



**Success Stories** // FALL 2016

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The Department of Homeland Security has created this brochure for the purposes of demonstrating how DHS's Small Business Innovation Research program can and has played a part in development and maturation of homeland security related technologies and may have contributed to the success of representative firms and their technologies. The inclusion of a firm or its products in this brochure in no way amounts to (1) an endorsement by DHS of the firm or its products or (2) a representation that the products discussed are or would be merchantable or suitable for the purposes discussed or any purpose. DHS assumes no liability for the use of these or any other products made by the firms discussed.

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## THE ROAD TO SUCCESS

Over the last decade, the Department of Homeland Security (DHS) has sponsored 185 Phase II projects through the Small Business Innovation Research (SBIR) Program. It is the goal of both DHS and these companies that have received SBIR funding, to transition products – whether that be to the commercial sector or within a government program. These resulting dollars are referred to as Phase III funding, and they encompass any non-SBIR revenue. Phase III dollars are a strong determinant of success. While success can't always be measured by the bottom line, the demand that subsequently results from these technologies paints a clear picture that these projects are filling vital needs. From real-time emergency response systems, to miniature chemical sensors for smartphones, the technologies developed through the DHS SBIR program have applicability extending far beyond the government sector.

The commercialization of these products may take one of many routes. Aligning with a large prime contractor to collaborate or license the technology may be advantageous to some research and development firms, which might not have the capabilities to manufacture and market their product. By forging this mutually beneficial relationship, ideas may be mass-produced and delivered to clients on a much broader scale. The formation of a spin-off is also a popular way to bring technology to market, which provides a dedicated and specified focus to the product, without compromising the core business model of the parent firm. Still, some small businesses may wish to research, develop, and manufacture if they possess the capital and capabilities to do so. All are viable routes to the transition of a product, and our selection of success stories encompasses a variety of paths to commercialization.



To take a closer look at the numbers, respondents from our follow-up data collection reported \$61.75 million in revenues resulting from the sale of a product, prototype, or service that was developed as a result of the corresponding SBIR technology. The largest source of funding reported was in the form of additional development grants, contracts, and purchase orders, totaling \$41.9 million. Outside of developing an entirely new product or service, respondents also indicated that they achieved approximate revenues of \$44.64 million as a result of enhancing an existing product or service by incorporating the DHS funded Phase II technology. Cumulatively, DHS Phase II project respondents reported approximately \$127 million in Phase III revenue.

The stories depicted on these pages are just a snapshot of this overall success. These particular companies were selected based

on their innovation, history of providing sought-after solutions, and of course, their Phase III success. We have also included a subset of companies, in the section titled "Small Businesses on the Move," that are showing great potential in the path to commercial success. Phase III dollars no doubt take many years to manifest, but these four small businesses were profiled based on the promise of their technologies, which have already turned many heads within DHS.

SBIR funding, as communicated by our respondents, is a vital component to the transition of a product, as it provides the means to look at a need and evolve the technology into a solution. It is our hope that the SBIR program will continue to nurture and fund the innovations of the future, not just within the Department of Homeland Security, but across other government agencies and beyond. ■■



# Aerosol Dynamics, Inc.

►► **PHASE III SUCCESS**

\$4 million in commercial sales and follow-on contracts

The recent success of Berkeley, California-based Aerosol Dynamics is all the more impressive when one discovers that it is merely a team of five tackling multi-million contracts and delivering solutions to the commercial sector and beyond.

Twenty-five years ago, Dr. Susanne Hering had an imminent interest in studying air pollution and the resulting problems on the human respiratory system. Haze in the sky is formed by tiny particles, below a micrometer in diameter. When one inhales these particles, they deposit deep in the airways of the lungs, and are hard to remove from the body. Smog, which is common in large cities across the United States and around the world, is the result of both emissions from sources such as motor vehicles

and chemical transformations that happen in the air. These conversions that happen in the air involve pollutants from a number of sources – some manmade and some natural.

In 2003, Dr. Hering developed a new way to measure these airborne particles. The process involved making the particles larger by condensing water on them in a continuous flow. This allowed for the particles to be counted through a condensation particle counter, and it was this process that interested the Department of Homeland Security.

DHS had a desire to collect particles in the submicrometer range, which had never been done before. The need was to provide a front-end collector that could be joined with other technologies that the agency was developing for biological analysis to identify potential threats. This vision had to start with the ability to capture these particles at such a small size. DHS attached this collector to a prototype system that included the collector and the analysis platform. They just completed testing in lab and field trials.

It was through this DHS SBIR-funded project project that Aerosol Dynamics developed a new way to apply water to these particles in a continuous flow, enabling an analyst to look at the cloud of particles that were formed. A commercial instrument resulted from this work, and Aerosol Dynamics licensed the technology for further analysis in the chemical composition of particles.

“If you can collect directly into a liquid, and have that be something that you can handle – that opens the door to so many things,” explains Dr. Susanne Hering, President of Aerosol Dynamics. “You can now analyze things that are difficult, or handle online analysis, skipping over a whole extraction step. These can now be delivered directly into your analytic system.”



Subsequently, Aerosol Dynamics did some follow-on SBIR work with the National Institute of Health to take collection technology and apply it to the air pollution problems in environmental monitoring. The company has licensed this and it is now being launched as a commercial product. They have also worked with the Department

of Energy on several instruments, one of which was recently deployed in the Amazon to look at biogenic and anthropogenic and manmade emissions and the effects of those emissions. Aerosol Dynamics has built a number of prototype low-volume collectors to capture particles from air at flow rates of a few liters a minute for a biosensor company, and for universities and national laboratories, both here in the United States and abroad. The company hopes to provide a bridge between what comes out of universities and their own ideas to meet commercial needs of interest for clients.

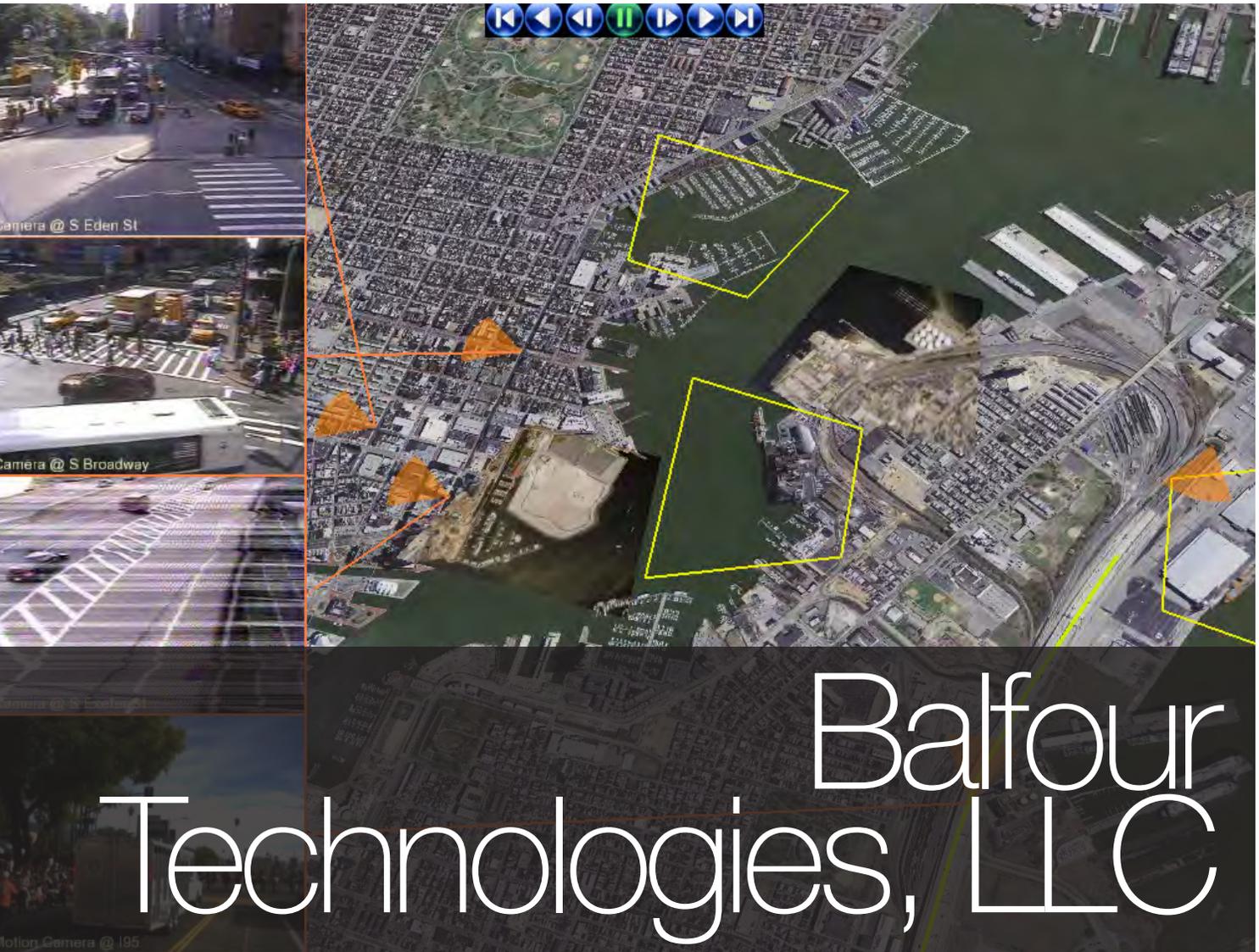
Because of the small size of Aerosol Dynamics, the company has implemented a business model in that they will stay a research and development firm. They do not have plans to directly commercialize, so instead they team up with instrumentation companies to take the products to market. Dr. Hering still sees enormous potential for this technology. One of these applications would be to provide a viable collection method of these particles. In other words, one could collect particles out of the air without killing them, so that they can be cultured and studied.

“If you can collect directly into a liquid, and have that be something that you can handle – that opens the door to so many things.”

Dr. Susanne Hering  
President of Aerosol Dynamics

When Dr. Hering first started the company, she relied on the work she was getting from the utility industry, which had an interest in studying air pollution. However, when the power industry was deregulated, budgets tightened and Aerosol Dynamics turned to the SBIR program, and the funds she found enabled the continuing development of their technology.

“The SBIR program is absolutely critical for what we do,” explains Dr. Hering. “The program is targeted at developing technology – it’s not only a pathway for licensing, but also a pathway for doing research in areas of interest to us and to our university collaborators, and enables us to provide tools that we wouldn’t otherwise have to study the atmosphere.” ■■



➤➤ PHASE III SUCCESS

Over \$4.5 million through contracts with the Department of Homeland Security, military and commercial sales; also over \$1 million of private investment capital

First responders at an incident scene are tasked with not only the stringent physical demands required to avert disasters and save lives, but also with simultaneously deciphering a multitude of information pouring in from various channels. Raw data fed to them via cameras, radiation detectors, and air quality monitors, to name just a few devices, must translate to an integrated and cohesive Common Operating Picture (COP). In an effort to increase the fidelity of the COP and achieve situational awareness across commands, the U.S. Department of Homeland Security Science and Technology Directorate (DHS S&T) set out to fund new technologies through its SBIR program.

Balfour Technologies, founded in 1999 by twin brothers Richard and Robert Balfour, knew it could provide this sought-after solution by applying its patented fourDscape® technology to meet the needs of DHS. The resulting innovation is a fourDscape Automated Situation Awareness (ASA) system that effectively manages a large number of cameras and other sensors and delivers a correlated, integrated, seamless view of extensive areas under surveillance in an interactive, 4-D display. 4-D refers to the three

dimensions of space, but with the added dimension of time which enables operators to evaluate the situation as it changes dynamically. Additional data, such as street names and building locations add another layer of essential information.

First responders using the technology can monitor video cameras at the incident scene, review the status of sensor networks, track assets, share multimedia data in real-time with other users, and set alerts to receive contextual and interactive updates, all of which aid in making tactical decisions in a time critical environment.

During its initial Phase I SBIR project with DHS, Balfour used a \$97K investment to develop and successfully demonstrate a scalable system architecture with live, interactive fourDscape-based demonstrations. The subsequent Phase II work utilized an \$800K SBIR investment and saw the development of a deployable ASA system prototype based on the architecture developed during the first phase. The result was a one-of-a-kind platform that can vastly expand awareness by interactively visualizing massive amounts of intelligence, surveillance, and infrastructure data in a single 4-D Common Operating Environment. fourDscape can be used on-site, at command centers, or remotely with smart phones, iPads, tablets and laptops.

“The ability of fourDscape to run in the ‘cloud’ and connect to a diverse set of real-time sensors and data makes it applicable to many other industries.”

Robert Balfour  
Chief Technology Officer at Balfour Technologies

“The DHS SBIR program supported our research and product development efforts,” says Richard Balfour, President of Balfour Technologies. “We were then able to complete designs, and with Phase III funding, bring to market a system that is currently being deployed in homeland security, public safety and security, and emergency response applications.”

fourDscape was first tested in 2008 during Operation Lupercal, an emergency response exercise involving DHS and the Los Angeles County Sheriff’s Department (LASD). The test simulated the release of a car bomb and a radiological dispersion device during a large public event, and included the LASD Bomb Squad and the Hazardous Material Response Team. FourDscape allowed users to see a layered view of county images, models of the parade route, simulations of

float traffic, information from a police deployment plant, traffic videos, and images from wireless helmet cameras and web cameras. These images were fused together seamlessly into a 4-D scene that enabled the first responders to act swiftly and accordingly. In 2009, fourDscape was field-tested during the Tournament of the Roses Parade, and it further demonstrated the value of four-dimensional visualization for tactical and operational applications.

Since then, Balfour’s innovations and the fourDscape product line have been utilized in both military and commercial applications. The benefit extends far beyond surveillance; the core technology promotes persistent awareness, which translates into better decisions in managing/securing infrastructure, assets, operations and safety across a wide range of organizations.

“The ability of fourDscape to run in the ‘cloud’ and connect to a diverse set of real-time sensors and data makes it applicable to many other industries,” says Robert Balfour, Chief Technology Officer at Balfour Technologies. Industrial applications include facilities operations, process controls, asset tracking, remote home/healthcare monitoring, and smart buildings to name a few.

In 2011, Balfour received the coveted Tibbetts award from the Small Business Administration for its fourDscape ASA technology. The Tibbetts Awards are presented to small businesses and individuals judged to exemplify the best in the SBIR program. Although Balfour was among 44 businesses and eight individuals presented with the award, it was the only company to be nominated by the Department of Homeland Security.

Balfour Technologies began as a two-person consultancy with expertise in real-time 3-D visualization, simulation and training. The company’s chief offering was fourDviz™ visualization software, which evolved into the award-winning fourDscape technology. Balfour has received six SBIR awards over the past nine years. The company’s steady growth is a testament to the SBIR program – in 2010 Balfour formed a fourDscape marketing and sales joint venture, VCORE Solutions LLC, and currently employs a team of fourteen fourDscape specialists. In 2014–15, Balfour was awarded additional DHS SBIR Phase I/II awards to leverage its fourDscape machine-to-machine (M2M) ASA technology to deploy a secure, mobile “Internet-of-Everything (IoE)” capability for first responders. ■■



# Expert Microsystems

➤➤ PHASE III SUCCESS

Over \$6.58 million in related revenues

Since

1995, Expert Microsystems has made a place for itself in the niche market of prognostics and health management for critical equipment. In the aerospace and power generation realm, this translated to precise techniques for monitoring the sensors of engines, power plants, and other infrastructure using specialized software. The company's patented SureSense® system provided the means to monitor automatically a complex system such as a power plant, from a remote location. The plant data is accessed using a distributed SCADA – Supervisory Control and Data Acquisition – system that is essentially a communications and control network that can open and close valves, operate pumps, and give other commands. The thought process then turned to the SCADA systems themselves – instead of monitoring just the plant equipment, why not monitor the control systems and ensure they are also of optimal health? With this in mind, Expert Microsystems embarked on an SBIR project with the DHS to apply these same proven principles to intrusion

detection with the goal of making the control infrastructure – which can be vulnerable to threats – more secure. During the Phase II portion of the project, Expert Microsystems demonstrated the feasibility of this new defense by actually hacking into a SCADA system at the Idaho National Laboratory (INL) and demonstrating the ability to identify the attack even while the conventional intrusion detection systems – commonly used today – did not. The INL-provided SCADA system provided an opportunity for testing where no real damage to public infrastructure could be caused by the testing.

“In doing this project, we added a whole set of new and useful capabilities to our core technologies for prognostics and health management,” explains Randy Bickford, Founder and President of Expert Microsystems. “Our original goal was to apply our PHM techniques to the problem of intrusion detection in control systems, and we successfully proved that this core technology has an extended applicability across a wide range of other computing platforms as well.”

The work the Sacramento-based company did in 2006 with DHS is continuing to come to fruition – in early 2014, Expert Microsystems was awarded a U.S. patent for its asset surveillance methods, which were based off of the same technology developed under the SBIR sponsorship. This patent, in combination with twelve related patents for the company’s core PHM technology, demonstrate a long history of successful innovation.

The path of success led Expert Microsystems to the commercial marketplace. The company chose to pursue opportunities in the computer networking and server industry. This entailed applying the same techniques of PHM to a computer server and monitoring both hardware and software within a network infrastructure. This is especially important for financial or security institutions which engage in high-end transactions. Whether a threat might compromise the server hardware or software, detection of the problem is critical to prevent a server crash. Ultimately, this technology was licensed to one of the largest software manufacturers in the world, and they have been successful in applying the technology to database and transaction servers. Here, the technology has several advantages over existing products including fewer false positives, the ability to analyze very large data sets and variables from multiple sources, and the ability to monitor cyber networks automatically in multiple and differing environments.

In addition to licensing the technology, Expert Microsystems won a follow-on Phase II contract with the Department of Energy (DOE), and most notably, a Phase III designated procurement contract with NASA. Using its SureSense

software package, Expert Microsystems demonstrated the ability to accurately detect and diagnose sensor faults and identify anomalous system operating states in a wide variety of power plant and spacecraft equipment. The SureSense package is also being embedded in other computer programs and control systems for providing real-time data analytics.

Today, Expert Microsystems is combining its SureSense product line with a newer and complementary product that it is developing for the Electric Power Research Institute (EPRI) and DOE. This fleet-wide PHM Suite combines the output from SureSense with other plant information, such as results from inspections or maintenance actions, to further refine the diagnosis based on the instrument data processed through SureSense.

New applications are broad and Expert Microsystems is actively seeking licensing opportunities with a global player in the power generation space. There is also interest on the part of DHS to monitor first responders and from the Department of Defense to monitor soldiers. While the core technology is essentially a “doctor” for machines, this same prognostic principle can apply to the health of individuals. New uniforms are currently being constructed for firefighters that sense the wearer’s vital signs. The sensors have a wireless link to a local station – either on the truck or an office – and the interest is in knowing which person is healthy and which is in distress. If a firefighter is down, vital signs can be monitored in real-time and medical personnel can be alerted automatically with precise diagnostic information about the firefighter’s condition.

Contrary to what people may conclude, this software does not and will not replace the human expert. In fact, it is quite the opposite. Rather than have the doctor seek out and analyze data to find the abnormal condition, the software does the early work - it finds the problem, and synthesizes the data to an initial diagnosis. What it does not do is decide the necessary course of action and treatment. The goal is to enable the human expert to implement the most effective response at the earliest possible time.

“Letting problems accumulate in both machines and humans has the same detrimental effect on the overall health of the unit,” says Bickford. “So whether we are dealing with equipment, or the ‘human’ machines of the heart and other vital organs, longevity through continued prognostics and maintenance is what we are seeking.” ■■■



# Geocent

## ►► PHASE III SUCCESS

2014 revenue of \$28M; recently signed a \$10M contract with the U.S. Navy to deliver software and systems engineering solutions and an additional contract with SPAWAR

## Emergency

management teams often cite communication issues as their biggest challenge during natural disasters. This was never more transparent than during the devastation of Hurricane Katrina on the city of New Orleans. First responders, military personnel, federal agencies, the Federal Emergency Management Agency (FEMA), municipalities, city officials and state governments were all trying, unsuccessfully, to get on the same page as to where assets were located, where troops were stationed, who needed emergency medical attention, which roads and exit routes

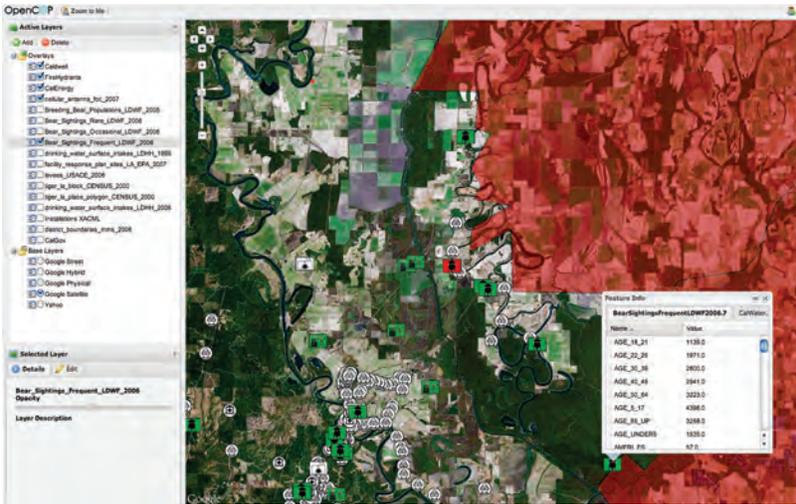
were blocked or destroyed, and other critical logistics. Louisiana-based Geocent knew that if these organizations could somehow share geospatial information on a map that could work with each team's own tools, communication would be greatly enhanced. This led the company to respond to a SBIR solicitation from the DHS on how to support emergency response capabilities. The result was a technology that could be used across multiple agencies for a more comprehensive common operating picture.

“Through this SBIR, we built our Open Common Operating Picture, or OpenCOP, which is an open-source, open-architecture integration platform for enabling the dissemination of complex geospatial data,” explains Keith Alphonso, Chief Technology Officer of Geocent. “It is a platform that allows emergency managers to better operate in critical situations and to share situational awareness. We received follow-on funding from Governor’s Office of Homeland Security and Emergency Preparedness (GOHSEP) and used this technology during the BP oil spill, Hurricane Isaac and Superstorm Sandy as well.”

Geocent then used that core technology for its Navy customers to integrate weather data. Multiple contracts with the Navy soon followed, including a \$22.1 million award from Space and Naval Warfare Systems Command (SPAWAR) to work with the agency in San Diego on Command and Control Technologies and Experimentation (C2T&E), capabilities and Internet operations. Additionally, Geocent was awarded an SBIR Phase III competitive contract to provide the Naval Oceanographic Office (NAVOCEANO) the ability to display their forecasted ocean weather data and observations of current ocean weather data on a geospatial map so that it can be viewed on tools such as Google Earth and other Open Geospatial Consortium based map viewers.

For its DHS customers, Geocent is continuing to provide Geospatial Technical Support Services (GTSS) under a Blanket Purchase Agreement worth \$98 million – which was awarded to Geocent and three other small businesses. Through this agreement, DHS will secure geospatial technology services to produce maps of natural hazards such as floodplains, as well as assess critical infrastructure risk and vulnerabilities. DHS also has a goal to use the technology to track and monitor law enforcement activities and support reconnaissance operations, conduct urban search and rescue operations to recover survivors affected by disasters, plan security operations for special events, and facilitate vessel and cargo tracking and inspection.

Geocent’s hugely successful stint in the SBIR arena is a testament to its team, who looks beyond the initial award and sees what potential exists in the marketplace for a particular technology.

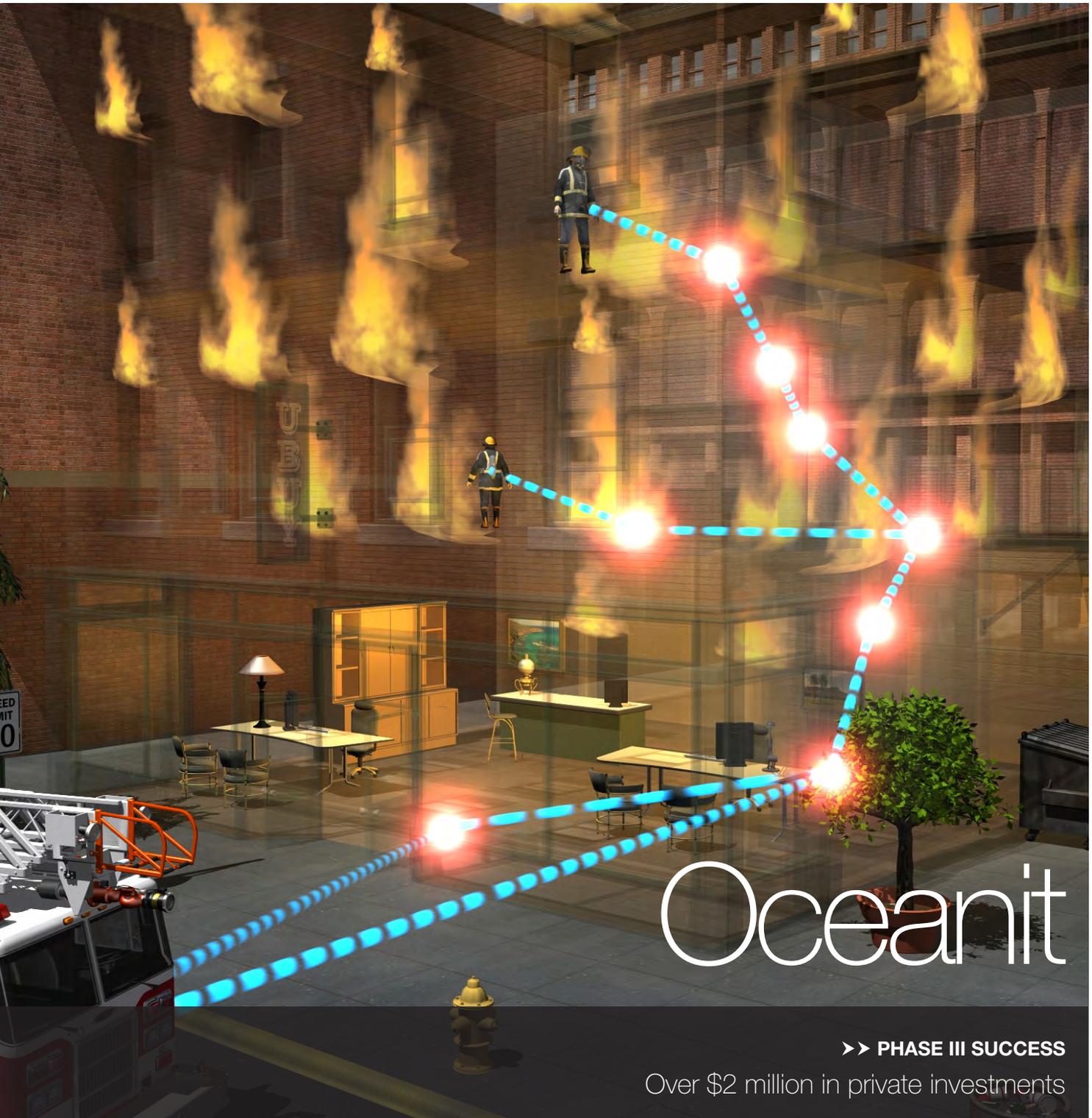


“Commercialization is something we look for in SBIRs and in fact Phase III is a big thing for us to strive for,” explains Ridge Bourgeois, Federal IT Sector Director for Geocent. “The SBIR program has been a cornerstone of where we live and operate in terms of the innovation perspective, and we still try to be on the cutting edge and to solve the technical solutions that otherwise would fall to the wayside without the program. As a small business, you are busy in operations and maintenance of things, but with SBIRs we can continue to expand in our core competencies of software engineering and data integration and push the envelope.”

Continuing on its SBIR journey, this year Geocent was awarded a NASA SBIR to develop earth science data processing algorithms in the cloud. This ties in two of the company's core capabilities – data processing and geospatial data. Since NASA collects a great deal of earth science data with satellites, they want to make this information readily available to the public.

“What we are doing is instead of just having data in the cloud, you can also have processing in the cloud,” adds Alphonso. “Raw data is one thing, but to have the ability to process that data for specific purposes is the value that we are bringing. Maybe you want to take an image of the coastline and compare that image to one taken five years ago to assess coastal erosion. Those are the types of things the algorithms can provide.”

The state of Louisiana also continues to be a great customer for Geocent, who was honored with several awards in 2014. In addition to the coveted 2014 Tibbetts Award from the U.S. Small Business Administration, Geocent received the Boeing Performance Excellence Award, along with the Marshall Space Flight Center Small Business Subcontractor Excellence Award. With the government’s demand to increase its technology platforms each month, 2015 is shaping up to be the biggest year yet for Geocent. ■■■



►► PHASE III SUCCESS

Over \$2 million in private investments

# When

firefighters enter a building, communication with the outside world can be hindered behind thick steel structures and concrete walls. This issue came to light during the terrorist attacks of 9/11 and in several instances thereafter, prompting the Department of Homeland Security's Advanced Research Projects Agency (HSARPA) to take a proactive approach and develop a system to stay in contact with first responders. The resulting technology is the Wireless Intelligent Sensor Platform for Emergency Responders (WISPER), designed and developed by a small business based in Honolulu, Hawaii.

Oceanit originally responded to the SBIR Phase I solicitation in 2008. The vision was to create an ad hoc mesh network that would act like a trail of breadcrumbs, hopping information from one crumb to another. The WISPER system is connected to either a belt, self-contained breathing apparatus (SCBA) tank, or other equipment carried by emergency responders and it self-deploys nodes about the size of a quarter, creating a mesh network of transmitters and receivers. The network connects all first responders within range, and transmits crucial information back to the base station.

“The issue wasn’t just losing voice communication with the first responders,” explains Dr. Ken Cheung, Science & Technology Director at Oceanit. “A system was needed that could assess how they were doing. The goal was to create a body area network so that each emergency responder could have a suite of sensors to track their conditions and even locations, and this network would then transmit that information out of the building.”

Oceanit had been successfully developing solutions in the biomedical and sensor industry since 1985, making this project a natural fit. The company had already brought to market a few physiological monitoring projects, including a “smart” stretcher that tracked a patient’s vital signs without any wire connections. They also possessed a strong platform of radio frequency antennas and transceiver technologies, which would be utilized in this new solution for DHS.

During the Phase II portion of the SBIR, Oceanit optimized the system and built a final prototype. They did this by talking extensively to first responders, and figuring out the exact needs of the personnel who would be using it. A partnership with the University of Virginia provided the complex algorithms that would essentially tell the system when and where to drop the nodes. The product demonstration happened inside a large building in Washington, D.C., with lots of stairwells and hallways. The success of the initiative was a great starting point for the company.

“The SBIR was everything; without it, it would just be an idea,” says Cheung. “The program gave us the critical funding we needed and we are appreciative that DHS took that risk with us.”

Despite the utility WISPER can provide to the first responder community, prohibitive costs led the team at Oceanit to discover a brand new applicability within the commercial sector.

Instead of the nodes that communicate physiological information, Oceanit used that same technology to create

nodes in the form of a socket. This “IntelliSocket” has tremendous potential within the energy efficiency industry, essentially creating a smart network of appliances and devices. Inserted into a standard electrical outlet, users then plug their equipment into this mesh network and information is relayed back and forth to a central location such as a personal computer. The system does not use Wi-Fi, but utilizes its own communications protocol. The IntelliSocket encrypted network provides secure real-time monitoring and remote control of every electrical device plugged into the network. By utilizing this network, users can track the entire energy usage of homes, offices, and large commercial buildings. It is estimated that 10-15 percent of energy costs are related to “vampire loads.” This is the electricity drawn (mostly at night) from leaving devices plugged into an outlet.

“The SBIR was everything;  
without it, it would just be an idea.”

Dr. Ken Cheung

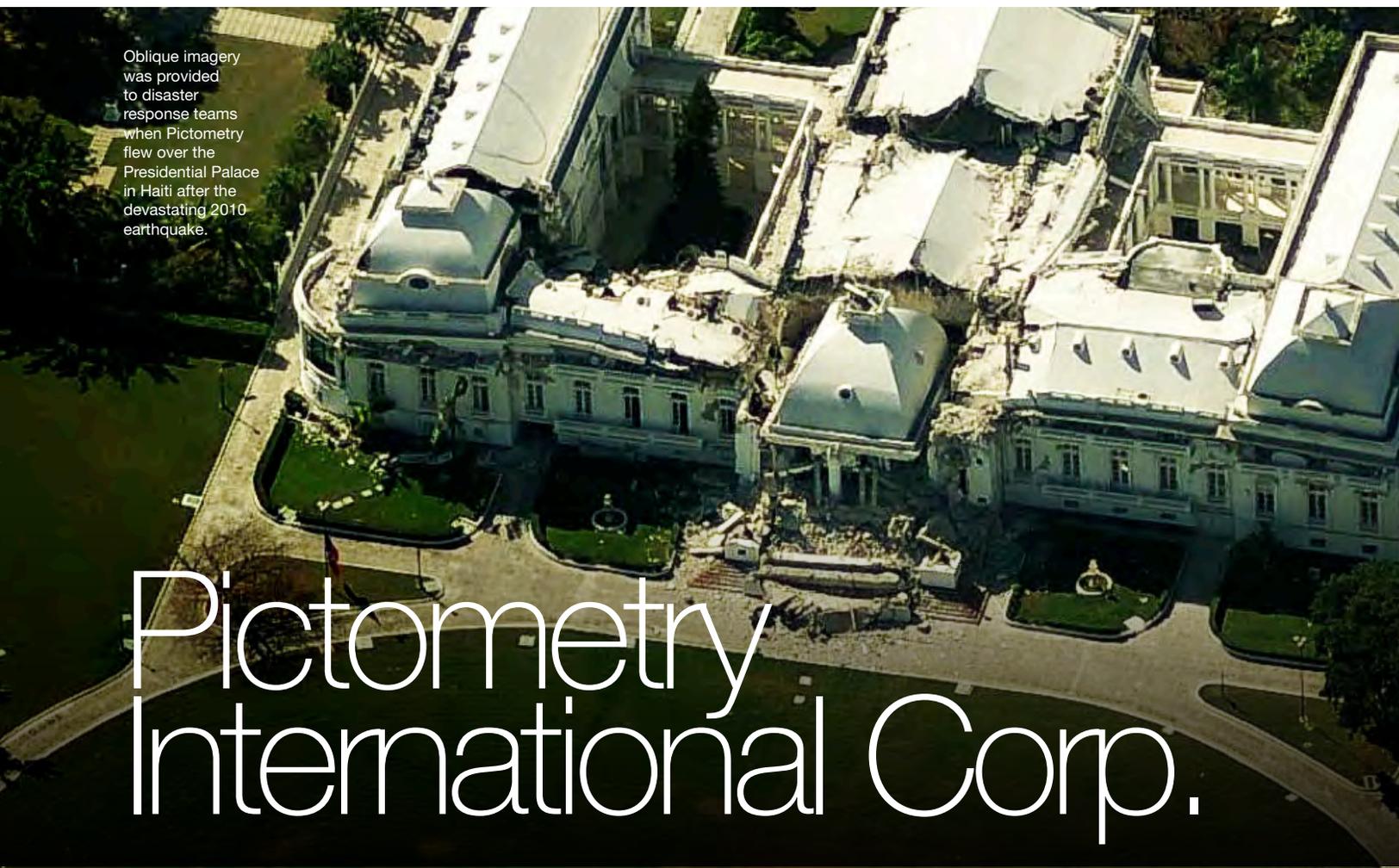
Science & Technology Director at Oceanit

“The real power is in information,” explains Cheung. “If your office building is outfitted with smart sockets, then you can start seeing trends; you can start getting an energy profile of the building. This helps to not only save energy, but to assess problems as well.”

Oceanit spun out a separate entity, IBiS Networks, to commercialize this patented system based on its original WISPER technology. IBiS Networks helps large organizations achieve visibility and control over thousands of socket-level electrical devices. One of the surprising benefits to potential customers is that the system doesn’t cost a dime, but rather comes out of the resulting energy savings, creating a win-win for everyone. Potential industries are broad, and include hotels, universities, and large corporations. IBiS is currently in talks with a few large partners, and are demoing some products this year.

With 160 employees and offices in Hawaii, Houston, Virginia and California, Oceanit will continue to be an innovative engine, focused solely on seeding new technologies, while spin-off companies will focus on the commercialization aspect of success. This business model is proving to be a successful one – Oceanit has a broad platform of new technologies it is developing, for use in both the government and commercial sectors. ■■

Oblique imagery was provided to disaster response teams when Pictometry flew over the Presidential Palace in Haiti after the devastating 2010 earthquake.



# Pictometry International Corp.

## ►► PHASE III SUCCESS

Over \$2 million through contracts with the Department of Homeland Security; over \$3 million in indirect sales resulting from the SBIR technology

If a disaster is happening on the ground, chances are, the Pictometry team is hovering above, transmitting real-time critical information to facilitate rapid response and ultimately save lives. With an 82-plane fleet equipped with ultra-high-resolution imaging gear and satellite communications, Pictometry has successfully made an international name for themselves in the emergency response industry.

Prior to securing an SBIR with the Department of Homeland Security for the development of an innovative new real-time emergency response system, Pictometry had worked for DHS, flying post-Hurricane Katrina with its original imaging technology. By capturing data from above, analysts on the ground could determine a variety of essential information on flooded areas, bridges and roads to avoid, and determine viable exit strategies. While Pictometry's work during the aftermath of the catastrophic storm provided this essential data, processing time was a hindrance. Images were captured, planes had to land, and images had to be processed on the ground. This led DHS to issue a new solicitation on real-time emergency response. Pictometry immediately began developing a solution, and successfully embarked on its SBIR work with the agency.



“The goal was to get aerial imagery quickly into the hands of first responders,” explains Frank Giuffrida, Executive Vice President of Engineering at Pictometry. “The raw sensor data had to be processed inside the plane, with high-speed radio links to transmit the images to the ground. The tracking dish, stationed on top of a truck, would follow the plane as it flies.”

In the Phase II project, Pictometry successfully demonstrated a working prototype during a test flight in West Virginia, using technology from Harris RF Communications, which they had worked with during the Phase I portion. A follow-up test included a simulated earthquake, where the prototype picked up images from the disaster site and relayed them immediately to first responders.

Pictometry was subsequently awarded a Phase III contract with the Department of Homeland Security, where they installed a Risk Assessment Management System (RAMS) on a civil air patrol aircraft in support of FEMA. Deployment occurred in September 2014. Damage Mitigation is a key goal for FEMA. When flooding occurs and FEMA is inundated with requests, the technology assists decision makers with data that can expedite high-volume temporary housing requests. Since Pictometry is constantly capturing imagery and data from above to keep its technology current, images can always be compared in a pre- or post-compilation. Every pixel of the imagery is georeferenced, so a user can click on any area of the image and get its exact coordinates in physical space. Adding this layer of information to the image turns data into knowledge.

Commercially, the applications for Pictometry

“The goal was to get aerial imagery quickly into the hands of first responders.”

Frank Giuffrida

Executive Vice President of Engineering at Pictometry

expand as far out as its eagle-eyed view of the world. The company currently contracts with Alabama Power, in what showcases the immense potential in the utility field for damage mitigation. Prone to hurricanes, tornados and other natural disasters, the company has set up four receiving units with the vision that when a storm does occur, Pictometry will be there with a fleet to capture images in real time. This will supplement Alabama

Power’s existing damage assessment activities that address downed lines across large geographical areas, and will assist support crews on the ground. This all aids in rapid power restoration – an immensely attractive feature for power companies and residents alike.

With over 1200 county customers and counting, the product and service that Pictometry provides is utilitarian to say the least. The company experienced a rapid spike in growth after providing some useful services to the state of Iowa.

“At one point, we had three county customers in Iowa,” recalls Giuffrida. “When the Mississippi River flooded, we were working for Cedar Rapids. Once we flew the area and provided the counties with the data, they were so appreciative that they told their neighbors. We now have 80 county customers in Iowa.”

Pictometry has since brought a new angle to its SBIR technology – oblique photogrammetry. Pictometry’s patented software allows locations and measurements to be extracted from the images, which are captured at an angle to reveal the world from a more natural perspective so objects are easier to recognize and interpret. With resolutions better than 3-inch Ground Sample Distance (GSD), users can see meticulous detail while viewing every feature, structure and parcel from north, south, east, west or straight down. Pictometry’s software allows for a side-by-side comparison of an image, with the before and after views, for an added layer of assessing damage.

911 centers are also utilizing Pictometry’s technology to pinpoint persons who need assistance. Although most smartphones have GPS, many times it is not enabled. By using imagery that is georeferenced, emergency call centers have located individuals in distress and have saved lives by dispatching first responders within the critical window of time.

Based in Rochester, New York and employing 223 workers, Pictometry has a defined set of goals going forward. By focusing on helping FEMA, along with the broad potential in the utility sector and some international aspirations, the company is positioning itself as the preeminent company on providing the “big picture.” ■■■



# Spatial Data Analytics Corp.

NOW PART OF DIGITALGLOBE INTELLIGENCE SOLUTIONS

## ►► PHASE III SUCCESS

Over \$50 million in contracts with the Department of Homeland Security, Army, Navy, TSA and commercial sales

A race against the clock is always an impediment when it comes to coordinating a massive manhunt. How can one cover the maximum amount of ground with such a short and crucial window of opportunity? It would help, say, if one could hone in on an exact location based on a proven anticipatory model. This was the thinking that led Spatial Data Analytics Corporation (SPADAC) to develop its geospatial predictive mapping tool, and the buzz from its success echoed throughout many branches of the government.

Originally funded by the DHS's SBIR program, this project envisioned a narrowed search base built upon strategic algorithms and a number of other factors to help mitigate risks. Since time is always of the essence, this tool helped to construct a map that aids law enforcement in finding exactly what they are looking for.

"It is part psychological, and part geographical all rolled into one," says Jim Stokes, Vice President of Insight Technology Solutions at DigitalGlobe. "This activity based intelligence, or behavior modeling, helps us to understand geospatial preferences that the target may knowingly or unknowingly be drawn to."

These preferences may point to physical terrain, or they could be man made elements; they could include proximity to highways or infrastructure; or it can be sociocultural indicators. Not only does the software tool project a predictive heat map – its empirical nature allows the data to speak for itself and manifest trends that the human eye can't always see. Once a map is produced, a subject matter expert comes in to make sense of it all. Although the data is never black and white and does require a human being to interpret the data, the company has achieved a consistent 95 percent area reduction success rate.

The SBIR program funded the development of this technology, and before long, it evolved into much more than one piece of



“This activity based intelligence, or behavior modeling, helps us to understand geospatial preferences that the target may knowingly or unknowingly be drawn to.”

Jim Stokes

Vice President of Insight Technology Solutions at DigitalGlobe

software. It became an entire solution, which could focus on threats and vulnerability. This translated to immense Phase III success, both within the Department of Homeland Security for the evaluation of domestic threats and other government agencies. DigitalGlobe has secured contracts with the Naval Surface Warfare Center, the Army in tandem with United States Southern Command, the Transportation Security Administration Federal Air Marshalls, and the National Geospatial-Intelligence Agency. Although applications vary throughout agencies, the common theme is solving real-world problems with the innovation.

Although targeted applications are generally in law enforcement, counter-terrorism, and critical infrastructure protection, there are other potential routes for transition within the commercial sector. Even something as simple as where to put a coffee shop, or more detailed, where to drill for oil, are all questions that can be better answered by a geospatial predictive mapping tool that communicates demographics and how to overcome logistical issues.

Today, DigitalGlobe owns and operates a constellation of the world's highest resolution satellites. It serves not only the United States and allied governments, but numerous commercial industries as well. Many of DigitalGlobe's traditional customers, such as those in the energy and location-based services industry, buy satellite imagery to serve their business needs. DigitalGlobe also focuses on extracting features from the imagery to build 3-D models of the cities. DigitalGlobe's analytics business, in which SPADAC was a key innovator, focuses on answering key questions that help decision makers decide where to deploy their assets. This sector is proving to have a high-growth potential based on the sheer number of customers and applications that can leverage geospatial information extracted from DigitalGlobe's imagery.

“As we graduated into becoming a large business, we've been able to maintain the spirit of SBIR,” says Stokes. “As you get bigger, it's hard to innovate, but if you're constructed to continue innovation, then it gives you a great excuse to do so, and we've done just that. Now here we are, almost a decade later, and we are still coming up with new ideas.” ■■■



# Synkera Technologies, Inc.

## ►► PHASE III SUCCESS

Over \$3 million in contracts with the Department of Homeland Security and commercial sales

## Known

for supplying large and high-powered sensors for industrial applications, Synkera, a small business based in Longmont, Colorado, had a stream of steady clients and commercial success. When the Department of Homeland Security set out to develop a miniature chemical sensor for smartphones, Synkera thought that maybe it could “shrink” the newest version of its sensor and meet the goals of this solicitation. What transpired was the development of an innovative and in-demand platform of sensors that would not only save lives, but would ultimately set new standards for environmental monitoring and personal protection.

The original vision of DHS involved inserting a chemical sensor into smartphones that would provide a crowd-sourced hazard detection tool in the event of a chemical accident or attack. An early commercial implementation of the product is a very small and lightweight personal detector for first responders. While firefighters had long been carrying gas detection instrumentation on their trucks, there is a significant need for affordable, personal detectors.

“First responders are often not as protected as they could be – chemical sensing is not always available or on the right person at right time,” explains Synkera CEO Debra J. Deininger. “The ability to supply firefighters with a personal detector that is so small and low-powered is extremely advantageous.”

Another exciting application leverages the ubiquity of smartphones to enable consumer chemical sensing, without specialized equipment. The hardware, combined with a smartphone app, would warn users about carbon monoxide levels, and other potentially harmful chemicals and/or gases in the air.

“The ability to supply firefighters with a personal detector that is so small and low-powered is extremely advantageous.”

Debra J. Deininger has the ability to sense the air around it, is Chief Executive Officer of Synkera a potential opportunity for us.”

The first step was winning a Phase I award from DHS, where Synkera, along with three other companies, set out to prove feasibility. Synkera did this successfully and subsequently won a Phase II. It was during this stage they partnered with Qualcomm and continued to develop the prototype. While Synkera built a module around the sensor with Bluetooth, Qualcomm developed the corresponding smartphone app, and together, the two companies participated in several demonstrations sponsored by DHS. The most notable was a demo with the Los Angeles Fire Department, where first aid training dummies were exposed to high levels of carbon monoxide. The smartphone was nearby and proved the concept for an early alarm, making the reality of a portable, ubiquitous sensor all the more feasible.

After receiving a Phase III contract from DHS to further develop the chemical sensor for first responders, Synkera has since aligned itself with an instrumentation company that will produce and market its sensor technology for the first responder application.

Synkera has witnessed the massive potential within the commercial market for this type of innovative technology. Despite

federal regulations regarding carbon monoxide detectors in homes and hotels, the fact is that thousands of people die every year from carbon monoxide poisoning. A sensor in a phone could not only sound an alarm if it detects a danger, but it also could get help for the user – the phone can be set to call somebody on a contact list, or dial first responders.

While carbon monoxide is just one example of a gas worth monitoring, Synkera’s vision was a multi-sensor system that also included breath alcohol levels, and air quality, such as Volatile Organic Compounds (VOCs), NOx and ozone. Part of the UltraKera™ product line, this multi-sensor system could provide a significant safety net for those with compromised lung functions or anybody who wished to monitor the environment around them.

The actual hardware amounts to less than one dollar per unit. Synkera is currently looking to align with partners in the mobile and wearable market industries, to see if there is an opportunity to embed the sensors in the phones or other useful devices.

“What we have developed is a sensor for environmental awareness. We can put that in a smartphone but it doesn’t have to stop there,” says Deininger. “Any product that would be made smarter or more useful, if it

Deininger is grateful for the tools provided to her through the Department of Homeland Security. “Commercialization is something that DHS tries to help with. I came from a technical background, but as the company grew and evolved, my role changed,” she says. “The training seminars are very useful for technical people who are in business positions. We learn about what to do and what to expect.”

The transition planning has certainly paid off. Synkera was named an International CES Innovations 2013 Design and Engineering Awards Honoree for its UltraKera™ SMT gas sensor under the embedded technologies category. Synkera’s UltraKera™ SMT gas sensors are an extension of the UltraKera™ family and have a total power consumption of less than 1 mW on average, allowing for use in applications that require minimal battery consumption or energy harvesting techniques. This sensor design has a life expectancy of greater than five years and is easily integrated into smartphones. This family of sensors will include carbon monoxide, VOCs, breath alcohol, and methane (CH<sub>4</sub>), with the planned addition of many other gases, including humidity, toxic chemicals such as chlorine and ammonia, environmental hazards (such as ozone and NOx) and others in the product roadmap. ■■



# Systems & Processes Engineering Corporation (SPEC)

## ►► PHASE III SUCCESS

Over \$4 million in commercial revenue and private investments

## Spanning

nearly 4,000 miles, the U.S.-Canadian border – referred to as the International Boundary – is the longest international border in the world. With long stretches of mountainous terrain and heavily forested areas, new technologies are heavily pursued to secure the perimeter and ensure individuals only cross in designated border controls. When the Department of Homeland Security issued a solicitation in 2008 to further secure the border with Laser Detection and Ranging (LADAR) technology that could detect a moving target, the Austin-based Systems & Processes Engineering Corp. quickly responded to the request. Founded in 1986, SPEC has a long history of developing creative technologies and integrated product solutions for both military and corporate customers.

After securing a Phase I SBIR award with DHS and proving the feasibility of the concept, SPEC embarked on a Phase II project to develop a covert, unattended sensor for real-time monitoring of the passage of people and vehicles in critical, remote border areas. This Advanced Unattended Ground Sensor (AUGS) forms a robust network of sensors, using a variable information bridge, to relay actionable information to the end user. Advanced image processing techniques are used to discriminate targets of interest from naturally occurring objects and events. AUGS employs SPEC's advanced, miniature LADAR technology in a single-ended tripwire sensor and an imaging camera, as well as adaptable, networked communications and anti-tamper mechanisms. Although the original goal was to put these units along the border by camouflaging them into tree trunks and across coves on the Great Lakes, SPEC ended up finding success in the commercial marketplace first.

"We had been working on some 3-D imaging Light Detection and Ranging (LIDAR) for NASA, and when this program came along, that technology evolved and we started to add image fusion with the LADARs to get that change detection," says Brad Sallee, Vice President of Systems Technology at SPEC. "We are essentially geolocating the object, imaging it and then grappling with it and dissecting it before putting it back together again as the object that changed and its size."

SPEC found new potential applications for the innovative sensors developed under the program. One of these applications is in explosive detection, where they can capture a 3-D image out of a LADAR and then look at the Raman Spectroscopy and detect the chemical composition. Since explosives are similar to perfumes, leaving a trail where they go, this technology can pick up a single molecule layer of explosives. This is essential in detecting chemicals and residues to determine the location of homemade bombs, or in interrogating packages for explosive residue.

This same kind of technology can also be applied to forest management. By looking at the volumes of trees and counting the animals underneath, customers in the environmental sector can keep close tabs on wildlife even under heavy foliage. SPEC is currently assisting an oil consortium in

Canada, to ensure its impact on the environment is minimal. "Commercially, there is a lot of potential in the farming industry," says Sallee. "By having this LADAR and RGB camera together, you can view down through the crops and assess the vegetation levels and look at the health of the plants. A little Unmanned Aerial Vehicle (UAV) scans the entire area – you just plug in the GPS coordinates of the field and press go. The UAV then flies the field and pumps out the data."

SPEC recognizes the impact of the SBIR program and hopes that they will continue to provide solutions within the government sector.

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Brad Sallee

Vice President of Systems Technology at SPEC

"The best thing about the SBIR program was the opportunity we had to combine all of these technologies and the software that resulted from the program," says Sallee. "We were able to really evolve the technology and that has opened up a lot of doors for us in the commercial sector."

SPEC has long utilized the SBIR program across many agencies. From developing terrain mapping LADARs for the Army, to individual solidier LADARs for Defense Advanced Research Projects Agency (DARPA), to the miniature ground mapping LADARs for NASA, the company has made a name for itself within the SBIR community for delivering integrated product solutions. With just thirty employees and the market for advanced imaging techniques not nearly reaching its peak yet, SPEC will certainly be a company to watch during its transition phase. ■■■



# dbS Productions

Each year, approximately 125,000 search and rescue missions are conducted for lost Alzheimer's patients – a staggering statistic that sheds light on one of the most pressing problems our elderly generation faces today. Individuals with dementia might not know why or where they are wandering, making the first few minutes and hours of a rescue operation critical for its success. This epidemic led the founder of Virginia-based dbS Productions to compile a vast database of statistics and reports on missing persons, and the outcome was a tool that could help search and rescue teams to locate any lost person by deciphering where exactly they should be looking.

“I use past behavior to predict future behavior,” says dbS Productions Founder and CEO Robert J. Koester. “If there is a missing four-year old child who ran off into the woods, what does history tell us about where that child ends up? Which way do they run? How do they behave and what are the factors that influence that?”

Koester, a neuroscientist, who also authored a book titled: *Lost Person Behavior: A Search and Rescue Guide on Where to Look – for Land, Air, and Water*, has been compiling these kinds of statistics since founding his company in 1989. It wasn't until 2013 that he responded to a solicitation from the DHS through the SBIR program. A Phase I award was granted, followed by a



Phase II. The aim of the project was to develop innovative and life-saving software, which would show first responders a heat map with the probability of area for the missing person. Using that information, an initial response-tasking algorithm map shows exactly where search teams should be tasked. This essentially allows the power of formal search theory to be placed into the hands of initial responders with little to no formal training.

“The DHS project seemed to be the perfect match for our technology platform, and specifically in making spatial models/predictions of where lost persons are most likely to be found,” adds Koester. “If you are lost in the Grand Canyon, you behave much differently than if you are lost in an urban setting, or in say the Great Smoky Mountains. This model helps the search and rescue teams draw more accurate rings.”

Today, this information can be found on an app appropriately titled “Lost Person Behavior” for a \$9.99 purchase price. The app is available through Apple as well as Android platforms. dbS Productions has sold over 1,750 downloads to date. As a supplement, dbS also provides behavioral and statistical profiles for a variety of conditions, including despondent or mentally ill persons, or even abductions.

“R&D, by definition, means you don’t know what the answer/outcome will be. The SBIR programs gives you the ability to take an innovative idea and then conduct real research and development,” says Koester. “As a small business, I could not really allocate 90 percent of my time to research and development. SBIR allows me to come up with innovative ideas that have a certain amount of risk, but you get feedback and support, to bring those innovations to market.”

Over forty subject types are included on the Lost Person Behavior app. These include persons with mental illness, dementia, lost children, hikers, mountain bikers, persons with Autism, water incidents, and more. For each of the subject categories, there are four main pieces of information along with a behavioral profile, which communicates what this particular group is likely to do. For example, if you are looking for someone with dementia, a background is included on how they perceive their environment. All of this is summarized in a short, tactical briefing. Investigative questions are also included for the search teams. Finally, an initial suggested task list is generated to help the parties hone in on where to conduct their search.

The app provides statistics used to make the predictive spatial models. One example of this technology is a dispersion model, which deals with direction of travel. There is also an elevation model, which can decipher whether one is most likely to travel uphill or downhill, if you are dealing with mountainous terrain. Although dbS is currently finishing up the Phase II portion of the SBIR project with DHS, over 250 instructors around the world are using the app to teach courses on lost person behavior. In addition, first responders have also purchased and are using the app. Applicability extends to FEMA as well as the Natural Park Service, each of which plays a major role in search and rescue operations.

The app itself is just a small part of what dbS Productions is hoping to accomplish. The company currently has the largest database in the world of ground search and rescue incidents (almost 150,000 incidents), and is continually adding to its records as part of the SBIR. These stats have been collected from all over the world, and dbS is continually finding new ways to present this information. Another product in the suite is a collection and analysis tool that allows users to compile data in a standardized format to create their own map-based reports. Another product aims to take a variety of spatial models and transform them into something visual – a formal search and rescue theory that will communicate where to send teams. If there is a find, the data is automatically updated and used for future incidents.

Looking ahead, dbS hopes to continue its work in the field in which it has become a worldwide leader. Koester has taken his company’s knowledge and has a goal to provide critical information in a variety of formats. He also teaches “The Lost Person Behavior Course,” which has been taught to search and rescue professionals around the world and is currently used by several state agencies. ■■■

# Engineering Science Analysis Corporation (ESA)



## Rogue

drivers, whether fleeing from law enforcement or out for a joyride, are an issue all too common on the roadways. The question of how to stop a vehicle must be answered by taking into account the safety of both the officers laying the traps and the fellow civilians sharing the roads.

While spikes have proven effective, they present danger to law enforcement as many officers have been killed or injured while deploying these devices. In addition, any noticeable trap could send the driver on a crash course of avoidance. A system was highly sought after that could solve this issue without the risk of collateral damage and/or officer injury.

With funding from the Department of Homeland Security Science and Technology Directorate (S&T), Engineering Science Analysis Corporation (ESA) embarked on a solution. The system, called the Safe Quick Undercarriage Immobilization Device (SQUID) had mechanisms unlike any other device – it would remotely deploy spiked straps and fire tendrils to ensnarl the axles of the vehicle, ensuring a quick and effective stop. Inspired by a superhero, SQUID was designed to capture its “prey” with its sticky tendrils. Like Spiderman’s webbing, these tendrils were designed to stretch and absorb the kinetic energy of their fleeing target.

“We had never worked on anything like this before,” says Martin Martinez, President of ESA. “We knew we had the right background in design, computer engineering and product development, so we applied these to the SBIR, and we ended up taking this all the way to Phase III. While we were doing this, we also postulated the possibility of spiraling some of the technologies in SQUID to create other products.”



It was no doubt Martinez's vision, combined with his penchant for truly thinking outside of the box that contributed to the success of his innovation. A successful demonstration was the first step in proving the utility of such a system, and when the technology successfully stopped a pick-up truck in its tracks, Martinez knew he was on a roll. However, SQUID needed some strategic design changes in order to effectively maximize its potential to stop a vehicle traveling at high speeds. Martinez made the choice to license this innovative technology to a strategic partner who could help with the advancement of SQUID and its spiral technologies. This resulted in the development of spiral products and the commercialization of a patented, self-deploying tire deflation device, in what would soon become a self-deploying/retracting spike strip that is increasingly being used by law enforcement agencies nationwide.

One of the most effective portable vehicle pursuit termination systems on the market, the technology is highly effective in all chase scenarios, various terrains, and reduces the disruption of traffic flow. After the successful engagement of the target vehicle, spike strips are retracted back into the housing unit allowing traffic to flow without disruption.

The technology made headlines this year when Michigan State Police became equipped with the system. Officers may now remotely deploy the system across a roadway and retract the device just as efficiently and quickly. The product will also be featured on the Discovery Channel's *Daily Planet* early next year.

So far, the business model of strictly licensing without manufacturing has served ESA quite well.

These spiral technologies have led to other work across government agencies. For instance, a Phase II project with Naval Sea Systems Command (NAVSEA) spawned the development of SEA SQUID – which applies the same non-lethal stopping techniques to hostile swimmers, divers, boats and the semi-submersibles used by smugglers. Outside of government, ESA continues to partner with big players in industry such as Raytheon, Lockheed Martin, and Boeing, among others. ESA is currently working to leverage its spiral technologies to stop an aerial drone in flight and safely bring it to the ground for recovery.

ESA occupies 3,800 square feet of engineering, product design, analysis, manufacturing and testing facilities in Tempe, Arizona. It also houses offices in Prescott, Arizona. Founded in 1991, ESA has made a name for itself in providing product development, engineering design, simulation and analysis consulting services, as well as advanced analytical software tools for customer applications. The company's process driven services and software tools aim to provide a reduction in

“We knew we had the right background in design, computer engineering and product development, so we applied these to the SBIR, and we ended up taking this all the way to Phase III.”

Martin Martinez

President of ESA

product development time and subsequent costs. “The SBIR has great value – it allows us to develop our crazy ideas, which would not otherwise exist,” says Martinez. “It’s kind of neat to have these agencies as your investor; they support the development and in turn, you want to deliver for them. In our minds, an SBIR must get to Phase III – that is always the goal!” ■■■



FlexEl

First responders, especially firefighters, need constant access to battery power for the success of their missions. However, bulky batteries render it nearly impossible to maneuver through the various obstacles present in burning buildings. FlexEl, a Maryland-based custom battery development company, had the notion that a thin, wearable battery cloth could provide the needed power, without weighing the user down. It was just a matter of bringing that idea to life.

“I was judging a business competition at the University of Maryland, and one of the participants presented this concept of a thin, flexible battery technology,” recalls Bob Proctor, CEO of FlexEl. “I thought it looked interesting, and I ended up investing in the company and joined as CEO. But I knew we needed to get in front of a bigger audience.”

Right around that time, the DHS issued a SBIR solicitation for a wearable technology for first responders. It was a hand in glove type fit for the small business, and FlexEI set out to deliver. In the Phase I project, which they were awarded, the company demonstrated it could power something useful with a wearable, flexible battery. The technology was a location device that firefighters would wear on their belts.

“I went and completed a firefighter training, and it was very eye opening,” says Proctor. “You’re wearing a heavy fire suit, you’re crawling in the dark within small closed spaces, and stuff gets caught. You start to realize how difficult it really is and the benefits a technology like this can provide.”

FlexEI went on to win a subsequent Phase II award from DHS to further the technology. One of the main problems one must solve when creating a wearable battery is choosing a material chemistry that can handle abuse without causing harm to the wearer. The resulting technology became one of FlexEI's core products and competencies – the FlexEI Battery Cloth.

FlexEI's Battery Cloth meets demanding capacity and discharge rate requirements, making it suitable for use in a broad array of demanding applications. Like many of FlexEI's batteries, the Battery Cloth can be printed using high volume, scalable processes to achieve low cost and economies of scale in roll-to-roll processes. A standard 10 cm x 10 cm Battery Cloth is the thin, flexible equivalent of one AA battery, providing over 2 Amp hours of capacity. One square meter Battery Cloth is the equivalent of 100 AA batteries, providing over 200 Ah of capacity.

During the culmination of the Phase II SBIR project, FlexEI started to seek commercial partner support. The company ended up applying this same SBIR-funded technology into the consumer product space and teamed with several Fortune 500 companies to build innovative batteries for their product suites. One application is currently pending market research and the other will be available in the commercial marketplace within the next few years.

Today, FlexEI provides a range of battery capabilities. While FlexEI started with the aim of commercializing its original proprietary thin film technology, it has since moved into adjacent battery technologies and built deep expertise in battery innovation and engineering. The company, which considers itself to be ‘chemistry and packaging agnostic,’ takes proven chemistries and engineers them in innovative ways to meet their customers’ unique battery requirements. Owing to the expertise that FlexEI has built up in active material synthesis, various packaging technologies and scale

up of battery processes, the company has built innovative battery solutions for their customers including microbatteries (about the size of three human hairs) for medical applications, seawater batteries for military and commercial applications, and thin-film flexible batteries for wearable applications. All batteries are tied to FlexEI power sources, which can be operated at constant current draw or in pulse mode; and they can be used in conjunction with a voltage boost multiplier. FlexEI is also developing advanced printing and assembly technologies to support a growing number of very demanding and sensitive flexible device applications that are enabled by its core battery technology.

FlexEI's batteries are ideal for wearable or transdermal applications that require thin, flexible, nontoxic, high capacity, and typically low discharge rate power sources. The batteries are flexible, safe in operation, and are made exclusively of nontoxic materials. They are also environmentally benign, and do not need special regulations for shipping and disposal. The company's battery engineering expertise enables such applications since the highly flexible battery is also scalable in size, capacity, and discharge rate, and can conform to any form factor depending on its use.

The company credits the DHS SBIR program with helping them to take that leap into the commercial marketplace.

“We certainly would not be in existence without the DHS SBIR program,” says Proctor. “From a technical readiness perspective, when a company is performing R&D, it is too early to garner engineering dollars, and from a commercialization perspective, we were too immature in our battery engineering. But now having gone through that effort, we successfully matured the technology as well as the engineering processes, methodology and approach, and that helps us attract the talent and partnerships that are critical in helping us get to the next level.”

To accommodate growth, FlexEI has just moved into its new home – an 11,000 sq. ft. facility and lab space in the heart of Maryland, where both R&D and manufacturing will be performed. The company vision for the next five years is to continue developing, scaling up, and manufacturing high specific capacity, high-specific energy, and high-energy density environmentally benign thin film batteries. However, FlexEI is also embarking on custom battery development for large OEMs that have national or global distribution. The anticipated output for the envisioned customer is estimated to be well over 100 million units per year. ■■



# Robotic Research

In the summer of 2015, a bank robbery and hostage situation in Stockton, CA, shed light on some improvements needed in law enforcement robots. Unable to determine whether or not the criminals actually had hostages in their possession, police sent in a robot to provide situational awareness. The device, which cost more than \$100,000 to manufacture, was shot and destroyed immediately. More robots were sent in, and by the end of the day, close to \$1 million in robots were destroyed.

The purpose of using robots in law enforcement missions is to minimize the risk to police in otherwise dangerous situations. While the robots in the hostage situation accomplished that, it exemplified a major problem associated with this technology – cost. It also did not provide the level of situational awareness that was intended. Most robots are extremely expensive to manufacture. Although robots for the Department of Defense have and will continue to provide a host of benefits, robotics designed for DHS applications are much more varied.



First responders can never be sure of what they will need, nor when they will need it. It is because of this fact that an entire spectrum of specialized robots is desired, and users must be able to manufacture them in a quick and cost-effective way.

“With the recent flooding in South Carolina, you had first responders chasing caskets down a flooded road – there is no way you can prepare for those sort of events; there is no training manual,” says Robotic Research President Alberto Lacaze. “So we approached this issue by saying – a lot of the systems have similar components inside, why not create a marketplace where these parts can not only be designed, but 3-D printed as well. That way, the same internal components can produce 50-60 different models. You can manufacture out of thin air.”

The target price is just \$2,500 per robot, which essentially marks the new era of the disposable robot. Now, if a robot is destroyed or shot down, another can take its place with ease.

Although Robotic Research was founded in 2002 when the military expressed a renewed interest in unmanned vehicles, it wasn't until 2012 that the company got acquainted with the DHS SBIR program. A solicitation was released for a Swarm Robotic Sensing Platform for Search and Rescue. The goal of the project was to develop and demonstrate

an autonomous robot with situational awareness. This would be achieved by leveraging the autonomous capabilities and low-cost platforms that were already a part of the company's core competencies. This start with the DHS program put the company in front of the right DHS personnel, and allowed them to work on filling a niche need within the government. In 2014, at a White House ceremony, Robotics Research accepted the Tibbetts Award from the U.S. Small Business Administration (SBA) for excellence in SBIR.

“The value of the SBIR program is huge,” says Lacaze. “The government is able to create this very specific set of topics based on exactly what they need, and the topics are small enough where

a small business can tackle them and be successful.”

Robotic Research is in the process of creating a marketplace where robot parts can be designed from anywhere, sent to the end user, and 3-D printed onsite. The company will model this initiative much like it did in 2014, when it held a competition designed to create and print in-demand parts for drones. At Virginia Tech's *3D Printed Aircraft and Ground Vehicle Additive Manufacturing Grand Challenge*, which Robotic Research co-hosted with the Air Force, students submitted designs that played into organizations' plans to drop shipping containers full of 3-D printers and basic printing and assembly supplies to isolated war zones, humanitarian and disaster areas. Engineers would then print the drones, download and print replacement parts, and create mission or task specific components. This would greatly reduce the amount of resources rescue workers would need in disaster zones or dangerous areas that may be cut off from traditional aid, support and reinforcements.

Vehicles were constructed using as many 3D printed parts as possible, and supplemented only with off-the-shelf electronics kits, receivers, batteries and small motors. Harsh, real-world conditions were simulated.

The marketplace for robot parts will run in a similar fashion to how a smart phone app store works. Let's say a student designs an in-demand part – they would then add that design to the library, and it would be available for download. The ownership of the design would belong to that student, and he would assign a price for it. Once the user pays, the student gets paid, and both Robotic Research and the corresponding agency would get a royalty.

Robotic Research is continuing its work with DHS by developing a sensor-smart affordable autonomous robotic platform (SAARP) with the goal to perform searching, mapping, and navigation tasks with minimal operator interaction. These inexpensive robotic platforms will have the ability to be quickly deployed by first responders to provide a wide range of capabilities for a variety of missions. These include search and rescue; carrying sensors to determine environmental conditions such as chemical, biological, radiological, oxygen levels, explosive detection, and heat levels; 2-D and 3-D mapping; and overall situational awareness for firefighters, law enforcement, and command center coordinators. Because there may be disruptions in communications, especially when working in and around collapsed structures, inside buildings, or tunnels, and also a limited number of personnel to operate robotic assets, the system will have autonomous capabilities, be communications resilient and work in both GPS and GPS-denied areas. ■■

