal for carrying its numerous payloads while combating windy environments. It does not require pre-flight planning, boot-up or assembly. InstantEye® has approximately a 1-kilometer line-of-sight (LOS) range and a 30-minute endurance.

TECHNOLOGY TRANSITION:

InstantEye® development, manufacturing and commercialization has had several investments. $2.9M has been invested through the Technical Support Working Group, under The Combating Terrorism Technical Support Office, and Rapid Reaction Technology Office (RRTO), Under of Office of the Secretary of Defense. Additionally, $300K from the Massachusetts's START grants program, almost $600K from the U.S. Army and RRTO, and product sales to the U.S. Armed Forces in excess of $5M has been provided for the InstantEye® Mk-2 GEN3 and the InstantEye® Mk-2 GEN4 in commercialization funds. The result of this investment is a high-performance, low-cost unmanned aircraft system (UAS) that is being fielded by the U.S. military, being purchased and used by the Department of Homeland Security, purchased and used by federal law enforcement agencies, and is being readied for international sales. In 2014, the InstantEye® Mk-2 GEN3 became a SOCOM Program of Record (PoR), and the InstantEye® Mk-2 GEN4 is currently being fielded by the U.S. Army as the Short Range Micro UAS. Alan Shaffer, Principal Deputy, Assistant Secretary of Defense, Research and Engineering told the ArmyTimes about InstantEye® and how, "U.S. troops were able to use the device to identify and neutralize seven insurgents in Afghanistan. These insurgents were waiting to ambush the patrol." (Jahner, 2015)[2]. Another story released on army.mil shows the 10th Mountain Soldiers in Baghdad,

Iraq using the InstantEye® UAS in support of Operation Inherent Resolve. Pfc. Taylor Chapman, C Troop, 3-71 Cavalry, discusses how InstantEye® improves situational awareness during a patrol. "When conducting patrols, you will be able to see what's in front of you with (InstantEye) scanning," Chapman says, "When you are done with the objective and you're walking back out, it can be used to cover (you)." (Sgt. Cheryl Cox, 2016)[3]

InstantEye® Mk-2 GEN3 and GEN4 systems are now fielded with every branch of the U.S. Armed Forces. InstantEye® systems are continually upgraded with new capabilities through new payloads made possible by the system's innovative payload architecture. Today, InstantEye® systems provide ISR video, communications relay, payload delivery, weather data collection and GPS-denied navigation capabilities. While InstantEye® systems have shown success in commercialization, development continues to advance the capabilities. An Army SBIR Sequential Phase II was awarded to improve navigation in GPS-denied environments. The majority of new developments, such as increase the autonomy and operative behaviors with other robotic systems, are funded from the sale profits of the technology.

[2] Jahner, K. (2015, April 6). RPGs, grenades and dummies: 9 Soldier-tested gadgets. Retrieved from ArmyTimes: https://www.armytimes.com/story/military/tech/2015/04/06/benning-aewe-battelab-tech/70214876/

[3] Sgt. Cheryl Cox, 1. B. (2016, March 3). InstantEye brings security, situational awareness to 10th Mountain Soldiers. Retrieved from army.mil: https://www.army.mil/article/163463/InstantEye_brings_security__situational_awareness_to_10th_Mountain_Soldiers

HAPMED™ MEDICAL SKILLS TRAINING SUITE

CHI Systems Inc. | www.chisystems.com, www.hapmedtraining.com
U.S. Army Research Laboratory-Human Research and Engineering
Directorate (ARL-HRED)

The leading cause of preventable death on the battlefield is blood loss from extremity wounds. The other most common causes of preventable death are collapsed lung and airway obstruction. If bleeding control and airway management education was improved, the majority of preventable battlefield deaths could be averted. Many existing full-body mannequin trainers are expensive to purchase, difficult to use and require use of messy synthetic blood and replacement parts. This makes them ineffective for rapidly training large numbers of Medics and first responders. A well-practiced skill, such as tourniquet application, may require hundreds of initial trials and on-going refresher training trials, but there are few existing opportunities to get extensive hands-on practice. Airway management skills are typically practiced on cadavers. Cadavers are expensive, rarely accessible and do not provide the opportunity for trainees to repeatedly practice mastering their skills.

To address these challenges, CHI Systems has developed and patented the HapMed™ Medical Skills Training Suite awarded by the Army SBIR Program. HapMed™ is comprised of multiple instrumented manikins to teach hands-on skills in tourniquet application and airway management. HapMed's Tourniquet Trainer provides a unique training approach that allows

trainees to repeatedly practice proper use of a tourniquet while developing decision making skills in a variety of situations. HapMed's Airway Trainer allows Medics and advanced life savers to practice the delicate skills of locating the proper incision point then cutting and inserting an air tube to restore breathing during an emergency cricothyrotomy procedure. HapMed™ systems provide patient assessment, decision making and hands-on practice through a series of built-in training scenarios that feature real-time feedback on performance and after action review. HapMed's unique hands-on training approach allows combat Medics and first responders to repeatedly practice critically-needed life-saving skills in a low cost, scalable solution.

TECHNOLOGY TRANSITION:

Phase III funding of $3.3M was awarded to CHI Systems and managed through the U.S. Army Research Laboratory-Human Research and Engineering Directorate, Advanced Training and Simulation Division (ARL-HRED ATSD) resulting in a commercial-ready version of the tourniquet training solution and a mature prototype for the cricothyrotomy trainer.

HapMed™ is actively marketed and sold to military and civilian tactical Medical casualty care and advanced life saver training institutions. DOD sales to the Defense Medical Readiness Institute, the Naval Medical Logistics Command and the Air Advisory Academy support continued training for Medics in the field. Commercial sales from several hospital and emergency Medical schools, such as The University of Minnesota Medical School, The Cambridge Hospital and Bergen County EMS Training Center, have used HapMed™ to give civilian Medics the same extensive training for the most common causes of preventable death. The Federal Law Enforcement Training Center uses the HapMed™ Tourniquet Trainer to prepare federal law enforcement personnel, first responders and other emergency tactical Medical personnel for situations requiring bleeding control skills.

HapMed™ is used by military and civilian research laboratories, including the U.S. Army Institute of Surgical Research, to advance tourniquet design and training outcomes. The research conducted on HapMed™ helped shape the military and civilian tourniquet policies of today.
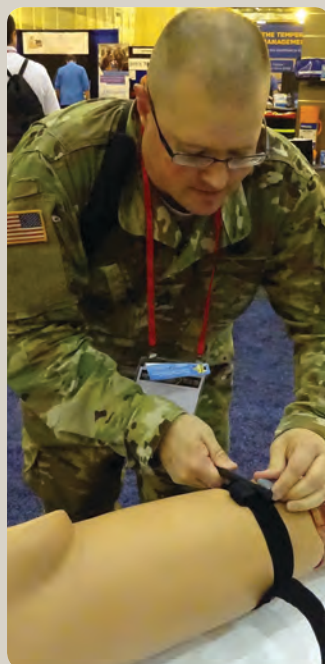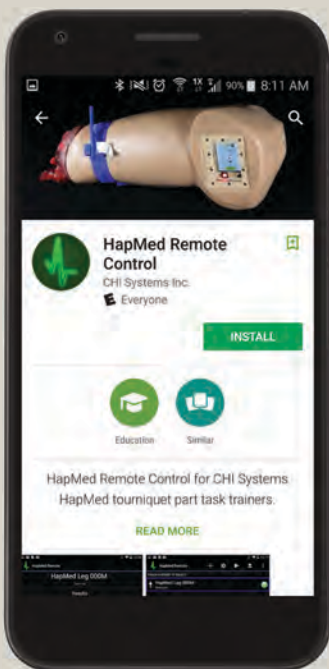
TERRAIN DATABASE FORMAT AND SERVICES TO SUPPORT EXTREMELY HIGH RESOLUTION NATURAL ENVIRONMENTS

Dignitas Technologies LLC | www.dignitastech.com
U.S. Army Research Laboratory (ARL)

Increased capability in natural environment data capture, such as light imaging, detection and ranging (LIDAR), dramatically increases the need for even higher resolution terrain representations and services. Previously, the most complex synthetic natural environment (SNE) representation focused on correlation with a visual representation; but live, embedded and automated applications require correlation with the complexities of the real world. At the same time, embedded applications have limited storage and processing capacity. As a result, there is a growing need for lightweight, high resolution terrain engines.

Through the High-Fidelity Runtime Database Engine (HFRDE) program, Dignitas Technologies and Applied Research Associates (ARA), developed a reusable terrain database format and services to support extremely high resolution natural environments, with minimal processor and memory footprint requirements. This component provides an advanced terrain analysis capability on mobile and embedded devices.

The terrain services component, known as the Layered Terrain Format (LTF), provides terrain services such as line-of-sight and collision detection on extremely compact and high resolution data. This capability can support live, virtual and constructive training scenarios. Building upon LTF functionality, a series of innovative mobile device applications (apps) were implemented, including the Tactical Terrain Analysis (TTA) app providing Soldiers the ability to conduct mission planning and analysis functions on mobile devices without access to a wireless network. Dignitas developed TRACR Ultra Lite (TÜL), which

provides control of targets at live fire ranges from an Android tablet. This app allows training facilitators to control range targets without radioing back to a central control tower.

TECHNOLOGY TRANSITION:

Each of the key development pieces had great transition success. The TTA app has been used for analysis to support orienteering courses at the United States Military Academy at West Point. The TTA app was installed on the cadets' tablets, so it could be used during their courses. Other user trials resulted in feedback on functionality and greatest value for individual Soldiers. TÜL has been demonstrated at Fort Pickett's Army National Guard Maneuver Training Center and fielded at Fort Irwin, Fort Riley, Camp Ripley and Fort Stewart for squad and platoon training.

Dignitas Technologies was awarded $2.4M in commercialization funding investments that led to commercialization funding supported by Project Manager Training Devices (PM TRADE) and Advanced Training & Simulation Division (ATSD). Additionally, the National Reconnaissance Office (NRO), the United States Military Academy (U.S.MA), the University of Central Florida (UCF) and live fire training locations have invested labor in evaluations, user trials and collaboration efforts. These commercialization funding investments have been the springboard necessary to advance research topics into practical applications, while supporting current Warfighter needs.
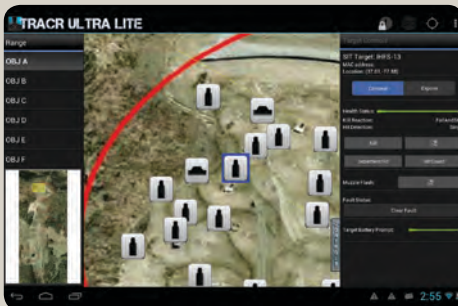
DYNAMIC ENGAGEMENT SOLUTIONS FOR ELECTRONIC WARFARE (EW) AND RANGE OPERATIONS

Systems & Processes Engineering Corporation (SPEC) | www.spec.com
U.S. Army Research Laboratory (ARL)

Systems & Processes Engineering Corporation (SPEC) developed Electronic Warfare (EW) products and range systems for operations in dense electromagnetic (EM) spectrums in support of critical air, ground and sea systems missions. SPEC's high-fidelity digital radio frequency memory (HiFiD DRFM) was awarded a SBIR contract from the Army Research Laboratory (ARL), which provided critical seed funding for SPEC's EW technology. This led to a multitude of cutting edge EW products, range systems, and cyberwarfare capabilities to support the Army and DOD. The agile digital effects processor (ADEP) dynamic engine technology manipulates incoming communications and radar signals creating a virtual EM reality. The technology consists of dynamic and complex radio frequency (RF) responses, signatures and images that counter enemy surveillance, prevent and disrupt communications, and defeat threat weapon systems. ADEP is a revolutionary advance in EW capabilities because of its size, weight, power and cost (SWaP-C), attainability as a commercial off the shelf (COTS) product and wide range of electronic techniques: electronic warfare support (ES), electronic attack (EA) and electronic protection (EP). The New ADEP products further reduce the SWaP-C requirements of existing products and are directly derived from previous generation in both architecture and software development.

TECHNOLOGY TRANSITION:

Following the successful Phase II program, SPEC attracted over $8M in private investments for both product and market development in addition to over $17.5M in commercial products and systems sales. Approximately $6M of the DOD sales came from the Army Research Lab (ARL). The remaining commercialization funds came from the Naval Surface Warfare Center, Johns Hopkins University, The U.S. Navy Naval Air Systems Command (NAVAIR), the U.S. Air Force, and New Mexico State University-Physical Sciences Lab. The commercialization funds were through the sales of hardware, firmware and software as COTS products.

Today, Phase III ADEP technology and products are geared for the most demanding EW and range applications for mission operations. This technology has been primarily used by ARL, NAVAIR and the Air Force. The original ADEP technology, stemming from the SBIR program, is incorporated into all products; this ranges from a design to incorporation of currently running COTS software. Along with the initial ADEP 1300, ADEP 800, and ADEP T4000 systems, SPEC has recently announced two next generation products: the ADEP Ultra-CTG and the ADEP Blade. The Air Force uses multiple ADEP 1300 (predecessor to the ADEP Ultra CTG) and ADEP T4000 systems at Nellis Air Force Base ranges for electronic target generation. This saves a lot of time and money when compared to physical targets; in addition to providing flexibility to choose which target is displayed. As testing requirements increase nationwide, the ADEP technologies are expected to integrate with other ranges.

The ADEP Blade is a communication and radar EW product with RF processing. Because of its field ready ruggedness and SWaP-C, the ADEP Blade is an EW system with multi-mission configurability for autonomous and semi-autonomous operations in harsh, complex EM environments. The ADEP Blade is versatile and can be easily integrated into different system platforms. The ADEP (DRFM) Blade is integrated into the Army Research Lab Optimized Modular EW Network (ARL OMEN) system, at the U.S. Army White Sands Missile Range, to test the advanced communications and radar systems and provide realistic operational training for ground, air and naval weapons systems.

WEAPON ORIENTATION – ACCURATE MEASUREMENT OF BARREL ORIENTATION FOR INDIRECT FIRE WEAPONS

Inertial Labs Inc. | www.inertiallabs.com
U.S. Army Research Laboratory (ARL)

The mortar's versatility and power make it potentially one of the most critical weapons in the U.S. military arsenal but are among the most underutilized weapons. Underutilization stems from the Army's inability to simulate mortar indirect fire during live training exercises at Combat Training Centers. Current laser based tactical engagement simulation training systems are limited to line-of-sight engagements with the target. Because the target impact point cannot normally be observed by the mortar crew, laser based simulation of indirect fire weapons is not feasible. Additionally, current mortar aiming systems require slow, substantial setup and the point of aim is easily lost after each shot requiring additional time to reengage a target. Under this Army SBIR award, Inertial Labs developed a solution to these challenges inherent to indirect fire weapons, such as mortars and grenade launchers. Furthermore, the technologies used for the base effort are being applied to direct fire weapons (rifles, machine guns, etc.) training systems in a series of option efforts to improve live training on a wide range of small arms.

The Inertial Labs' development of its optically enhanced weapon orientation module (OptoWOM) is a new approach to enable simulating indirect fire weapon engagements. Aided by an onboard camera, it uses a robust feature recognition algorithm with data from sensors used to measure motion and orientation, such as accelerometers, gyros and magnetometers. This accurately tracks mortar movement and orientation in the presence of strong magnetic disturbances. The computer vision and sensor fusion software along with the system integration was done by Inertial Labs for the Army Research Lab (ARL) as part of an ongoing effort to develop more realistic live training systems for dismounted Soldiers. The technologies used in the OptoWOM are being used in other prototype systems developed under this contract to achieve similar performance gains while attempting to minimize improper training caused by hardware and situational limitations.

While originally developed for ARL with the intent to improve mortar training, the OptoWOM was picked up for use by the operational Army and is now the key subsystem for the U.S. Army's Weaponized Universal Lightweight Fire Control (WULF) system being developed by ARDEC at Picatinny Arsenal. WULF provides accurate weapon orientation to allow the fire control system to convey proper movement of the barrel to engage the enemy target – eliminating the need to use the current sight unit and aiming stakes. As a result, Soldiers are able to setup and complete the aiming process more quickly and engage targets more accurately than before. With WULF, the average setup time for an 81mm system aimed on target from a dismounted state is cut by roughly 75 percent. Additionally, the time to re-aim at the target between shots is reduced by 90 percent allowing for more rounds to be placed on target, increasing lethality. By digitizing mortar aiming, the WULF system becomes a natural training tool and provides knowledge for live training scenarios of where mortar rounds would land in force-on-force simulation.

TECHNOLOGY TRANSITION:

Inertial Labs Inc. was awarded $23M in funding over the past five years from a combination of Army branches including the Army Research Lab (ARL): Human Research and Engineering Directorate, Advanced Training and Simulation Division, Program Executive Office for Simulation, Training, & Instrumentation (PEO-STRI) Project Manager for Training Devices and the U.S. Army Armament Research, Development and Engineering Center (ARDEC). Much of this funding was provided by ARL and ARDEC to develop the initial concept to successfully achieving a Technology Readiness Level 6, in September of 2016, based on meeting or exceeding various performance metrics. Throughout the effort, various features were added to improve the system's performance, add capabilities and make it more robust. The OptoWOM, under the WULF program, will undergo final development and transition to the operational Army from the Product Manager for Guided Precision Munitions and Mortar Systems (PdM GPM2S). Once complete, WULF will be a digital fire control solution for mortar weapon systems. As a result, the Army will achieve quicker and more accurate target solutions, leading to greater lethality and ultimately saving the lives of men in the field of battle while also minimizing collateral damage. The effort received funding from ARL and PEO STRI to look at the technologies in OptoWOM for suitability in other small arms training systems. Inertial Labs has been evaluating and integrating various sensors and communications technologies, derived from the first SBIR award, to develop a modern method for simulating live training events that would provide more realistic training. Additional benefits of an open weapons effects simulator for live fire would have greater flexibility with accurately portraying different weapons systems and improved adaptability as the weapons and operating environment change.

POLARIZATION IMAGERS HAVE THE POTENTIAL TO SAVE LIVES BY REVEALING UNDETECTED DETAILS AND THREATS

Polaris Sensor Technologies Inc. | www.polarissensor.com
U.S. Army Research Laboratory (ARL)

To improve a Soldier's situational awareness in the field, the Army released a SBIR topic looking for new technology with infrared (IR) video-imaging and real-time measurement capabilities, specifically using mid-wavelength (MidIR) and long-wavelength (LWIR) parts of the IR spectrum. Polaris Sensor Technologies Inc. was selected and awarded an Army SBIR contract to improve Soldier safety through the development of a unique, real-time video system using LWIR.

Polarimetric imagery is a 2-D image or video where pixel intensity is defined by polarization. Polaris used the Army SBIR award to create Pyxis®. It is the smallest, most cost-effective, lightest weight polarimeter on the market. These polarization-imaging cameras improve situational awareness and detect threats with the capability to identify and track targets through smoke. Current technology can be limited by cluttered, low thermal contrast environments. Pyxis® uses the polarization of light to detect targets even if they thermally blend into the background and are undetectable with an infrared imager. The cameras not only detect targets but deliver geometrical details to improve situational awareness. This includes the ability to identify a disturbed area of dirt. eTherm® software, developed with Pyxis®, is used to filter out a specific target from a cluttered environment.

Based on the Army SBIR topic requirements, Pyxis® operates in the longwave infrared waveband (LWIR) and generates real-time polarization video. The increased sensitivity, decreased size, and advanced algorithms make the use of thermal polarization for threat detection in the field a reality. The system collects four different LWIR images and combines them into one polarized image. This sensor is being further developed with ARL to improve day and night facial recognition capabilities. This will be funded by an additional Army SBIR contract still in the development stage.

TECHNOLOGY TRANSITION:

As a result of their successful SBIR activity, Polaris has been awarded over $4.4M in additional research from the Army. Pyxis® can also be used for non-military applications including the detection of oil and diesel on water. Pyxis® was recently tested in the field by the National Oil Spill Response Research & Renewable Energy Test Facility. The testing showed that the contrast provided by polarization improves images as much as 50 times compared to standard thermal imagery, depending on the situation and target. For example, in one

Polarization Imaging

situation standard thermal imagery gives a target to background contrast of 2, while polarimetry gives a contrast of 100. Pyxis® can be used for seep detection, continuous automated leak detection and monitoring of operational and abandoned oil rigs and platforms as well as the surveillance of ports and harbors where diesel is dumped illegally. Following the 2015 Santa Barbara oil spill, the Pyxis® system detected oil still in the area even after the clean-up. The Pyxis'® eTherm® software is used in more complex environments. For example, the software is able to distinguish oil from glints, kelp or variance in water color. Other commercial uses could include construction and agriculture. Pyxis® can improve safety for crews and autonomous equipment in commercial or military environments by detecting obstacles in real time. The Army invested $2.9M of the $4.4M Phase III funding to develop the Dual Wavelength Imaging Polarimeter (DIPOLE™). The DIPOLE™ system is derived from the Pyxis® technology to improve detection capabilities by integrating a dual LWIR and MiDIR into an IR focal plane. The Pyxis® and DIPOLE™ both leverage physics-based applied research funded under various subcontracts that proved polarimetry greatly enhances military intelligence, surveillance and reconnaissance (ISR) capabilities. Commercial advancements planned for the Pyxis® system will also improve the DIPOLE™ system user interface and performance. DIPOLE™ is due to emerge from the Polaris Laboratory in August 2017.
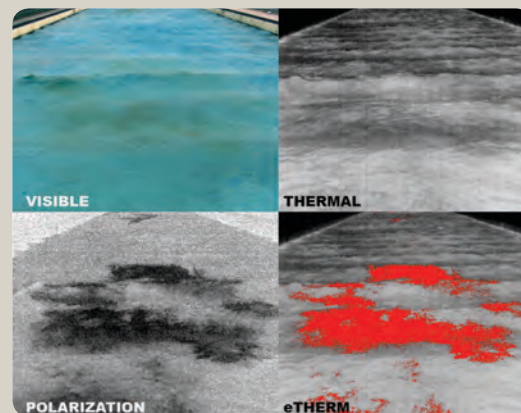
The Pyxis® polarization enhanced imager detects oil on water 400% better than standard thermal. Pyxis® can also be configured to provide color enhanced oil detection for even greater clarity. Data taken at Ohmsett in July 2016.

CELESTIAL AND POLARIZATION COMPASS FOR FAR TARGET LOCATION SYSTEMS

Trex Enterprises Corporation | www.trexenterprises.com
U.S. Army Research Laboratory (ARL)

Precision target location information provided by forward observers is utilized to perform surveillance, identify and engage threats at safe distances, call fire and accurately position troops, and engage enemies while reducing probability of fratricide or collateral damage. Conventional north finding techniques, which are relying on magnetometer-based solutions, are susceptible to magnetic interference and require manual in-field re-calibration.

With initial SBIR funding, Trex Enterprises Corporation has developed the patented Celestial Compass™, an optics-based absolute heading reference system which utilizes celestial bodies (sun, moon and stars) to determine target azimuth. The Trex Celestial Compass™ provides azimuth measurement accuracies of 2 mils during daylight hours and less than 1 mil at night. This is 10 times more precise than solutions provided by conventional digital magnetic compasses in benign environments and a hundred-fold improvement over azimuth solutions in the presence of magnetic anomalies.

There has been, and continues to be, active investment in research to further develop the Trex Celestial Compass™ technology to minimize size, weight, power and cost (SWaP-C); as well as improve availability of celestial solutions to support a range of next generation of targeting and designation, precision-guided munitions and navigation systems. Under a Phase II SBIR program, Trex has developed a hybrid Celestial & Polarization Compass which expands the availability of non-magnetic azimuth solutions to 85 percent for worldwide weather; including operation in cloudy and overcast conditions while maintaining the same small SWaP-C.

TECHNOLOGY TRANSITION:

Since the Trex Celestial and Polarization Compass™ overcomes a joint operational capability gap for a non-magnetic, non-GPS-based absolute attitude and heading reference system, it is highly relevant for transition into several DOD programs of record that involve target location, precision-guided weapons and navigation systems.

Over the past several years, Trex has received $10M in DOD contract awards to mature the Celestial & Polarization Compass™ technology and develop products for field deployment. Trex licensed the Celestial Compass™ technology to Northrop Grumman Laser System and transitioned it to full rate production for integration into the battle-proven, man-portable Lightweight Laser Designator Rangefinder (LLDR, Army Program of Record). Currently the LLDR is fielded to Army Forward Observers and Air Force Forward Air Controllers and is used to find, range and designate targets for laser guided munitions. Additionally, the system can pass target information on to other units for situational awareness or fire control solutions. The improvements to the Celestial & Polarization Compass™ are under development for integration into a next generation prototype of Far Target Location systems such as an updated Army LLDR and the Joint Effect Targeting System (JETS).

FUEL FLEXIBLE GENERATORS FOR MAN-PORTABLE AND REMOTE POWER APPLICATIONS

SAFCell Inc. | www.safcell.com
U.S. Army Research Laboratory (ARL)

Power on the battlefield is of uppermost importance. For the dismounted Soldier, there is an increasing need for a high-energy density and lightweight power source that can run on logistic fuels. SAFCell's fuel-flexible power systems run on patented, solid acid fuel cell stacks that convert fuels into electrical power silently and efficiently, and can handle the highest impurities found in military logistic fuels (i.e. JP8). In Phase II and ongoing Phase II Enhancement efforts, SAFCell and system partner UltraCell LLC., are developing a 50W man-portable power generator with system energy density (> 1000 W*hr/kg) that will reduce pack weight by 3 times compared to use of typical high capacity batteries (i.e., BB2590/U).

The power unit will run on military or commercial fuels with efficiencies approaching 30 percent in comparison to 3 to 15 percent for other small power generation technologies. The SAFCell power unit is at least two times, up to ten times, more efficient than current fielded technologies. This greatly reduces fuel costs, fuel logistics and rucksack weight burden for mobile power. Based on a military specified design, SAFCell's PP-50-Flex: Portable Flex-fuel Power System, can be quickly transported and deployed where necessary even under demanding field conditions. The unit is designed to enable universal use of high power communication devices, targeting systems and anti-IED or anti-mine units.

For commercial applications in Oil & Gas sectors, SAFCell modified the 50W propane fueled power system to run on industrial methanol (a fuel found on-site at almost all modern wellheads) and power equipment used at the surface of the drilled hole. In laboratory testing, the system has demonstrated operation down to -40°C and up to +50°C and with 50W (net) continuous operation for over 1000 hours. The system has demonstrated operation in pulse power mode, required to power wellhead pumps and controllers, with peak powers up to 300W (duty cycle ~ 15 percent) for hundreds of hours.

TECHNOLOGY TRANSITION:

Phase II Enhancement efforts are focused on system packaging of Phase II prototype to hit the Army's stringent weight and volume requirements. UltraCell provided matching funds of $250K for the Phase II Enhancement. Packaged and stress tested demonstration units will be delivered to the Army for initial field trials in early 2017. Phase III efforts will involve integration of a compact JP8 reformer from InnovaTek Inc. into field trial units for extensive evaluation by the Army Research Office. SAFCell has received $6.5M in venture capital funds from Lake Bridge Capital, and $3.7M from a DOE grant in Phase III funding to aid in development efforts of both military and commercial SAFCell power generators. Key in securing this Phase III funding were stack and system level demonstrations produced under Army SBIR contracts. Commercial product development has focused on remote power applications in the O&G sector. Specifically, small power units for wellhead communication, monitoring and control that can deliver reliable, year round power even under the extreme weather conditions (-40°C to +50°C) found in the O&G industry.

Field trials with O&G partner started in the fall of 2015, and integration into commercial wellheads is scheduled for the summer of 2017. Initial lab and roof testing were conducted with Calscan Energy Solutions, a commercial company specializing remote power and electrification of wellheads. To test the reliability in all weather conditions, replicating usage in military applications, visits to Calscan were conducted from December 2015 to July 2016. Final configuration testing will start in December 2016 on Calscan's roof in Edmonton, Alberta to ensure the technology is able to withstand winter weather. Future field trials are scheduled for 2017 with ConocoPhillips on the condition that Calscan gets awarded additional funding from the Canadian government.

VEHICLE EXTRICATION TRAINING SYSTEM

Design Interactive Inc. | www.designinteractive.net
U.S. Army Research Laboratory-Simulation and Training Technology
Center (ARL-STTC)

In response to threats, U.S. Army vehicles became increasingly heavy. With poor road conditions and IED blasts, vehicle roll-over became a leading cause of serious injury and death. To lessen the severity of injuries and improve roll-over survivability, the Army sought new technology to improve a Soldier's ability to train for and respond to vehicle roll-over.

V-Xtract addresses a necessary combat skill set that had been traditionally overlooked. One example of training was the high-mobility multipurpose wheeled vehicle (HMMWV) Egress Assistance Trainer (HEAT), which focused on the ability of Soldiers to remove themselves from a roll-over vehicle. The V-Xtract system targets the skills needed for extrication and Medical treatment for victims during and after vehicle roll-over. V-Xtract is a portable training system that allows Soldiers, Medics and first responders to practice the skills associated with responding to a vehicle roll-over. V-Xtract provided a full scale vehicle model, capable of rotating 90 to 180 degrees. Complete with olfactory, audio and visual battlefield stimuli, V-Xtract provides Soldiers with practice of removing non-ambulatory causalities from roll-over vehicles. Unique to the V-Xtract is the robust performance Medical Metric Suite (MMS) developed within the system. Performance metrics range from the extrication process and outcome measures, to a variety of Medical task processes and outcome measures. Designed to target a gap in combat Medic training, the capability to collect objective performance measures by using a low-cost, rugged platform, is the first of its kind. To allow the system to be applied across a variety of Medical models already on the market, the system was designed as a suite that includes over 50 sensors to measure Medical care processes and outcome performances. The system is the first on the market to provide an objective and detailed measure of how to thoroughly look for open wounds after a vehicle roll-over occurs. By outlining the key zones that were not examined and the percentage of each limb examined during care, Medics will have a clearer picture on their patient's status. All MMS performance data is exported wirelessly to an instructor tablet and provides summary and detailed information on trainee performance to drive efficient after-action report sessions.

TECHNOLOGY TRANSITION:

Since receiving the Tibbets Award for SBIR Excellence, V-Xtract and incorporated MMS technologies is currently being used and transitioned to the Combat Medic and Combat Lifesaver Training Program at Fort Indiantown Gap. The U.S. Army Research Laboratory Human Research and Engineering Directorate Advanced Training and Simulation Division applied approximately $1.4M of Joint Program Committee-One (JPC-1) of the Military Health System/Defense Health Agency to ruggedize the Phase II design, provide extensions that met Army training needs, extend MMS capabilities and provide a towing option. The Pennsylvania National Guard Medical Training Battalion Site at Fort Indiantown Gap, PA, continues to use the V-XTRACT to train Army Combat Medics and Combat Lifesavers. The total investment into V-XTRACT is approximately $2.5M.

Other technologies have been spun off from the initial Army SBIR project, V-Xtract. For example, the technology developed in the MMS has transitioned to the Transportation Security Administration (TSA). The TSA had a requirement to develop a low-cost and durable approach to improve the effectiveness of Transportation Security Officers (TSOs) performing specific security tasks. Leveraging the MMS developed under V-Xtract, Design Interactive is meeting TSA's need by extending the sensor and feedback technologies in the MMS to develop an instrumented training system. While the MMS developed under V-Xtract provided training feedback on critical combat lifesaving tasks, the TSA training system will provide immediate feedback to performers on how well they perform security procedures. These training systems will initially deploy to a limited number of major U.S. airports with the possibility of expanded deployments in future phases. The TSA will be testing the modified MMS from August to November 2017. Several of the olfactory, visual, and auditory cueing sensor technologies, developed in V-Xtract, transitioned into PEO STRI's Transport Medical Training Laboratory (TMTL) system. The TMTL system is currently being used to train Combat Life Savers and Army Medics at Fort Sam Houston.

ADVANCED DYNAMIC TERRAIN RESEARCH AND DEVELOPMENT FOR U.S. ARMY MODELING, SIMULATION AND TRAINING PROGRAMS

Dignitas Technologies LLC | www.dignitastech.com | U.S. Army Research Laboratory-Human Research and Engineering Directorate (ARL-HRED) Program Executive Office for Simulation Training & Instrumentation (PEO STRI)

U.S. Army simulation systems employ sophisticated models to provide realistic, high fidelity synthetic environments to train and prepare today's Warfighter. Dynamic terrain models the changes to the synthetic environment due to real-time simulation events. However, dynamic terrain is one technology area that has not kept up with today's Army simulation training. Often, dynamic terrain models are based on 20-year-old technology, providing simple and primitive representations of changes to the synthetic environment.

Army Dynamic Terrain research and development efforts produced many technologies to advance dynamic terrain for modeling, simulation and training. Army Phase I, Phase II and Phase II-Enhancement SBIR projects developed open, non-proprietary technologies for advanced interactive dynamic terrain. These technologies provided many features such as subsurface soil models; weather effects on the environment; physics-based interactions including, soil resistance and procedurally generated environment objects. This SBIR research and development focused on transition of developed technologies into Army modeling, simulation and training production programs.

TECHNOLOGY TRANSITION:

Dignitas was awarded over $6.8M for four separate Dynamic Terrain commercialization contracts to continue research and development of advanced dynamic terrain technologies for transition to Army simulation programs. Commercialization investments were provided by a

number of sources: ARL-Human Research & Engineering, Advanced Training and Simulation Division, PEO STRI Synthetic Environment (SE) Core, PEO STRI Aviation Combined Arms Tactical Trainer (AVCATT), and PM Combat Engineering and Material Handling Equipment. This investment extended technologies to enable terrain modifications throughout the synthetic environment, terrain skin modification at any depth or height, terrain modifications through weapon detonations or interactive activity and distribution of the modifications to support collective training. The subsurface soil model includes soil attribution, soil horizons and soil profiles enabling complex soil interactions and behaviors (erosion, traction, compaction and physics-based resistances). For example, rain causes change to soil characteristics and behavior, including water saturation levels and accumulation.

The success of Dignitas' commercialization is demonstrated through transition of advanced dynamic terrain capabilities to several Army simulation programs. The technologies that have been integrated include the gridded terrain model into One Semi-Automated Force (OneSAF), the advanced dynamic terrain model into AVCATT and Common Driver Trainer (CDT), and the dynamic terrain network protocol into SE Core. Dignitas developed a Software Development Kit (SDK) so advanced dynamic terrain technologies can be easily integrated into simulation training systems. The SDK was also used as a reference implementation for the Constructive Equipment Virtual Trainer (CEVT) solicitation. Using the technology stemming from the initial SBIR award, Dignitas is coordinating the integration into two additional simulators for future use.

NATURAL LANGUAGE PROCESSING (NLP) ENTITY ANALYTICS ON UNSTRUCTURED TEXT DATA SOURCES
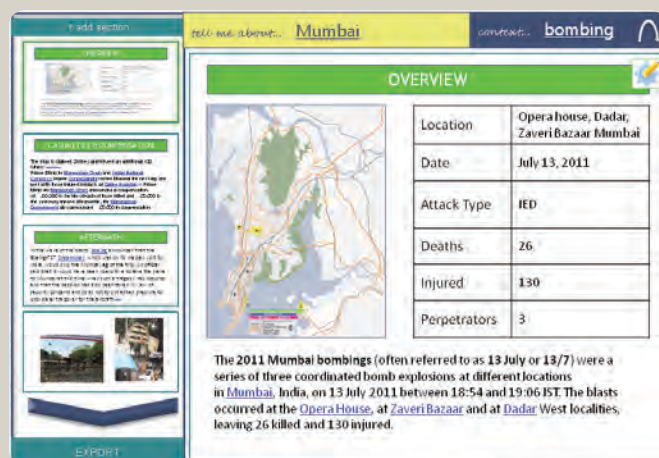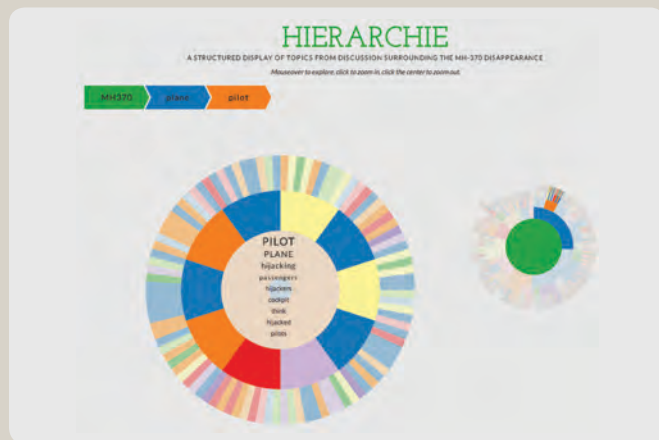
Unstructured text data sources contain a wealth of information for an intelligence analyst. However, by the very nature (i.e., unstructured) of the data sources, it can be easy for analysts to overlook key information in the text. This is the analyst's reality for a small amount of text and is compounded by the massive amount of unstructured text available in intelligence systems. Decisive Analytics Corporation (DAC) recognized the Army's problem that analysts need more time to perform analysis, as opposed to reading text.

To address the Army's problem DAC developed a suite of tools based on Natural Language Processing (NLP) that extracts topics, semantic concepts, entities and relationships from unstructured text and multi-source datasets. Analysts can search documents based on semantic concepts instead of listing multiple keywords; for example, the concept of a weapon includes guns, knives or rifles. Extracted entities include people, organizations and locations. These capabilities automatically categorize documents, label sentences with semantic concepts and roles, disambiguate entities, and build relationship-rich entity network graphs. These

NLP capabilities bring structure and organization to the chaos of a large collection of text documents.

The Program Executive Office Command, Control, Communications-Tactical (PEO C3T) awarded DAC an Army SBIR Phase I contract called "Smart Battle Command Information Discovery Agents". DAC explored, investigated, and identified the feasibility of high potential innovative data discovery mechanisms and smart data filtering algorithms within the context of a mission command infrastructure within a targeted timeframe of 2007 to 2011. In 2006, PEO C3T then awarded DAC a two-year Army SBIR Phase II contract that produced and demonstrated prototypes of data discovery mechanisms and smart data filtering algorithms called "Bayesian Optimization Battle Command Analysis (BOBCAT). BOBCAT was a single server system that provided topic modeling of the unstructured text documents to the analyst. Documents are associated with topics to provide the analyst with raw source material in order to understand the details of a topic. Analysts can quickly review the broad context of the overall document collection and drill down into specific documents relevant to their mission. The demonstrated prototypes were judged based on their low risk potential for further development to positively impact Warfighter utility, ease of use, infrastructure, and quality of service, portability and broad applicability across the mission command domain. The capability was evaluated based on potential for reuse, further integration constraints, efficiency, coding documentation, information assurance, vulnerability, affordability and maintainability. The BOBCAT capability was initially shaped and guided by PEO C3T. DAC was awarded $2.9M in additional investments from the Army and Navy to further research and development on BOBCAT.

While this technology fulfilled the topic criteria, DAC received another Army SBIR Phase II contract for the Geospatial Temporal Evidential Reasoning System (GEO-STEERS) technology. This allowed enhancements with the ability to enrich topics with geospatial attributes. Analysts typically have a geographically defined Area of Responsibility (AOR). Therefore, analysts are focused on events occurring and groups operating in their AOR. The Army Geospatial Center (AGC) guided this enhancement such that analysts understood where an activity (described in text) occurred. From this technology advancement, $1.3M was provided in Phase III funding from the Army and two prime contractors: L-3 National Security Solutions and 21 CT. These funds allowed the user to see if topics in the unstructured text were related to a certain geographical area. Each following contract allowed enhanced topic modeling that showed geospatial attributes in relation to the discovered topics. *(continued...)*

DECISIVE ANALYTICS Corporation (DAC) | www.dac.us
Program Executive Office Command Control Communications-Tactical (PEO C3T)

BOBCAT includes a feature known as topic modeling. This organizes content and entities into automatically learned categories. The Large Tactical Sensor Network (LTSN) program, within the Office of Naval Research (ONR), and the Special Projects office of the U.S. Army Intelligence Center funded the transition of topic modeling to support the mission of analyzing open source text documents. Through these two sponsors, the topic modeling capability was matured to execute in a cluster of application servers.

BOBCAT's semantic model capability was transitioned to the ONR Expeditionary Warfare program. Between the two programs, $5.6M in Phase III funding was provided. This project matured the Semantic Role Labeling (SRL) capability allowed execution using a cluster of application servers, providing increased performance and reliability. The topic and semantic modeling results were standardized in a common format in the ONR analytic enterprise. Resource Description Framework (RDF) was used to store these results. RDF allowed analysts to gain consistent intelligence from text documents that were processed by multiple analytic capabilities.

Funding from the Army Intelligence and Security Command (INSCOM) G7 program, allowed further research and development of the technology. All tools were integrated into the Army's cloud computing enterprise, increasing the amount of text that could be processed. These NLP capabilities were deployed to the Unified Cloud Data (UCD) platform. This allowed DAC's analytic results to be integrated with analytic results from other contributors. Components interfaced with operational data sources, extracted text from operational messages, and allowed applied security classifications to messages stored in the UCD platform. The text was processed by the NLP capabilities, and the analytic results were stored in the cloud. Analytic visualizations and web services were developed to access the intelligence extracted from the text documents.

The DOD Rapid Innovation Fund is driving the next stages of development. NLP Entity analytics are being enhanced to process text at operational volume and frequency. The entity relationships and concepts are used as features within entity disambiguation. Entity disambiguation recommendations are automatically presented to the analyst instead of manually tagging and resolving each entity mention. These enhanced capabilities are being integrated into the Tactical Cloud Reference Implementation (TCRI) platform. The Distributed Common Ground System-Army (DCGS-A) is the target Program of Record (PoR).

Other research and development led to these capabilities being deployed into the Distributed Common Ground System-Navy (DCGS-N) trials and exercises. DAC delivered a secure end-to-end solution of data source interfaces, text extraction, text processing and visualization of analytic results. DAC is currently working on delivering NLP Entity Analytics to both DCGS-N and DCGS-A. The DAC technology is currently a candidate for inclusion in both DCGS-A and DCGS-N Increment 2. DCGS-A is in source selection and DCGS-N is in the draft-RFP stages at this time.

In total DAC has received over $9M in commercialization for the technology stemming from the original BOBCAT technology. Both ONR and INSCOM use the following capabilities from the BOBCAT technology: entity extraction from text documents, entity disambiguation across documents, and relationship extraction between entities. These agencies use these capabilities to process a wide variety of text documents. Some examples are patrol reports, intelligence reports, open source documents and social media data. The technology was used by these agencies because of the time consuming process to manually tag each entity. This time consuming task prevented analysts from performing their actual mission of analyzing intelligence.

The BOBCAT technology, GEO-STEERs and additional developments give analysts access to consistent, timely and geographically accurate information to analyze, continuing to keep the nation safe from potential threats.
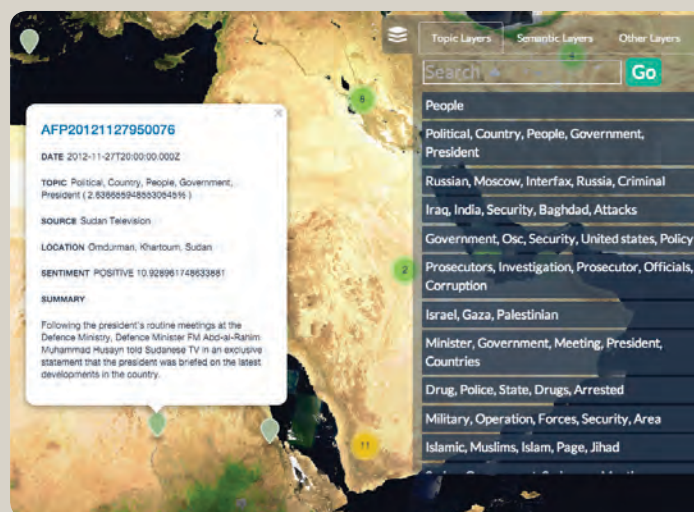
ATA'S MHD ARS TECHNOLOGY ENABLES RAPID NORTHFINDING AND ENHANCED FAR TARGET LOCATION CAPABILITIES

The objective of the Miniature North Seeking Module (MNSM) program was to improve the Warfighter's azimuth measurement capability in a crowded urban or battlefield environment. By increasing performance, azimuth error decreased and acquisition time was reduced. This reduced the size, weight, power and cost (SWaP-C) of north seeking systems for target location and designation. This was the first step in the evolutionary process of Applied Technology Associates' (ATA) Northfinding solution. This step took a Proof-of-Concept (POC) demonstrator to a full Precision Azimuth and Vertical Angle Measurement (PAVAM) solution.

During Phase I of the MNSM Small Business Innovation Research (SBIR) program, ATA demonstrated key aspects of the MNSM concept to prove feasibility. The fundamental approach involves precisely measuring the orientation of the Earth's spin axis using ATA's patented Magnetohydrodynamic (MHD) Angular Rate Sensors (ARS). The MHD ARS relies on the principles of magnetohydrodynamics; the dynamics of the magnetic properties in electrically conducting fluids, e.g. plasma or liquid metal. The MHD ARS exhibits a number of unique beneficial characteristics including strategic grade noise performance, high bandwidth, high dynamic range and low sensitivity to bias errors in an extremely robust and rugged package. For the Phase I Option, the MNSM team refined its mechanical design in preparation for the Phase II build. In Phase II, the MNSM team identified the best available commercial components, developed fundamental integration, checkout and calibration procedures and built and tested the initial design (M2) as part of a spiral development effort. In Phase III, ATA produced a third generation design (M3) with significantly less mass and volume than the M2, and developed hand-held electronics suitable for field demonstration.

TECHNOLOGY TRANSITION:

During Phase III field testing at Quantico, the M3 demonstrated sub 4 milliradian (MRAD) azimuth determination in less than 60 seconds. ATA transitioned the technology developed in the MNSM program to the self-contained Earth Referenced Attitude Detector Technology Demonstrator (ERAD-TD) for the Army Night Vision and Electronic Sensors Directorate (NVESD) Far Target Location Improvement Program (FTLIP), and it demonstrated the same capabilities as the M3 in less than 30 seconds.

Primary markets for ATA's NorthFinding technology are the Army, the Navy, and Aerospace primes. The U.S. Army Space and Missile Defense Command/Army Forces Strategic Command awarded ATA over $1M in Phase III funding for the MNSM program and the U.S. Army Communications-Electronics Research, Development and Engineering Center/NVESD awarded ATA over $9M for the spinoff program, FTLIP. ATA received $442K in sales from Northrop Grumman for eight Northfinder units in support of the Northrop Grumman Communications, Intelligence, and Network Solutions (CINS) Sidewinder program. The total dollar amount of Phase III sales, investments, and contracts for ATA's Northfinding technology is $10.7M.

Friendlies — Hostiles — Current Designator — ATA Designator Improvement — Weapon Kill Zone
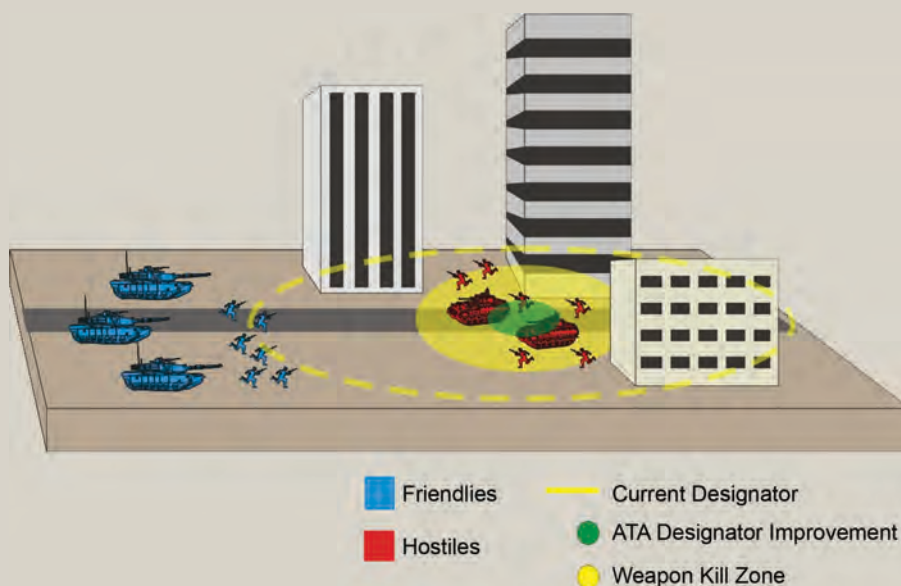
INTELLIGENT VEHICLE BEHAVIORS FOR EXPLOSIVE HAZARD DETECTION & NEUTRALIZATION ON NARROW UNIMPROVED ROUTES

5D Robotics | 5drobotics.com

Program Executive Office Ammunition (PEO Ammo)

The U.S. Army had a need to demonstrate remote, standoff detection and neutralization of buried explosive devices on narrow, unimproved routes.

A solution was needed that would enable low-cost, mid-sized robotic vehicles to protect dismounted troops on deep insertion missions, while providing intelligent control for orchestrating vehicle hardware and software components towards mission goals. The solution needs to be portable and reconfigurable so that it can interface seamlessly with multiple payloads, vehicles and sensors. While a highly skilled human operator may understand how to hold a sensor, where to position it, and what areas of the environment to investigate; successfully translating that skill into effective autonomous machine behavior is a problem that requires innovation. The solution would focus on intelligent and adaptive software behaviors that provide standoff operation in terms of navigation, detection and neutralization.

TECHNOLOGY TRANSITION:

As was reported in the 2014 Commercialization Brochure, 5D Robotics was awarded a Phase III SBIR effort, of $2.9M, to provide six (6) robots to the Rapid Equipping Force (REF) that included high accuracy ultra-wideband (UWB) radio autonomous positioning and sensor technology developed under the SBIR. Since then, the U.S. Army Tank & Automotive Research, Development & Engineering Center (TARDEC) has requested 5D to refurbish the systems with their latest software to provide the latest autonomous positioning capabilities. This will coincide with work being done under contract with TARDEC, to enhance the follow capability for unmanned ground vehicles.

On the commercial side, 5D is taking the technologies developed under the SBIR program and applying them to a variety of industrial domains. Below are a few examples of real-world industrial success:

- 5D has entered into agreement with equipment rental giant United Rentals Inc. to bring the latest autonomous positioning technology to equipment operations. United Rentals has made a significant investment to integrate the 5D autonomous positioning SBIR technology onto their rental vehicles to prevent collisions and enable multiple vehicles to follow a person or lead vehicle ("wagon-training") within the rental lot or other area of operation. This allows operators a quick and easy way to create and modify autonomous paths throughout a facility to move and store their equipment with limited human intervention. The 5D solution is much more accurate and reliable than GPS and unlike GPS can function indoors and outdoors in rain, dust, snow and fog. Currently, United Rentals has installed the 5D technology in a pilot facility for evaluation and plans to expand its use to multiple other locations.

- 5D is also using the SBIR positioning technology and autonomy to create beyond line-of-sight autonomy for large industrial companies. A variety of industrial partners are integrating and currently using the 5D SBIR technology to conduct field and facility inspections using drones, without the need for GPS. The technology allows drones to fly indoors or out in GPS denied environments by using high accuracy ultra-wideband (UWB) radios, and when available, transition to GPS aided flight. The UWB based constellation positioning is accurate enough to automate landing on a charging pad, or autonomously follow a vehicle in virtual tether mode without GPS.

- Finally, 5D is negotiating with the Department of Transportation (DOT) and a large automotive company to apply the SBIR positioning technology in millions of cars for safe, connected vehicles and autonomous driving.

DIM OR IMPERCEPTIBLE TRACER AMMUNITION

Physical Optics Corporation | www.poc.com
Program Executive Office Ammunition (PEO Ammo)

Technology was greatly needed to design, develop and demonstrate small caliber tracer ammunition only visible by friendly forces, not enemy forces.

Tracer ammunition continues to be a reliable means of target engagement for the Soldier. This allows the user to see the trajectory of the round and adjust aim. Threats and evolution of tactics and techniques revealed emerging requirements to develop ammunition that allows friendly forces to shoot "dim or imperceptible tracer ammunition" that cannot be perceived by enemy forces enabling them to detect the position of the user. This new ammunition will maintain current tracer performance in lethality, range and reliability. User validation, producibility, reliability and manufacturing maturity are key criteria for the success of the technology.

To meet this need, Physical Optics Corporation (POC) developed its Rearward Emitting Tracer Ammunition (RETA). RETA integrated mature materials and fabrication processes with internally developed and commercially available pieces. This resulted in prototype ammunition that produced visible and near-infrared light without causing a "bloom" or halo-effect in night vision goggles. The prototype's aim is to reduce the signature of the round while providing visibility of the tracer to the shooter.


TECHNOLOGY TRANSITION:

POC has received approximately $1.26M from the Army to further develop the technology by improving the tracer material for greater performance, reducing cost and improving manufacturing tools used for loading the tracer into the bullet at the factory. This Phase III money also helped fund participation in government sponsored demonstrations and testing in support of the U.S. Army PEO Ammunition/PM Maneuver Ammunition Systems program called One-Way Luminescence (OWL). OWL is currently a tracer technology development program designed to eliminate the 360 degree visibility in flight that the current tracer ammunition exhibits and maintaining the performance of the existing tracer ammunition. This will increase Soldier survivability and ultimately enable more accurate, lethal rounds on target. The POC solution is one of several technologies being evaluated for this program.

> "User validation, producibility, reliability and manufacturing maturity are key criteria for the success of the technology."

*Approximate Visual Signature
with Current Tracers*
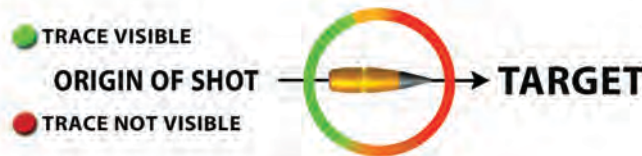
*Approximate Visual Signature
with One-Way Luminescence*

MODULAR INTELLIGENT MANIPULATION SYSTEM WITH INTUITIVE CONTROL (MIMIC)

RE2 Inc. | www.resquared.com
U.S. Army Tank Automotive Research Development and Engineering Center (TARDEC)

The Modular Intelligent Manipulation system with Intuitive Control (MIMIC) significantly increases the effectiveness of robotic manipulators by giving the operator of a robotic arm the sensation that their arm is manipulating an object. As the operator moves his/her hand, the robot arm mimics the operator's arm/hand movements. As resistance is experienced at the end-effector, the operator "feels" that particular resistance on his/her own hand. MIMIC's intuitive control system, coupled with RE2's innovative dexterous end-effector solutions, enables more advanced teleoperation capabilities such as using common hand tools, removing batteries or cutting wires. The comprehensive approach presented for MIMIC is well suited for integration into next-generation robotic systems. The modular design approach of MIMIC allows it to be converted to several distinct components that can be sold separately or as part of an integrated solution. This approach enables users to greatly enhance their robotic control, cost effectively, to allow intuitive control and allows the sense of touch with the dexterous end-effector. The MIMIC tools can be sold as a retrofit kit for currently fielded robotic systems or as a development kit for next-generation robotic systems.

Advancing through the Army SBIR program, RE2 Robotics performed a comprehensive analysis of potential methods for controlling dexterous manipulators through experimentation. This initial research identified an "imitative" style controller as the most intuitive method for teleoperating robotic arms, especially highly dexterous arms. The resulting Imitative Controller (IC) is an input control device of MIMIC that allows a human operator to remotely control, intuitively, one or two highly dexterous arm(s). IC is a scaled model of the arm(s) to be controlled. With the full scale arm(s) in a remote location, the operator can move the IC and the full scale arm(s) will mimic the motions. IC is a modular technology based on common joint modules that can be configured to match the dexterity of most robotic arms. Robot operators can become proficient with only one minute of training; they can become experts within hours. This allows operators to effectively perform missions while reducing costs.

TECHNOLOGY TRANSITION:

Through follow-on investment and product sales, RE2 has created multiple versions of the IC to control a range of manipulators with different configurations and levels of dexterity.

RE2 currently has strong relationships with the two major providers of small ground robots within the military market: iRobot Corporation and QinetiQ North America (formerly Foster-Miller), and the leading provider of ground robots within the Public Safety market, Northrop Grumman Remotec. RE2 plans to build these relationships to help ensure commercialization of MIMIC. The initial commercialization partners of RE2 are Ultra MSI, for the intuitive controllers, and iRobot, for the end-effector and dynamic control algorithms.

For currently fielded military robots, RE2 developed the End-Effector Retrofit Kit (E2RK) for the TALON robot in partnership with QinetiQ North America. Purchase orders and investments from various government agencies, totaling over $2M, have transitioned MIMIC components from Phase II prototypes to final commercial products.

IC will be undergoing a formal evaluation with PM Force Projection, Army Capabilities Integration Center (ARCIC), TRADOC Capabilities Manager Explosive Ordnance Disposal, Picatinny, and ATEC at Fort A.P. Hill in early 2017. Based on a favorable evaluation, ARCIC would be capturing a two-arm requirement in alignment with the Man Transportable Robotic System Increment II program of record.

ORNL Dual Arms Controlled by RE2 Intuitive
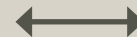
BRADLEY MODERNIZATION FINAL DRIVE

Loc Performance Products Inc. | www.locperformance.com
Program Executive Office Ground Combat Systems (PEO GCS)

The U.S. Army has a need to increase the torque capabilities of its final drives for their combat tracked vehicles without undergoing expensive powertrain upgrades. This need is driven by increases in vehicle loading due to weight growth and current financial restraints.

A "drop-in" solution was needed that would enable track vehicle final drives to increase their torque transferring capacity within the available packaging space, interface and weight constraints. These constraints create a paradigm: the increase in load due to weight growth is inversely related to life due to fatigue. Loc Performance Products Inc. (Loc) solution focused on manufacturing processes aligned to key selected materials and surface treatments to break through this paradigm.

The results of the SBIR efforts produced an optimized final drive design that addressed the increasing gross vehicle weight (GVW) of the Bradley Fighting Vehicle; while maintaining the current final drive packaging space, reducing lifecycle cost, and maximizing performance in terms of power density and extending the life of the product.

TECHNOLOGY TRANSITION:

Loc Performance was awarded a total of $3.67M in commercialization funding from DOD, Federal investments and exports sales contracts. The $3.67M is broken down into sales and investments per Table 1. Since, the completion of the initial U.S. Army Tank & Automotive Research, Development & Engineering Center (TARDEC) SBIR, Loc has been engaged with industry (BAE, SAIC and GDLS) to produce upgraded final drives with the SuperFinishing technology demonstrated during the SBIR.

Table 1: Revenue Break Down

DOD SALES	FEDERAL INVESTMENTS	EXPORT SALES
$3,228,139	$149,980	$290,600

Loc has produced final drive utilizing the SuperFinishing technology for several major programs of record. The Paladin Integration Management (PIM), Amphibious Assault Vehicle Survivability Upgrade (AAV-SU), and the Armored Multi-Purpose Vehicle (AMPV) all incorporated the SuperFinishing technology in to the final drive gear system. Specific program phases can be found in Table 2. The success of Loc's SBIR program has provided the Warfighter direct benefits.

The AAV SU is modern vehicle platform that will help the U.S. Marine Corps maintain a forcible entry capability from the sea and on land. At the heart of this program is increased armor protection and improved mobility. The final drive Loc designed and produced enabled the increased in horsepower and torque from the engine to be transferred efficiently and reliability to the track. Additionally, SuperFinishing technology also led to export contracts for General Dynamics European Land Systems (GDELS). This development program produces a compact final drive to be use on a 35 Metric Ton tracked combat vehicle. The loads use to validate this drive were in excess of other drives of similar weight class, placing this drive to the top of its class.

Table 2: Detail Break Down

CUSTOMER	PROGRAM	PHASE
SAIC	AAV SU	EMD
BAE	PIM	LRIP
BAE	AMPV	EMD
GDELS	ASCOD	Prototype

THE POWERFILM FORWARD DEPLOYABLE POWERSHADE

PowerFilm Inc. | www.powerfilmsolar.com
U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC)

The PowerShade structure was developed to provide power from solar energy and reduce heat load on the structures it covers. The amount of power produced, 1kW to 3kW depending on the variant, filled the Army's capability need to reduce the amount of fuel and batteries required to conduct combat and service support operations. The lightweight, flexible Amorphous Silicon thin-film solar panels provide the Warfighter with remote power available in large arrays. The PowerShade provides operational level power, and smaller man-portable systems provide tactical level power, allowing Soldiers to operate 72 hours without battery resupply. The PowerShade reduced generator fuel consumption from 20 gallons a day on their Forward Operating Base (FOB) to 2 gallons a day.

The Army SBIR Program supported development of technology for applying PowerFilm's flexible photovoltaic (PV) material to fabric and fabric structures. The two principal products coming out of this program were the PowerShade structure and the lightweight foldable PV array. The PowerShade structure can span most standard military tents and work areas providing solar power and shade. The smaller foldable arrays can be carried in a backpack and deployed to recharge standard military batteries including the BB2590.

TECHNOLOGY TRANSITION:

Significant follow-on investments came from both DOD and private sources to drive continual improvement and implementation of these products. PowerFilm received over $8M in Phase III funding to improve and expand the technology into new products. These funds also allowed significant expansion of the manufacturing capacity. Resulting success allowed PowerFilm to develop manufacturing capabilities, making them a strong supplier for integrating solar panel technology onto flexible fabric substrate. Over the past four years, this expertise led to an additional $12M in follow-on contracts with industry teammates in man-portable panels.

PowerFilm currently supplies a significant volume of these products to the Army and Marine Corps. Two examples include the Army's currently fielded Thales Universal Battery Charger (UBC) and Protonex Squad Power Manager (SPM), both equipped with the PowerShade solar panel technology designed to provide portable field power to the Warfighter. Applications include emergency communications and critical lighting applications at Forward Operating Bases. The U.S. Marine Corps and a Joint Task Force used the PowerShade technology while operating in Central and South America. The foldable array and offshoots of that product were also transitioned to the commercial market.

Commercial applications use the initial Balance of Systems (BOS) technology developed under Army SBIR. The BOS has three parts: harvesting solar power, storing the energy in the batteries and management by converting power from DC to AC or AC to DC. Two companies decided to combine their products with the PowerShade technology. Sea Eagle, a maker of inflatable boats, and Torqeedo, a maker of electric propulsion motors, saw an opportunity to use solar panels with electric boat motors. Each company worked closely with PowerFilm to integrate PowerShade solar panels creating a small-craft boat without a gasoline engine. This durable, long-lasting, solar panel doubles as a source of energy for the boat motor and shade from the sun. These panels and charging equipment are currently available for sale.

RESONANT ACOUSTIC MIXING OF SOLID ROCKET MOTOR PROPELLANT TO MINIMIZE PROPERTY VARIATIONS

Resodyn Corporation | www.resodyn.com
Armament Research, Development and Engineering Center (ARDEC)

The DOD is continuously seeking new and improved means for the development and production of advanced energetic materials, explosive fill and propellants. An essential element of this need is being addressed by an advanced mixing technology expressed in a DOD SBIR program topic. In response to a U.S. Army SBIR topic for the mixing of an advanced energetic material, Resodyn developed a break-through mixing process that has become very popular in the energetics industry: the Resonant Acoustic Mixing (RAM) technology. Success of the technology is evident by its popularity of use in the United States and nine other countries to develop advanced energetic materials. This method is used to manufacture energetic products currently used by American Warfighters. Because of its versatility, the RAM technology continues to expand into new and varied energetic production applications that include propellants, explosives and pyrotechnics.

The Resodyn RAM technology results in reduced manufacturing costs, improved product quality, reduced waste, improved safety, reduced mixing times and lower environmental impact for various products being manufactured. Additionally, the Resodyn RAM technology has enabled the manufacturing of energetic products not previously possible by any state-of-the-art mixing systems. The RAM is good for all energetic materials, to include explosives, propellants and pyro.

The technology uses low-frequency, high-intensity sound for mixing and attained wide market acceptance because of its ability to solve many mixing challenges, such as mixing viscous materials, powders of disparate sizes and shear-sensitive materials. In particular, the RAM technology excels in applications for hard-to-mix applications including plastic based explosives (PBX). Increasing the performance of cast cured PBXs without sacrificing the shock sensitivity during detonation, was

one goal for the new RAM technology. RAM technology mixes more evenly and 10 times faster than current state-of-the art mixers. For example, one Navy PBX formula took 15 minutes to mix using the RAM technology instead of 160 minutes using prior methods.

TECHNOLOGY TRANSITION:

Resodyn received Phase III funding of more than $9M from a combination of projects sponsored by the U.S. Army, U.S. Navy, U.S. Air Force, MDA and DARPA sources. These applications emphasized scaling up the RAM technology for practical use in mixing energetic materials. Under the Joint Insensitive Munitions Technology Program (JIMTP), one RAM-mixed PBX demonstrated a 5 percent increase in combustion velocity and a 10 percent decrease in shock sensitivity. NAVAIR used the RAM technology to prepare two PBX formulas that could not be processed using other mixing technologies. Over $42M in Phase III funding has been awarded by the DOD and other federal agencies, U.S. commercial sales and foreign sales throughout 25 countries, in a variety of applications. The market pull for this universal technology continues to evolve and mature from more than a dozen industries that include pharmaceuticals, power metallurgy, technical ceramics, aerospace adhesives, electronic conductive materials, dental materials, processing tissue (both soft and hard), pharmaceuticals, battery materials and nanomaterials. The pharmaceutical company Biogen is integrating this technology into their manufacturing processes for future Medical applications.

In addition to being effectively used as a mixer, the Resodyn technology has been adopted for industrial applications that include coating, grinding and sieving. New markets and opportunities are continuously being discovered. Most recently, (2016) Resodyn developed and demonstrated a continuous chemical reactor module that showed reaction efficiencies approaching that of a plug flow reactor (PFR). Nammo Talley, an ammunition and explosives manufacturer, is currently using the RAM technology to make "spotting cartridges" for the U.S. Army. The spotting cartridges act as spotting ammunition to increase the target hit probability, in combat and training and tracer ammunition, projectiles built with small pyrotechnic charges. This technology allowed them to increase their production capability, using fewer people and creating a safer production environment, without increasing costs.

With the ability to develop and produce advanced energetic materials, multi-dimensional capabilities and ability to mix all components in various ways, RAM technology has displayed an impressive improvement in mixing capability while continuing to look for future opportunities and advancements.

ADVANCED MUNITIONS PACKAGING MATERIALS AND MANUFACTURING TECHNOLOGY

Texas Research Institute Austin Inc. | www.tri-austin.com
Armament Research, Development and Engineering Center (ARDEC)

The DOD is always seeking low-cost, lightweight manufacturing technology for munitions packaging that meets environmental requirements. Texas Research Institute Austin Inc. (TRI) developed advanced injection molding and mold design techniques for highly abrasive, high heat capacity injection molding materials that support the manufacturing of both very large injection molding parts such as composite munition canisters for tank rounds, and very small injection molding parts.

With Army SBIR funding, TRI improved injection molding technology which resulted in the development of long glass fiber filled injection molded composite munition canisters and a new material called Ecomass®. Through the injection molding process, Ecomass® combines metallic powders and thermoplastic materials to achieve a wide-range of densities by using high-density metallic powders combined with a low density thermoplastic material. The density of the molding material can be highly controlled and tailored to the specific needs of the customer. The first Ecomass® formulations combined tungsten powder with thermoplastic materials to form a non-toxic substitute for metallic lead. Ecomass® compounds can be as heavy as metallic lead, but are non-toxic and as easy to fabricate as plastics. Toxic high-density materials can be duplicated without the exposure to the toxicity.

TECHNOLOGY TRANSITION:

TRI commercialized the Ecomass® technology (www.ecomass.com) by working with startup company Ideas to Market, LP. Ideas to Market, LP worked to identify and enter markets where Ecomass® compounds could be used to replace traditional materials. These metal materials have certain adverse physical properties including environmentally hazardous toxicity and the lack of frangibility in projectile applications. Frangible bullets are designed to disintegrate into very small particles when they hit the target or other hard surface to minimize penetration of other nearby objects. Small particles are rapidly slowed by air resistance, and are less likely to cause injury or damage to persons and objects other than the target. They are often used during close quarters combat training to avoid ricochets. The frangibility of Ecomass® projectiles is accomplished by using metal powder instead of solid metal slugs. Since inception, Ideas to Market, LP has generated over $45M in Phase III funding, primarily from the sales of its products to the commercial and government sectors.

The Ecomass projectiles can support the government's plans to phase out lead bullets by 2018, The U.S. Army invested $50K for further research and development of these nontoxic, lead free projectiles leading to purchases of over $26.6M. The U.S. Army uses millions of small arms ammunition rounds for training every year. Moreover, Ecomass® frangible projectiles are produced using a highly controlled injection molding process able to meet the strictest of military tolerances ensuring repeatable performance with full function and reliability. They are a 100 percent ballistic match to lead based projectiles at 25m for pistol ammunition and 100m for rifle ammunition. Ecomass® compounds have been used successfully as frangible projectiles for military training ammunition and 40mm door breaching grenade projectiles for law enforcement personnel.

In the commercial sector, the Ecomass® non-toxic high-density golf compounds helped golf club manufacturer PING Inc. engineers develop variable weights of the same part geometry and volume, cutting costs by eliminating the need for different raw materials, secondary machining operations and varying final part dimensions. Ideas to Market, LP continues to expand Ecomass® applications with additional injection molding products. This includes a new process developed to achieve a shiny, silver metallic finish on Ecomass® parts and applications. One example is a weight for luxury car key fobs.

FULL-MOTION VIDEO SPECTRAL IMAGING: REVEALING THE UNSEEN

Surface Optics Corporation | www.surfaceoptics.com
Armament Research, Development and Engineering Center (ARDEC)

Our deployed Soldiers need smaller, lighter and better capable imaging sensors than currently available for improved Situational Awareness (SA) and to effectively respond to a more sophisticated threat. Hyperspectral imaging (HSI) has been proven in combat by detecting targets such as, vehicles, personnel and materials. Existing imaging systems are large and slow, making them less ideal for most Unmanned Aerial Vehicles (UAV) and vehicle-mounted or hand-held applications. There is a need to transition hyperspectral imaging into the reality of a compact, Full-Motion Video (FMV) form with capabilities available from mobile, airborne and dismounted platforms.

Under the Army SBIR program, Surface Optics Corporation developed a new spectral imaging technique called the 3-D FMV Spectral Imaging (FMV-SI). The 3-D FMV-SI camera is compact and solid state with no moving parts. Based on an adaption of light-field imaging, the system produces spectral images at video frame rates and in a staring format. The system includes a real-time spectral image processor, providing real-time target detection and actionable intelligence directly to the Warfighter.

To expand the capability of the 3-D FMV-SI, a prototype of a hyperspectral scope — HyperScope — was developed under a different SBIR topic. The system builds upon real-time hyperspectral imaging technology and recently developed hyperspectral imaging techniques to generate a compact scope that can include a real-time overlay of identified objects of interest. Wavelength coverage extends from visible through short wavelength infrared to provide day and night operations without additional aides. The HyperScope collects, analyzes and shows hyperspectral images of at least 32 spectral bands. The results are then presented on integrated displays. This technology can also be used in analysis, quality control and more in depth detection efforts. Compared to other hyperspectral imagers, the HyperScope is relatively inexpensive to produce, operates at video frame rates and is more compact. By making hyperspectral sensors handheld, rugged and inexpensive, production of the HyperScope will enhance the capabilities of the Army to recognize, track and mark threats. This increases the ability to extract information unavailable with current tactical imaging systems.

TECHNOLOGY TRANSITION:

The initial SBIR effort developed the 3-D FMV-SI in the Visible and Near Infrared (VNIR) band. Surface Optics has received over $20M in commercialization funding for this technology. This funding supported the extension of the spectral range from ultraviolet to mid-wave infrared. Current DOD customers for the technology include the Army, Navy, Air Force and SOCOM. They use this technology for a number of applications including chemical agent detection, vehicle detection, and threat material detection. The technology also has non-DOD applications including integration into an underwater, remotely-operated vehicle to study sea life camouflaging techniques. Surface Optics has partnered with Providence Photonics, a commercial environmental monitoring firm, to produce a mid-wave infrared version of the system for industrial flare Combustion Efficiency (CE) monitoring. Experiments conducted on monitoring CE showed that use of a multi-spectral, high-frame IR is valid to determine where unburned hydrocarbons are entering the atmosphere, allowing the operator to correct problems and reduce waste and pollution. Another benefit is the ability to gauge the flame, correlating to the flare performance. The technology under Providence Photonics was fielded in 2014. Overall, the initial 3-D FMV-SI technology has over $2.7M in sales and $4.6M in investments from the government and commercial industry.

The second Army SBIR award, resulting in design of the HyperScope, will be transitioned into both commercial and military markets. With almost $800K recorded in sales and $1.9M in commercial investments from the Army, the HyperScope has over $2.7M in commercialization funding. Surface Optics Corporation received $1.5M in Phase III contracts with the Naval Air Systems Command (NAVAIR) for the development of a by-product of the HyperScope, the Unmanned Aerial Vehicle (UAV) Real-time Hyperspectral Targeting Systems. The Air Force Research Lab used this technology for 3-D photogrammetry, turning 2-D photographs into 3-D models, and in sensors that show real-time warnings of threats. The (UAV) Real-time Hyperspectral Targeting Systems optic scopes are fielded and detect camouflaged objects. $190K in investments from Johns Hopkins University expanded the visible and near-infrared (VNIR) in the 3-D hyperspectral Video Rate Camera. The expansion of VNIR refines and covers other wavelengths, not otherwise visible; such as, short-wave, medium-wave and long-wave infrared. Commercial applications for this expanded spectral range include: substance detection, forensics or recycling; detection of industrial contaminants and pollution; quality control of food preparation; non-invasive detection of cancer cells; and in law enforcement for narcotics detection. The U.S. Army's Project Manager Soldier Weapons program presented this technology at the Hyper Spectral/Multi Spectral Technology Advancement Industry Day in 2016. They demonstrated this technology's ability to locate a target that was not visible to the naked eye.

STTR SUCCESS STORIES

SUCCESS
STORIES

U.S.ARMY

DETECTION OF COVERT GROUPS ON SOCIAL MEDIA THROUGH LANGUAGE AGNOSTIC NETWORK ANALYSIS

Securboration Inc. | www.securboration.com
U.S. Army Research Laboratory-U.S. Army Research Office (ARL-ARO)

Monitoring potential threats using social media platforms has been a debate due to validity, reliability and meaning of the data collected. To produce more meaningful and accurate data involving potential threats using social media, social patterns would require identification using structural (networks) and non-structural (messages and demographics) information sources. Securboration was awarded an Army STTR contract in order to create a program for social media that could provide accurate, valid and reliable information for military, government and commercial uses.

The purpose of the Social Understanding and Reasoning Framework (SURF) is to detect covert group members on social media. SURF finds and classifies social media users based on motif-matching of connections, rather than on content. The SURF software analyzes network structure instead of dissecting social media messages. This makes SURF both language neutral and content independent. Content-independence allows the software to perform in scenarios where content-based methods fail such as, in dark networks or networks with little message traffic, i.e. posts or direct messages. This has been successfully tested in multiple languages. Cross-validation methods used verified domains where the outcome was already known and matched, then used Twitter motif activity with a control and a testing dataset. The Phase II developed a 'user watch' capability that would allow an analyst to see user classification over a period of time.

Due to an interest from the Army, SURF received a SBIR sequential Phase II to extend the algorithms used and broaden classification groups to gather all possible intelligence for the Army. While Twitter was found to be the primary tool for marketing and recruitment for potential terrorists, the large scale of the platform combined with different languages and variety of content made the algorithm less effective in finding recruiters.

TECHNOLOGY TRANSITION:

Securboration was awarded a second Phase II SBIR for $1M, based on community response, and success of prior research. The resulting capability is available to the U.S. Government as government off the shelf (GOTS), without any licenses or maintenance fees. SURF is a force multiplier for DOD organizations, tasked with analyzing overwhelming social media data streams. SURF is well suited for use in the commercial space by advertisers looking to identify potential customers in multi-language or low message traffic networks. These capabilities are extremely unique because threat inferences can be made without text in social media posts and/or direct messaging. This is imperative for an Intelligence Analyst because current programs only analyze the text seen, not the network as whole. Potential threats can be spotted as 'hub accounts', discrete accounts used as a central form of gathering and disseminating all forms of information.

An example of the potential commercial use is target advertising. For example, if a company bought online advertising space on Twitter for baby products, one target audience would be expectant mothers. SURF would be able to target that audience, regardless of how many account tweets or languages used, because it analyzes the network as a whole — who you follow or who follows you, not solely on text amount or word meanings.

SURF is now installed at ARL's Tactical Information Fusion Laboratory, and researchers are now demonstrating it at the National Ground Intelligence Center and at SOCOM's Intelligence Systems Support Organization. Output from SURF has been provided to the Intelligence Community and deemed actionable intelligence. Furthermore, SURF has been selected by the DOD to participate in the prestigious Joint Interagency Field Exploration (JIFX) Program. This multi-day experiment provides integration and field demonstration opportunities for DOD's most promising technologies. A blind-study was conducted and showed 100 percent accuracy in identification of social media accounts on a potential threat list, showing the promise of this technology in real-time application.

UNIFIED SOFTWARE/HARDWARE TOOLS FOR A COMPREHENSIVE UNDERSTANDING OF ELECTROMAGNETIC FIELDS IN RF CIRCUITS, SYSTEMS AND STRUCTURES WITH AN UNPRECEDENTED LEVEL OF PRECISION

EMAG Technologies Inc. | www.emagtech.com
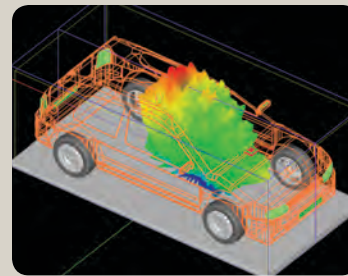U.S. Army Research Laboratory-U.S. Army Research Office (ARL-ARO)

Expansion of next generation wireless and sensor technologies are in rapid demand with the emergence of next-generation technological revolutions. Next-generation technologies include 5G wireless, internet-of-things (IoT), smart cities and use of autonomous vehicles. There is reliance on innovative, miniaturized, cost-effective and high-performance radio frequency (RF) devices and components, and demand of innovative methodologies for reliable RF system deployment and connectivity at massive scales. EMAG Technologies Inc. (EMAG) was founded to develop comprehensive, unified modeling characterization and measurement tools for RF engineers, designers and analysts. The goal is to understand and quantify the electromagnetic (EM) fields surrounding RF circuits and systems interacting with EM structures using advanced circuitry not previously possible. With initial funding from Army SBIR projects, EMAG identified two opportunities in computer simulation and measurement of the complex, interactive and rapidly varying fields. With successive Army SBIR/STTR funding, the capabilities of these two systems were extended resulting in a unique capability for designing, understanding and controlling complex RF circuits interacting with EM fields and structures.

The last two decades have indicated a persistent need for advanced simulation tools that can address system-level modeling of sophisticated multi-scale EM problems such as cosite interference in tactical military communication systems. A thorough understanding of these problems requires hybrid EM simulation methodologies that can accommodate completely different length scales, ranging from tiny RF devices and installed collocated antennas to large vehicle structures and their surrounding environment, terrain included.

EMAG received seven different contracts to build the EM.Cube and subsequent technologies by submitting proposals under multiple Army SBIR topics to fulfill Army needs. While every topic is different, each of the seven EMAG proposals and contracts helped to build, advance and field the EM.Cube and NeoScan technologies. The first Army SBIR project was able to develop the simulation tool EM.Picasso for design, analysis and optimization of planar microwave circuits, antennas, and arrays. A follow-on Army SBIR project resulted in the development of techniques for modeling-lumped active devices connected to EM problems. Funding under the Future Combat Systems (FCS) program culminated in the development of the simulation tool EM.Terrano for radio wave propagation modeling in urban environments. With the additional research and development, EMAG was awarded a third Army SBIR contract creating the foundation for EM.Cube.

EM.Cube is a unique modular simulation environment for hybrid multi-scale, multi-engine, EM modeling and EM-circuit co-simulation. EM.Cube was the channel used to integrate EM.Picasso, EM.Terrano and several other domains measuring time and wavelengths, and asymptotic EM solvers with analytical techniques over large areas using a fully parametric 3-D CAD modeler. The parametric, 3-D CAD modeler designs real-life objects and allows for easy modifications while recording design history. A fourth Army SBIR contract awarded to EMAG led to the development of the first and only full 3-D polarimetric ray tracer, used to measure and interpret EM waves. This is based on ultrafast k-dimensional tree algorithms, k being any numerical variable (ex. 3-D), able to solve radio wave transmission problems. This could involve extremely large, mixed urban canyon scenes and complex terrain, only taking a few minutes to measure and analyze the area. EM.Cube is the first and only EM simulation tool that rigorously addresses self-consistent co-simulation of large-

scale EM structures and RF circuits. This tool combined with mixed-signal analog/digital circuits, and black-box systems containing an arbitrary number of passive and active nonlinear devices, demonstrates EM simulation modernization.

With all of the modules built to work collaboratively with one another, EM.Cube is the only commercially available, multi-engine simulation environment with a fully integrated shared user interface. This provides a system-level EM-circuit analysis capability from direct current to light, and accommodates length scales from microns to miles. EM.Cube makes it possible to perform accurate simulation of the next generation electronic battlefields. This involves modeling high-interference, dense urban canyons able to span several square miles, while continuing to capture the geometric and physical details of individual transmitters and receivers in the area.

Computer simulations are only useful if they can be verified and validated with reliably measured data. The direct measurement of EM fields is a challenging endeavor since the fields can easily be disturbed by the presence of an external field probe. Conventional near-field scanning systems typically use a metallic radiator as a receiving antenna or probing sensor to sample the near-zone fields of the device under test (DUT). Since a metallic probe cannot get too close to the DUT without perturbing its near-fields, systems suffer from major limitations such

EMAG Technologies Inc. | www.emagtech.com
U.S. Army Research Laboratory-U.S. Army Research Office (ARL-ARO)

as, narrow bandwidth, low spatial resolution inadequate for device diagnostics and the inability to handle high-power devices and high-intensity beams.

The Army Small Business Technology Transfer (STTR) Program, led and managed by the Army Research Laboratory (ARL), is similar to the SBIR program, with the major exception requiring small businesses to work with a research institution, typically a university. Continuing further research and development, an Army STTR contract was awarded to create the foundation for a unique field measurement system, called NeoScan. NeoScan uses patented, miniaturized, non-contact electro-optic field probes. This is the first and only field measurement system that detects and probes the EM fields generated by RF devices/circuits and EM structures non-invasively while providing large operational bandwidth (> 20GHz) and high spatial resolution (< 200 microns). Unlike conventional near-field probes, NeoScan probes are made of metal-free parts that use miniaturized optical crystal tips mounted on optical fibers. The combination of an extremely small probe footprint and absence of metallic parts, connecting at the signal pickup area, makes RF interference a necessity to avoid. NeoScan provides an extremely large and dynamic range, greater than 70 decibels with the ability to measure very weak fields, smaller than 1 volt per meter ranging to very high intensity field strengths larger than 2 megavolt per meter. Development of NeoScan allows usage of the same probes to detect the variety of range in EM fields.

As EM fields are "first-principle" physical quantities, they can be used to compute many other secondary characteristics. One example is computing the far-field radiation patterns around the EM object. Under a different Army STTR topic, another awarded contract provided the opportunity to improve the performance of NeoScan with advancements in the accuracy and repeatability of measuring both amplitude and phase of the three individual field components simultaneously. As a result, NeoScan can effectively be used as a portable, ultra-wideband (UWB) alternative to compact near-field antenna ranges or costly echo-free chamber installations. Besides verification of EM simulation data, antenna characterization and RF device diagnostics, NeoScan systems can be used for a variety of other applications: electromagnetic compatibility and electromagnetic interference (EMC/EMI) testing, evaluation of high power microwave (HPM) systems, RF radiation calculation and quantification of EM radiation effects on biological systems, real-time field detection in various materials, and waveform tracking in high-speed digital circuits.

TECHNOLOGY TRANSITION:

In addition to the several Army SBIR and STTR awarded contracts to develop both the EM.Cube simulation environment and the NeoScan field measurement system, EMAG has received eight additional Phase II SBIR and STTR contracts from other DOD agencies. These contracts provided funds for research work, either directly on the development of EM.Cube and NeoScan, and/or on related applications of these tools. EMAG has received more than $4.2M of non-SBIR contracts from various DOD agencies, including DARPA. Both EM.Cube and NeoScan have been offered to commercial customers in the last five years. EMAG directly markets its software and hardware products, establishing several distributors world-wide. The sales of software products and measurement systems have generated more than $2M in revenue. Service contracts, related to these products, generated more than $800K of additional revenue.

Currently, researchers from the Army Research Laboratory (ARL) are actively using EM.Cube in their organizations. The Air Force Research Laboratory (AFRL), at Brooks Air Force Base (AFB), has been actively using several NeoScan systems since 2011. These systems have been tested at Brooks and Kirtland AFRL facilities. In 2015, University of Surrey in the United Kingdom purchased a NeoScan system for research and development on gallium nitride (GaN) power amplifiers. Raytheon Company recently purchased of a multi-channel NeoScan for their radar manufacturing facilities. EMAG has been providing extensive field measurement services for customers like Pratt & Whitney and Systems & Technology Research (STR) Corporation.
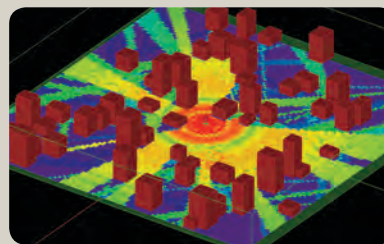
Both EM.Cube and NeoScan can be used by all RF engineers, in various government agencies and commercial industries, for many different applications.

Applications include antenna design and characterization, EMC/EMI analysis and testing, microwave and millimeter-wave device analysis, design and diagnostics, radar signature modeling and testing with evaluations of high power microwave weapons. EMAG continues to expand their user base of EM.Cube and NeoScan with other government agencies, the DOD and commercial industries.

SWITCHABLE ACOUSTIC RESONATOR FOR RF FREQUENCY SELECTION

Structured Materials Industries Inc. | www.structuredmaterials.com

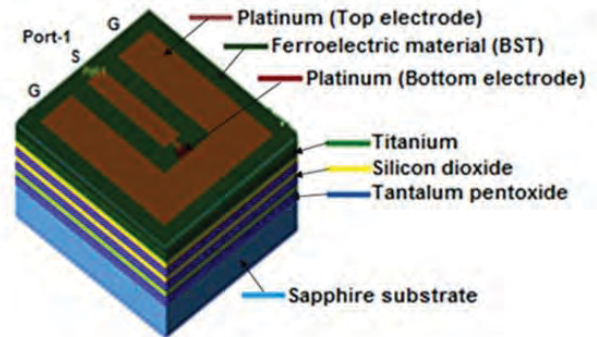U.S. Army Research Laboratory (ARL)

Almost every electronic device communicates over the airwave using radio frequency (RF) energy. Users want these devices to be smaller, lighter, faster, cost effective and use less power increasing longer battery life in the case of portable devices. Piezoelectric resonators are used as frequency standards in communication and tuned at specific frequencies. An example of this application is a smart phone containing several dozen piezoelectric resonators, to enable frequency selection for phone calls, GPS, Bluetooth and use of the internet. The Film Bulk Acoustic Resonator (FBAR) is a critical component in RF systems. FBAR's enable selection of the particular frequency on which to communicate. Present state-of-the-art FBAR's are passive devices and are neither tunable nor switchable. Therefore, these systems need separate RF filters for each frequency, and each resonator must be backed by an RF switch. Systems which operate on multiple frequencies use many resonators. These extra resonators and extra RF switches add size, weight and cost to the overall system. The extra parts introduce losses which increase power consumption and reduce battery life.
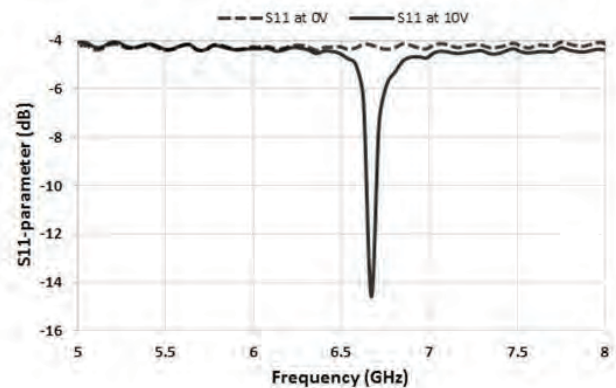
In Phase II of the STTR Project, Structured Materials Industries (SMI), working with the University of Colorado at Colorado Springs (UCCS) and the University of Connecticut (UConn), demonstrated a switchable and tunable FBAR device. When used in the manufacturing of RF systems, switchable/tunable FBAR devices can reduce total parts count, reducing size, weight and cost. The key enabler is SMI technology for depositing thin films of barium-strontium-titanate (BST). SMI is working to transition this technology to both military and commercial markets.

Schematic diagram of the Switchable RF resonator.

Transmission parameter versus frequency for the switchable resonator in the OFF (0 volts) and ON (10 volt) states.

TECHNOLOGY TRANSITION:

Total commercial investment for this STTR project is $686K. Presently, SMI has received funding from a major defense contractor to deposit our BST films onto their device wafers. SMI is currently working with them to optimize the material, and integrate the technology into their device. The knowledge and experience gained from this application will help SMI in transitioning the technology to commercial applications. Commercial applications in a smart phone would make these products smaller, lighter, cost effective and improve battery life. For future uses in military systems, the tunable/switchable resonator would enable frequency agile operation allowing better encryption and reduced detectability.

> **"Commercial applications in a smart phone would reduce these products' SWaP-C and improve battery life."**

COMPACT AND RUGGED FIBER OPTIC TRANSCEIVERS FOR 50 BILLIONS OF BITS PER SECOND (GBPS) DATA TRANSPORT

Ultra Communications Inc. | www.ultracomm-inc.com
U.S. Army Research Laboratory (ARL)

The use of fiber optic networks is wide-spread in existing Army combat vehicles, such as the Abrams Tank, and upcoming platforms like the Future Vertical Lift. Fiber optic networks are used to connect equipment used in surveillance systems, precision weapons systems, electronic warfare and communications. Advances in fiber optic technology can increase the performance of the networks, reducing latency and increasing resolution. The fiber network equipment has pluggable optical interfaces that allow for removal and installation in the field; for example, to re-configure an aircraft mission. These fiber connector interfaces are vulnerable to contamination during the connecting and disconnecting of the fiber connectors. Ensuring clean interfaces, and diagnosing fiber contamination is time-consuming and requires specialized equipment. Additionally, because connectors must be opened for diagnostics, additional contamination can occur – creating an opportunity for maintenance induced failures. Fiber optic transceivers with built-in-test (BIT) capability enable rapid detection and isolation of fiber faults without opening the connector, and isolating the faulty connector for maintenance.

Modernized fiber optic transceivers with BIT capability increase the availability and performance of Army tactical weapons. The incorporation of BIT functionality within the fiber optic network reduces maintenance time, and allows rapid changing of the vehicle equipment to be fully optimized for a mission. This increases the overall aircraft performance (mission-time vs. downtime) and weapons availability. Systems to improve weapon accuracy through higher resolution imaging, and reduced lag in real-time video systems.

TECHNOLOGY TRANSITION:

This technology is transitioning through commercial product sales to prime contractors responsible for advanced development of fiber optic systems. Lockheed Martin, Northrop Grumman, Raytheon, General Dynamics, and L3 Communications are just a few companies to express commercial interest. Many subsystem and system contractors around the world are evaluating integration of fiber optic connections in their platforms. The main reasons for using fiber optic connections are reduced weight, reduced susceptibility to electromagnetic interference and high bandwidth. The product is baselined into programs for the high performance imaging with in terrestrial and airborne applications. The product is undergoing a qualification program and vetted across multiple platforms to expand the suitability with retro-fit and next-generation fiber optic network installations and upgrades. The sales of this product resulted in over $1.1M in direct sales to 17 customers and $2.5M in follow-on government programs. Currently in the field is a satellite system that requires a fiber optic link between a high resolution camera and the system used to process collected data. Another fielded use is a radar system that uses the fiber optic link to distribute data from the radar to electronic equipment for processing. This technology has been fielded into a satellite system requiring a fiber optic link between a high resolution camera and a data processing system. It has also been incorporated into a fielded radar system to distribute data from the radar to other system components. Lastly, this technology is currently being integrated into a potential future Army Abrams Tank upgrade. The Lockheed Martin sensor system uses software to track inbound enemy fire and rapidly target the attacker. Ultra Communications is working to integrate this technology on to other DOD platforms in the future.
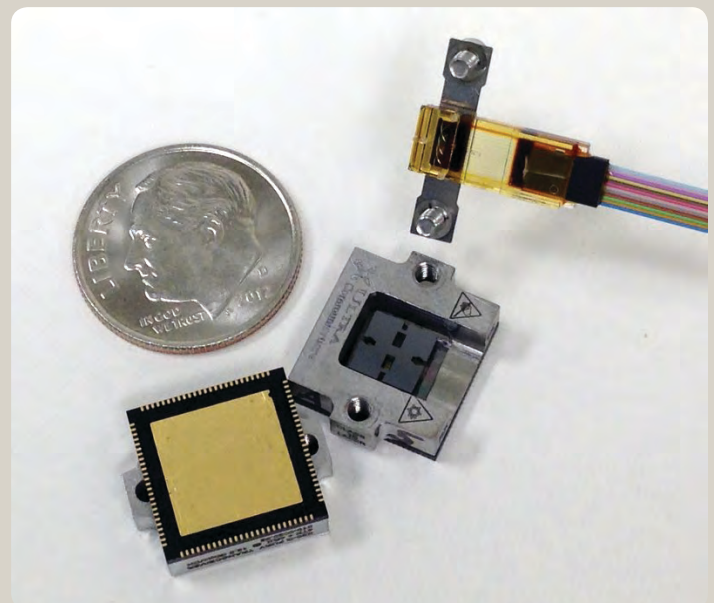
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Photos courtesy of the U.S. Army, www.defense.gov