



Emergency Response Tools

Missile Defense Technology: Applied



Number of firefighters in the United States:
More than 1 million. Approximately 750,000 of those firefighters are volunteers.

Number of full-time employees at local police departments around the nation:
Approximately 556,000, including about 436,000 sworn personnel.

Number of full-time employees at sheriffs' offices:
Approximately 291,000, including about 186,000 sworn personnel.

Number of nationally registered emergency medical technicians (EMTs):
More than 155,000.

Total personnel: More than 2 million.

Source: First Responder Initiative, The White House

The MDA Connection

The mission of the Missile Defense Agency is to develop, test, and prepare for deployment of a missile defense system.

Building the tools required to accomplish this mission presents a host of complex technical challenges. To help address those challenges, MDA funds businesses, as well as universities and national laboratories, to develop technologies that can play a role in missile defense. The innovations that emerge from these partnerships with MDA range from computer systems to sensors to advanced materials.

Each year the agency funds scores of research and development projects in an effort to help promising missile defense technologies thrive. But MDA alone cannot fund the entire development life cycle for each technology. So MDA-funded researchers also must seek commercial opportunities that will allow their innovations to mature.

By finding commercial partners and new market opportunities, researchers can pull in additional capital and resources to improve their technologies, meaning that promising technologies are not limited to MDA use only; the innovations can find application beyond missile defense. The benefits of a new material, for example, can be enjoyed by commercial markets—not just limited to military users.

Ultimately, MDA can benefit from commercial enhancements to the technologies. Commercial customers of MDA-funded innovations such as software or imaging technology, for example, might suggest improvements or features that MDA one day might find helpful also.

MDA's investment in new technology already is starting to pay off in many commercial sectors. This special report on Emergency Response Technologies examines only one area in which MDA-funded technology is being applied to address real-world problems.



Table of Contents



Introduction

Section One

Seeking, Sensing, Monitoring, Informing

Detect chem-bio agents more reliably	8
Radiation Monitoring Devices, Inc.	
See through smoke to find hot spots	10
Jet Propulsion Laboratory	
Share information more easily in a group	12
InfoValley Corporation	
Detect gas leaks rapidly	14
Physical Sciences, Inc.	
Position equipment with greater precision	16
Sagebrush Technology, Inc.	
Improve image displays for search and rescue	18
nPoint, Inc.	
Detect fires with artificial intelligence	20
LNK Corporation	



Section Two
Protecting, Moving, Saving, Supporting

Lift people to safety with greater ease24
 Quoin International, Inc.

Filter airborne threats with portable masks26
 IntraMicron, Inc.

Stay cooler near fires28
 Hayes & Associates

Generate emergency power in the field30
 Aura Systems, Inc.

Purify water to meet emergency needs.....32
 CDT Systems, Inc.

Power equipment with smaller vehicles34
 Raven Technology, LLC

"This publication, which is part of the cooperative agreement between the National Technology Transfer Center and the Missile Defense Agency, is but one example of the synergy between programs with similar missions and goals. Efforts such as this joint, cooperative document will benefit the missions of MDA, NTTC, other Federal organizations, and American businesses. The final beneficiary will be the U.S. people, through improved, efficient access to advanced technology."

Introduction



Defining problems

Emergencies happen every day: Storms surge. Plains flood. Cars crash. The earth quakes. Chemicals spill. Fires blaze.

For first responders, emergency managers, and other personnel, emergencies and disasters offer a host of uncertainties. . . .

“What new threats or dangers will surface in the wake of an emergency situation? For example, coastal flooding from a strong storm or hurricane might leave people stranded on rooftops or trapped in vehicles in rain-swollen ditches. But floods also can paralyze infrastructure such as water-treatment plants, or they can wash chemicals into the environment—creating a new set of emergencies. So what surprises await me?”

“Will I have the funding and equipment I need to respond effectively to any emergency that comes my way?”

“How much information will I need to respond to and manage an emergency?”

“At an emergency scene, will equipment adequately protect people from the hazards they encounter?”

“And time is critical. So will I be able to respond faster than an emergency situation can unfold? How great an enemy will time be?”



But for those who must manage and respond to emergencies, there are certainties: needs.

To do their jobs—to prevent physical harm, loss of life, loss of property, and disruption of services—emergency managers and first responders need tools to help them work swifter, more safely, and with greater ease and efficiency. They constantly seek improved tools for monitoring and assessing emergencies, for protecting emergency workers and victims, and for providing operational support.

Searching for Solutions

New technology promises to fill these needs, and many technologies originally funded for missile defense also hold promise in emergency response. This report highlights a few of those technologies.

Since Sept. 11, 2001, the focus on emergency response has grown. The threat of terrorism has emergency managers and civic leaders considering technology in a new light. They might have the resources for addressing fires, floods, and natural disasters—the emergencies that they expect—but are they prepared for a deliberate, calculated man-made emergency that could sap all their resources in a short period of time?

Decision makers are looking for new solutions—better solutions. They want to be prepared for anything at any time, and they need intelligent solutions to old and new problems. They are looking to do more with less. They want to remove guesswork and unnecessary work from the emergency response equation. As they are forced to be more creative with their resources to address these dynamic needs, they are looking for answers in new places. And technology funded through missile defense initiatives is one area in which members of the emergency community can find them.



“All levels of government must be prepared to respond quickly and effectively to any emergency. . . . America’s first responders need to be well-equipped and they need to be well-trained.”

—President George W. Bush, speaking at the FBI Academy, September 2003

Section One

Seeking, Sensing, Monitoring, Informing

Responding to emergencies and averting disasters relies on acquiring crucial data, analyzing it, and delivering information instantly to the people who need it. This information comes in many forms. It is the identification of a chemical agent, a detailed image on a screen, an alert, or a warning. It is a status report or an assessment. Information is the red flag that sends personnel into action. It becomes the central resource that workers seek and use when managing incidents.

New technologies are helping emergency responders get the information they need to save lives, to protect property, and to mitigate disasters.

These tools can help emergency personnel . . .

- Detect chem-bio agents more reliably..... 8
- See through smoke to find hot spots.....10
- Share information more easily in a group12
- Detect gas leaks rapidly14
- Position equipment with greater precision16
- Improve image displays for search and rescue18
- Detect fires with artificial intelligence20

Detect chem-bio agents more reliably



Chemical and biological agents released during an industrial accident or other disaster can spread undetected. New, more affordable, and more reliable sensors could provide emergency workers with the detection tools they need.

Relevant Scenarios

- Chemical spills
- Industrial accidents
- Pipeline leaks
- Transportation accidents
- Infectious disease outbreaks

In 2001, anthrax-laced letters sent to Senate offices set off a mild panic throughout Capitol Hill and showed that a biological or chemical attack can take many forms and occur almost anywhere. The Senate incident, which was followed by a series of harmless hoaxes and false alarms, showed a need for putting monitoring technology into the hands of more people. But sensors for detecting biological or chemical agents can be bulky, expensive, and unreliable. Those factors limit the availability of the tools among users who might need them. For widespread monitoring, future systems must be smaller, more reliable, and conducive to mass-production. Improved components at the heart of such systems are essential.

The Tool

Radiation Monitoring Devices, Inc. (RMD; Watertown, MA), has developed planar avalanche photodiodes (APDs) and photodiode arrays for use in spectroscopic chemical and biological sensors. Solid-state avalanche photodiodes are smaller, more rugged, and have a higher quantum efficiency than the photomultiplier tubes (PMTs) used in most low-light detection applications. But the high cost of manufacturing APDs has kept them from being competitive.

RMD, however, has designed an avalanche photodiode that, unlike previous designs, can be produced using standard semiconductor manufacturing techniques. Using these processes should

reduce cost and makes possible new device shapes and more affordable arrays. Arrays of RMD planar APDs, with each pixel designed to be sensitive to a particular chemical or biological material, will be useful for detecting multiple compounds simultaneously.

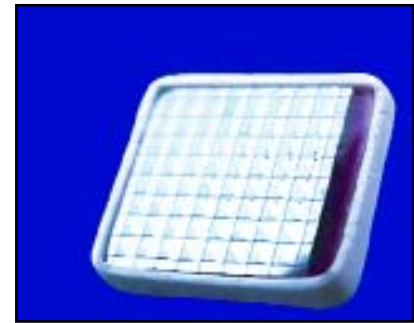
Its Status

The BMDO SBIR program funded RMD to develop methods to produce low-cost APDs and APD arrays for lidar, optical communications, and radiation monitoring. The company is currently selling its APDs for use in sensors and is working with several universities to develop sensor array prototypes.

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Photodiodes for sensors can be made using standard manufacturing processes, resulting in significant yield increase, cost reduction, monolithic, and new device shapes.



■ *Avalanche photodiode.*



See through smoke to find hot spots



Smoke can blind emergency workers during a fire. Better vision technology could help speed the task of firefighting.

Relevant Scenarios

- Wildfires
- Structural fires
- Search and rescue

Fighting a fire is not only demanding on a firefighter's limbs and back. It's also demanding on the firefighter's eyes. Clouds of smoke make finding the lingering hotspots in a fire challenging—adding to the time, energy, and resources spent fighting the fire and leaving open the potential for later flare-ups. To suppress wildland fires in 2002, Federal agencies alone spent an estimated \$1.6 billion. Piercing through the smoke with new imaging technology could help workers tackle blazes more efficiently.

The Tool

NASA's Jet Propulsion Laboratory (JPL; Pasadena, CA) has improved on infrared (IR) camera technology by using long-wavelength quantum well infrared photodetectors (QWIPs). The QWIP camera has greater sensitivity, resolution,

and stability than competing IR cameras and has many applications, such as detecting lingering fire hot spots through smoke. Night vision for search and rescue is another potential emergency response application.

The camera's large-area focal plane arrays (FPAs) cover longer wavelengths than is possible with other photon detectors. The heart of the FPAs are the IR photodetectors built on gallium-arsenide-based quantum wells—tiny manmade structures that are extremely sensitive to temperatures as small as 1/40 of a degree. Because quantum wells are atom-sized, they can also be packed together in extraordinary densities, allowing them to capture IR radiation with good efficiency.

Its Status

Researchers already used the QWIP camera to observe fires, allowing users of the camera to see through smoke to pinpoint hot spots during the October 1996 fires in Malibu, CA. QWIP Technologies, Inc., currently holds a license to make and sell the IR photodetector sensors as part of a focal plane array, and the company has been rolling the technology into its product line, which includes sensors for surveillance and monitoring. Meanwhile, the JPL QWIP team has been collaborating with Indigo Systems, Inc., to develop improvements. MDA predecessor BMDO originally funded JPL to develop imaging cameras for ground-based and space-based infrared surveillance at long wavelengths.

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The JPL-developed QWIP camera offers high sensitivity, resolution, and stability for seeing through smoke.



■ QWIP camera.



Share information more easily in a group



Having fresh electronic information during a crisis can help an emergency manager decide how many resources are needed to tackle a problem, as well as which resources are available. But often, others responding to the crisis need information access, too. Sharing and collaboration become critical.

Relevant Scenarios

- Central disaster coordination
- Incident management
- Command centers

During Operation Iraqi Freedom in 2003, mission planners at U.S. Central Command in Doha, Qatar, and commanders in the field were able to see a common computer-aided view of the situation on the ground. The ability to see and share digital images meant that military leaders could make decisions quickly, based on the same information that their colleagues were using. But military managers are not the only ones who need such information harmony and speed. For large or complex emergencies such as earthquakes, fires and hurricanes, the same needs emerge. Behind-the-scenes managers—whether in the field or at central locations—must coordinate the people and resources necessary to deal with a crisis. Such coordination means collaborating and sharing information in a fast-paced environment.

The Tool

InfoValley Corporation (King of Prussia, PA) has developed Team Computer Interface (TCI) technology, giving a team of workers simultaneous access to a large display wall that serves as a common computer screen. TCI consists of proprietary software, hardware, and networking technology. When coupled with the display wall, the interface also allows workers to access their individual computers and applications.

The wall, which the company calls the Interactive InfoWall™, allows several users to access it at the same time. For example, an entire team of workers might display information from their individual computers such as spreadsheets, video files, and electronic maps, side-by-side on the InfoWall. The users do not even have to be in the same room. One or more of them could be

based at a remote location and still contribute and access InfoWall information—as long as that remote user is connected to the same network as other users of the wall.

A typical Interactive InfoWall includes a rear-projection screen measuring roughly 3 feet by 12 feet, including a composite of three projected displays. This setup includes a special computer system comprising a display controller, networking equipment, software, wireless microphones, and laser pointers. By creating such a large, high-resolution, information display “canvas,” users can avoid huddling around the single screen of one user’s desktop when collaborating on a project. And users can see multiple information displays or computer applications running side by side, instead of toggling among applications on small computer screens.

Users of the InfoWall can navigate applications and access data using coordinated voice commands and a laser pointer instead of a computer mouse. Such untethered tools allow command-center managers to share information with a group without being confined to a desktop control panel. The system also has the ability to capture the laser-written text that users write on the board.

Its Status

MDA, through a Phase I SBIR award in 2002, originally funded InfoValley’s TCI technology for possible use in Battle Management and Command and Control (BMC²). MDA also awarded the company a Phase II SBIR contract in December 2003. The collaborative interface grew out of InfoValley technology funded by the Air Force Research Laboratory. InfoValley also sees the technology being used for managing military projects. The interface and the display wall could apply to homeland-security applications, command centers, and cyber-warrior training, as well as computer network-management centers or broadcasting control rooms.

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The Interactive InfoWall allows a command-center manager to share information with a group without being confined to a desktop control panel.



■ *Interactive InfoWall.*

Detect gas leaks rapidly



When invisible chemical threats lurk in the air, getting the big-picture view can be difficult. Monitoring an existing or potential source of chemical danger is key to responding to, as well as preventing, disasters.

Relevant Scenarios

- Chemical spills
- Pipeline leaks
- Industrial accidents

Gas leaks are explosions waiting to happen. The 1994 Northridge earthquake in California, for example, resulted in approximately 17,000 natural-gas leaks and dozens of related fires. Similarly, industrial accidents or chemical spills can spell instant disaster, since any number of chemical agents wafted through the air can cause illness or even death. Keeping tabs on such leaks—whether the result of major disasters or common construction accidents—presents a challenge for utilities overseers. Detecting chemical agents quickly is a first step in getting people out of harm's way and stanching the flow of dangerous compounds through the air.

The Tool

Physical Sciences, Inc. (PSI), has developed an adaptive infrared (IR) imaging spectroradiometer (AIRIS), for the remote detection and rapid identification of airborne chemicals. The AIRIS

tunable filter allows for selective sampling at wavelengths that are known to be associated with a suspected substance or signature, greatly reducing the amount of data collected and time needed to analyze it. AIRIS provides the accuracy of other IR sensors, but those competing technologies detect light in up to 128 different wavelengths simultaneously and therefore require significantly more computer power and time to analyze the data. AIRIS, however, selectively samples only wavelengths specific to the detection task. It is most sensitive in atmospheric transmission windows that range from 2 to 3 microns, from 3 to 5 microns, and from 8 to 12 microns. (The region of 8 to 12 microns is where most organic vapors have their strongest and most distinctive identifying signatures.) The key component in AIRIS is a patented electronic tunable Fabrey-Perot etalon filter, which can be programmed to allow individual wavelengths of IR light

to pass through it. The filter consists of two mirrors that are approximately 2 inches in diameter and are 4 to 10 microns apart. The distance between the mirrors is adjusted to allow different wavelengths to pass. Coupled with a focal plane array and IR camera, AIRIS can provide computer-generated images of a gas cloud.

Its Status

PSI has tested a ground-based device that could be deployed ahead of U.S. Army troops to reveal VX, sarin, and other dangerous gases. In another project, the company has been developing a helicopter-borne sensor to see natural-gas leaks in pipelines and at storage sites. BMDO, MDA's predecessor, originally funded the technology for its potential use in detecting and assessing threats.

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PSI's technology selectively samples the air at wavelengths known to be associated with a suspected substance or signature.



■ A PSI spectroradiometer for detecting natural gas.

Position equipment with greater precision



When looking for a needle in a haystack, a steady eye is important. Shaky search-and-rescue cameras can generate hard-to-view images.

Relevant Scenarios

- Search and rescue
- Transportation/
maritime accidents
- Surveillance

Search-and-rescue teams cover hundreds of square miles when looking for missing persons. And such operations are everyday occurrences. For example, in just one year (fiscal year 1999), the U.S. Coast Guard district that monitors Alaskan waters saved 255 lives through search-and-rescue efforts. Across the country, rescue agencies—be they Federal, state, or local agencies—are aided in their work by sensors, cameras, or imagers mounted on patrol boats, helicopters, or other aircraft. As such technology is put into action, the gimbals (or positioner) controlling that equipment get a serious workout. Nevertheless, the positioning system must move smoothly and with precision, to ensure the greatest accuracy in collecting images. Shaky cameras can

generate shaky, hard-to-view images. Moreover, positioners for cameras and sensors must be durable, lightweight, and low-maintenance—so emergency crews can devote more time and resources to the job at hand.

The Tool

Sagebrush Technology, Inc. (Albuquerque, NM), has developed a rotary drive system called the Roto-Lok® rotary drive to precisely position instruments. To deliver the high precision without backlash and vibration, cables (in lieu of gears or chains) are wrapped around a cylinder (a drum) and a capstan in a figure-eight pattern and attached using tensioning springs. The springs maintain a constant tension on the cables, even as the system wears over time. As the capstan

turns, friction between the cables and the cylinder provides smooth rotation of the drum and instruments mounted to it. The tensioned cables provide high torsional stiffness without backlash—a design problem in precision gears that reduces pointing accuracy and transmission efficiency. Also, because the cables do not slide on the drum or capstan, there is virtually no wear, which decreases maintenance cost and extends the life of the system, relative to competing technology. In addition, by using multiple cables, any imperfections on a single cable or on the drum are averaged over multiple cables, providing an extremely smooth and accurate drive.

Its Status

MDA predecessor BMDO funded the technology for a laser communications project that used Roto-Lok drives to align laser transmitters and receivers in a communications network. Sagebrush now offers to Federal customers an array of precision motion-control systems through the General Services Administration Schedule. The company also offers its products to original equipment manufacturers and to customers seeking custom designs.

Sagebrush and the Current Corporation of Port Moody, British Columbia, have collaborated to develop a marine night-navigation system that incorporates Current's night-vision technology with Sagebrush's Model 30 positioner in both unstabilized and stabilized configurations. Current Corporation sells the night-navigation system and offers several configurations in which the Sagebrush Model 30 can be mounted on coastal patrol boats, high-end pleasure craft, or large ships to identify potential marine hazards as well as perform search operations from long stand-off distances.

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Sagebrush's precision positioning technology can be mounted on coastal patrol boats used in search-and-rescue missions.



■ A night-navigation system incorporating Sagebrush's positioner.

17

Improve image displays for search and rescue



Even sophisticated electronic eyes have their limitations. When such eyes fail to see, lives can be lost.

Relevant Scenarios

- Search and rescue
- Surveillance
- Low-visibility operations

In the aftermath of a devastating earthquake that hit western Turkey in August 1999, rescuers used everything from dogs to thermal imagers to find survivors. In surveying the surface of a disaster scene, infrared imaging devices and special cameras can show what the human eye misses: What appears to be dust-covered rubble might actually be a survivor's elbow or a knee. In like manner, these imaging devices when mounted on aircraft also can help spot people lost at sea. In the push to improve the range, speed, and acuity of infrared imagers, their manufacturers are turning to a new class of scanning head that was developed for use in nanotechnology.

The Tool

nPoint, Inc. (Madison, WI), has created extremely fast scanners capable of accuracy and repeatability at the nanoscale that are being used for the precise and

rapid processing of infrared images. In order to create an infrared image, these scanners move a lens or photon receptor in a pattern analogous to printing with a dot-matrix printer. Fast, precise scanners allow the infrared light to land on more pixels in an imaging device, producing a more intense, and therefore more distinct, image with increased recognition value for the operator. The improved technology of nPoint's scanners supports imaging over greater distances and at higher speeds. nPoint's technology offers an out-of-plane motion less than 5 nanometers for a 100-micron x 100-micron scanning stage and accuracy down to 0.5 nanometers. The company's design methods allow nPoint to produce a family of standard, off-the-shelf products with scanning ranges of up to 500 microns suitable for a wide variety of applications.

Its Status

In 2000, BMDO awarded nPoint predecessor Piezomax a Phase II SBIR contract to develop advanced nanopositioners with enhanced speed and range of motion made from novel materials to improve the measurement, positioning, and machining of technology used in missile defense systems. The company has built upon the BMDO-funded nanopositioners to develop its scanning technology. Current nPoint products have been qualified for use in production of infrared imagery devices by FLIR Systems, a maker of infrared camera technology. nPoint already has received a production order from FLIR for its technology. The company also has manufactured its systems for other original equipment manufacturers in sectors such as semiconductor tools and microscopy.

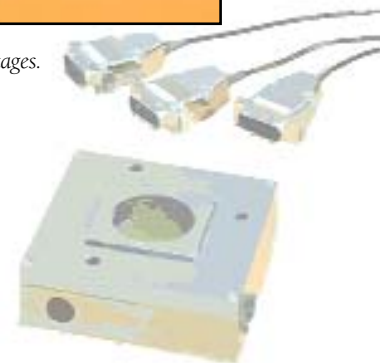
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Improved scanners in sensors means imagery can be generated with greater speed and accuracy.



■ nPoint scanning stages.



Detect fires with artificial intelligence



Wildfires might be wild, but there is a certain amount of predictability to them. They can be tamed.

Relevant Scenarios

- Forest fires
- Brush fires
- Surveillance and monitoring

In 2003, more than 57,000 wildland fires consumed more than 3.8 million acres and destroyed thousands of homes and other structures, according to the National Interagency Fire Center. In California alone—where the Santa Ana winds of October fanned massive fires—flames consumed more than 750,000 acres and 3,640 homes.

Snuffing out young fires before they become unpredictable infernos would save both natural resources and personal property. But detecting a wildfire in its early stages can be a challenge. Human eyes can't see all. Fog sometimes prevents views of wildfires. And even infrared sensors designed to spot fires can register false alarms. But coupling sensors with artificial-intelligence (AI) software can help fire managers get a better handle on the spread of fires.

The Tool

Using imaging algorithms from LNK Corporation (Riverdale, MD), infrared sensor technology can help wildland fire managers detect forest fires and determine associated wind directions. LNK researchers envision their software coupled with a network of fire-monitoring sensors mounted on towers, with the technology combo recognizing fire patterns to identify and predict the path of fires. LNK's artificial-intelligence technology also can be used to determine false alarms and the density of fog. Coupling the technology with a geographic information system (GIS) can give users information about other factors such as gas lines, streams, and geological structures in an area. Such a GIS-powered tool also could give users information on the location of the closest fire-fighting team and pinpoint populated areas.

LNK's software tool actually is a hybrid of two AI systems: neural networks, which are algorithms or devices that resemble the biological circuits of the brain, and expert systems, which make decisions based on a database of knowledge. The approach can fuse data from multiple sensors to track and recognize objects of interest. The software can identify multiple moving targets against a cluttered background. Processing techniques also can reveal an object's shape, three-dimensional position, and velocity.

Its Status

MDA predecessor BMDO awarded LNK an SBIR Phase II contract for software to enhance real-time pattern recognition for tracking missiles. The company has received interest from the Department of Agriculture (home to the U.S. Forest Service) as well as U.S. military agencies. LNK markets its artificial-intelligence software commercially as image-processing and analysis products.

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Software from LNK can help determine the shape, position, and velocity of a wildfire.



■ LNK's tool can identify multiple moving targets, such as flames or smoke, against a cluttered background.



“I want to thank the local folks, state folks and the county and city police, firefighters and emergency responders and the mayors for their hard work, as well. The truth of the matter is the front line on any emergency is the local people. . . . The true character of this country comes out during times of stress and emergency. And this country has responded once again. So on behalf of a grateful nation, I want to thank people at all levels of our government for working extra hard to help our country when it needed help.”

—President George W. Bush, speaking at the Virginia State Police Academy, commenting on emergency response to Hurricane Isabel, September 2003

Section Two

Protecting, Moving, Saving, Supporting

*A*ir, water, fire, earth. The personnel who must respond to an emergency sometimes find themselves in conflict with these forces of nature. Contaminants might dwell in the air and water. The heat, flames, and smoke of fire might stand as a wall against rescuers. Challenging operating locations—from ravines to isolated fields to crowded city streets—present physical obstacles to those who respond to emergencies. But new materials can help emergency workers to better protect themselves and the public. And new machinery can help emergency workers go where they need to go to fulfill their overall mission and to save lives.

These tools can help emergency personnel . . .

- Lift people to safety with greater ease24
- Filter airborne threats with portable masks.....26
- Stay cooler near fires28
- Generate emergency power in the field30
- Purify water to meet emergency needs32
- Power equipment with smaller vehicles34

Lift people to safety with greater ease



When it comes to pulling a person out of danger, speed, safety, and weight really matter.

Relevant Scenarios

- Airlift rescues
- Flood victim evacuation
- Maritime disasters
- Mining accidents
- Earthquakes
- Building evacuations
- Hiking/rock-climbing accidents
- Automobile accidents

After 12-year-old Andrew Fortier walked off a trail and fell 20 feet down a chute at Yellowstone National Park in June 2001, other park visitors tried tying T-shirts together to save him before one visitor volunteered to climb down an extension cord to rescue the boy, who was clinging to a root and who might have fallen 100 feet or more had he not been saved quickly.

Rescuers facing similar situations each year could use something more than brute force and an extension cord—or even ropes and harnesses—to save lives in out-of-the-way places. But often, the equipment necessary to pluck a person out of harm's way can prove cumbersome or useless. Winches on ground-based rescue vehicles are worth little if the vehicles can't access victims in remote areas, for example. And a large winch on a helicopter can add significant weight, leaving less room for supplies or people.

Moreover, a rope wrapping around the capstan of a winch can become tangled and cost serious life-saving time.

A quick, simple, and portable mechanized lifting device could be a much-needed answer to prayers.

The Tool

Quoin International, Inc. (Ridgecrest, CA), has developed a lifting technology that combines the benefits of low weight with speed and enhanced safety. The powered ascender, called PowerQuick™, is driven by a turbine and high-pressure air (compressed air or air generated by a solid propellant). Both the air source and the turbine are built into a single unit, which can be incorporated into a variety of lifting chairs or other platforms. The device works by propelling an individual along the length of a rope or lifeline rather than winching all the rope onto a capstan at the other end.

The 7-pound device includes a 2.5-inch-diameter pneumatic impulse turbine, spinning at 50,000 RPMs, which drives through a two-stage gear-reduction system to provide about 230 RPMs at the unit's capstan. The Quoin drive system provides sufficient torque to lift 181 kilograms (408 pounds), at a rate of 1 meter per second.

Its Status

Quoin's plans call for commercial unit availability in 2004. Company officials are pursuing opportunities with the military and helicopter makers, as well as the oil and shipping industries. The PowerQuick technology has emerged from BMDO-funded work on turbine and flywheel technology for use in kinetic-energy kill vehicles.

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Quoin officials are pursuing helicopter makers and the oil and shipping industries as potential customers of the lifting technology.



■ Quoin's PowerQuick™ ascender.



25

Filter airborne threats with portable masks



Protecting the body from chemical or biological agents can prove challenging and cumbersome with heavy gas masks or escape hoods. But a pocket-size solution could solve problems.

Relevant Scenarios

- **Chemical leaks**
- **Industrial accidents**
- **Biological disasters**

In March 1995, members of a religious cult released sarin gas in the Tokyo subway, killing 11 people and harming an additional 5,000. Few, if any, were prepared. Today, such attacks still haunt emergency managers, who must be ready to protect hundreds or even thousands of people quickly during chemical or biological disasters. If similar incidents occur in the future—whether by design or by accident—small, easy-to-use gas masks could offer at-the-ready protection.

The Tool

IntraMicron, Inc. (Birmingham, AL), a spinoff of Auburn University, is developing foldable, pocket-size gas masks based on the university's microfibrinous materials technology (MMT), an enabling technology that allows sustained chemical reactions to occur more efficiently

than with other commercial products. The masks provide protection against airborne threats, including chemical and biological agents. They are small, flexible, and lightweight, allowing law enforcement personnel, first responders, and civilians to carry hundreds of them easily for distribution to others if necessary.

As far as production is concerned, when combined with a high-speed roll-to-roll paper-making process, MMT results in a porous interlocking composite network with high electrical conductivity and a surface area of approximately 1,000 square meters per gram. High electrical conductivity, when combined with the large surface area, allows for effective entrapment of harmful particles.

Its Status

MDA predecessor BMDO originally funded Auburn University's materials work to develop smaller and lighter capacitors for weapons systems. From this work, IntraMicron is spinning off new nonlethal products by developing the gas masks as well as collective protection systems, which include regenerable filter and sorbent canisters to stop and mitigate chemical and biological threats.

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New masks are small, flexible, and lightweight, allowing first responders and civilians to carry hundreds of them for distribution.



■ A mask incorporating IntraMicron's material.

Stay cooler near fires



Man discovered fire thousands of years ago but is still learning to tame it. Materials for controlling heat can protect people and key assets in extreme environments.

Relevant Scenarios

- Structural fires and explosions
- Chemical containment
- Wildfires
- Cold-water rescue

A full-blown structural fire can easily exceed 1,000° F, and even fires at lower temperatures—say, near 600°—produce plenty of heat that can scorch lungs and melt clothing. Protecting the body better during a fire can give a first responder a few more seconds to save others' lives—and their own.

The Tool

Hayes & Associates (San Diego, CA) has developed a number of materials that can store and release heat in a controlled manner to protect people and critical assets from extreme temperatures. The materials can serve as protective clothing for firefighters or cold-water divers, but the materials also can be incorporated into electronic equipment and storage facilities—from safe-deposit boxes to warehouse walls to containers for gas, ammunition, or chemicals. The

Hayes technology absorbs, dissipates, and releases heat quickly and can be formulated into a wide variety of materials for many uses. The technology can take the form of a chemical powder, structural material, or a thin, flexible film resembling a household food wrap. Such a material can serve as a liner for clothing, function as a protective drape, or act as a barrier in tight spaces.

As a liner in fire suits, the material could keep temperature levels tolerable for rescuers working close to heat and flames. Or, used in a wetsuit, the material could retain heat and release it slowly to keep divers warm in chilly waters. It also could serve as a firewall in buildings or other structures. Moreover, the material technology could help control temperature in guns or other weaponry as well as flight data recorders. The Hayes

materials do not function as traditional insulators. Rather, they incorporate a polymer that chemically absorbs and releases heat at a specified temperature. The multilayer materials the company has developed consist of an inner region of thermally active material sandwiched between protective outer layers of plastic or metal. The inner section contains a polymer that undergoes a thermochemical reaction or phase change to absorb and release heat at a critical temperature. Such an approach means that a designer could develop a suit with fairly exact specifications. For example, engineers could build a suit for users who might need to be in a 500°F room for 30 minutes, with the temperature inside the suit itself staying at or below 100°.

Its Status

The company's composite-fabric endothermic material was initially developed for SDIO, one of MDA's predecessors, as a heat shield to protect missiles and satellites. Hayes & Associates is not commercially mass-producing materials, but the company is licensing its technology to others. The company already has licensed its technology to PepsiCo for Pizza Hut delivery opera-

tions. Pizza Hut has used the material in a food-warming tray that maintains the right temperature to keep pizza hot and crisp. Smiths Industries also inserted Hayes' technology into its Voice and Data Recorder™ product line, which consists of cockpit voice recorders, flight data recorders, and combined recorders for commercial and military aircraft. Additionally, Hayes & Associates licensed its technology to Honeywell International, Inc., for use in flight data recorders on Boeing aircraft. And recently, the U.S. Navy and the U.S. Forest Service have tested Hayes & Associates technology as a liner for fire suits.

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Instead of serving as a traditional insulator, the material chemically absorbs and releases heat at a specified temperature.



■ Hayes material has been incorporated into fire suits and flight data recorders.

Generate emergency power in the field



When man-made disasters or natural disasters such as hurricanes occur, restoring order to the chaotic aftermath demands modern equipment. And modern equipment needs electricity—something that can be scarce after a disaster.

Relevant Scenarios

- Hurricane response
- Tornado response
- Mining accidents
- Earthquakes
- Mobile hospitals
- Extraction
- Command centers

Winds from Hurricane Isabel knocked down countless trees along the East Coast in September 2003, leaving more than 5 million without power. With no electricity coming from the power grid, citizens were forced to improvise or do without. But those who responded to the emergencies could not do without. They had to find back-up sources of power, such as portable generator sets (gensets). A mobile command center set up to respond to an emergency—be it a hurricane, an air disaster, a tornado, or some other calamity—has significant energy needs. The center needs electricity to run lights, operate rescue machinery, and run computers. Mobile hospitals also need reliable power. Even when power grids are left intact, electricity at remote disaster scenes can be scarce. A new underhood generator for vehicles, however, offers emergency responders a way to make power easily and efficiently.

The Tool

Aura Systems, Inc. (El Segundo, CA), has leveraged its research in high-fidelity actuators (HFAs) into a powerful underhood mobile generator. The company has developed a patented rotary device called the AuraGen™ and is marketing it in a 5-kilowatt or 8.5-kilowatt generator configuration that can be mounted under the hood of an automobile. AuraGen products are belt-driven by an engine, converting a small portion of vehicle energy into electricity, providing continuous 60 hertz (Hz) of AC power at all speeds that is better than home electricity power specifications. The AuraGen technology implemented in another configuration also serves as a AC-to-DC and DC-to-AC inverter and as a 14- and 28-volt battery charger, simultaneously with the generation of thousands of watts of pure-sinewave AC power. In comparison, conventional alternators

capable of continuous operation typically provide about 1.8 kilowatts of power, 21 percent of what an Aura System is capable of. Also, comparing power to equipment weight, AuraGen produces nearly six times more power per pound than equivalent heavy-duty alternators. Conventional gensets, while having lower-quality power output, can provide thousands of watts of power, but gensets are hundreds to thousands of pounds heavier and tens to hundreds of cubic feet larger than the AuraGen. Further, the AuraGen, unlike gensets, requires no prep, fiddling, or scheduled maintenance.

AuraGen can generate power whenever the vehicle engine is running and delivers simultaneous 120 and 240 volts AC. It consumes less fuel, has reduced component wear, and is much lighter and quieter than standard power generators. AuraGen produces full power at speeds slightly above engine idle, typically 1,400 RPMs, as compared with 3,600 RPMs required by standard generators to get 60 Hz. The AuraGen also draws power from the engine proportional to its energy demand. Therefore, when there is no load, the generator does not draw power from the engine.

Its Status

MDA predecessor BMDO funded Aura Systems' research into electromagnetic actuator technology for use in high-response thrusters. The company has thousands of its AuraGen units on the market today. Users include the Department of Health and Human Services' Office of Emergency Preparedness, which plans to use AuraGen in emergency response communications vehicles; the Federal Bureau of Investigation, which is using the AuraGen on crisis response and other vehicles; police and fire departments across the country; and U.S. military forces in Afghanistan and Iraq, among other locations.

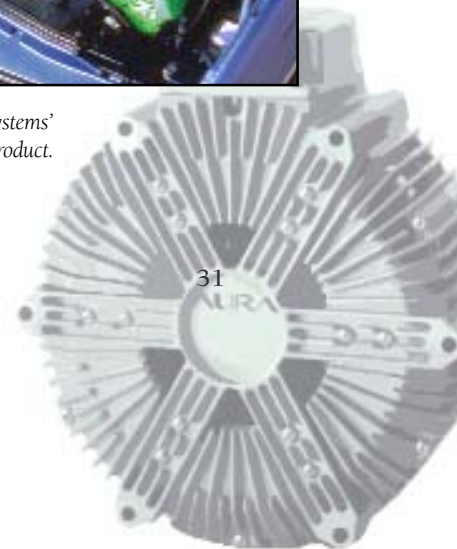
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Aura's technology can generate power whenever a vehicle engine is running and operates at standard 120 and 240 volts AC.



■ Aura's Systems' AuraGen product.



31

Purify water to meet emergency needs



Life depends on water, but natural calamities can make potable water scarce. New materials can produce clean water from polluted sources.

Relevant Scenarios

- Floods
- Hurricanes
- Earthquakes
- Droughts

After Hurricane Floyd hit North Carolina in 1999, flooding contaminated 2,800 wells and 14 public water systems, according to the North Carolina Re-development Center. Too much rain or lack of rain means disaster for civic managers and emergency personnel. Floods leave low-lying areas under several inches of water, causing wastewater plants to fail and allowing polluted water to co-mingle with clean water. Droughts meanwhile can deplete clean and trusted water supplies, requiring some water authorities to consider alternate sources. In either case, the problem can't be ignored. Water is not a luxury. It's a necessity.

The Tool

Turning dirty or brackish water into clean, potable water can become a simple process. Specially crafted brick-like AquaCells containing a carbon-aerogel material can absorb ions such as sodi-

um and chloride, removing salt and impurities from water. The AquaCells, made by CDT Systems, Inc. (Dallas, TX), provide a simple way to treat impure water, using less energy and requiring less maintenance than conventional methods.

In CDT Systems' process, water containing salts, heavy metals, or even radioactive isotopes passes over AquaCells made up of sheets of carbon-aerogel electrodes through which the inlet water stream passes. An electric potential is then applied across the electrodes, attracting the negatively and positively charged ions to purify the water with each pass over an AquaCell removing 1,000 parts of contaminant per million. One AquaCell (12 x 24 x 30 inches) can process up to 1,000 gallons of water per day. Each AquaCell should have a lifespan of approximately 10 years. The CDT Systems technology has no moving

parts and needs only 1.2 volts of power to operate. It uses simple electrostatic regeneration, compared with ion-exchange systems that require acids, bases, or salt solutions for regeneration. CDT Systems' product does not require the use of membranes or high-pressure pumps, which reduces maintenance requirements. When a CDT Systems AquaCell has become sufficiently loaded with removed contaminants, it is bypassed, and water is routed to other AquaCells with remaining capacity. The loaded AquaCell is then shorted out or reverse-polarized, expelling the contaminants into the waste stream for disposal or recycling.

Its Status

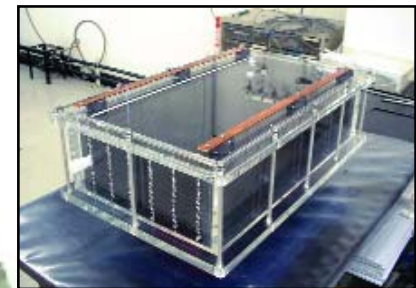
The company has been negotiating to supply a possible client with mobile CDT emergency water-purifying systems for use in the Middle East. Each system would produce 5,000 gallons of drinking water per day from brackish water sources. The company also has undertaken a pilot project in Japan, reclaiming water used in electronics production, and a pilot project in California, purifying wastewater. Planned pilot projects include one to treat water used at power plants, one at large greenhouses, and one by the Texas Water Development Control Board.

CDT, formerly Far West Group, Inc., licensed the technology from Lawrence Livermore National Laboratory. MDA predecessor BMDO partly funded the lab's carbon-aerogel research to develop lightweight batteries for space power applications.

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One AquaCell measuring 12 x 24 x 30 inches can purify up to 1,000 gallons of water per day.



■ An AquaCell for industrial applications.



Power equipment with smaller vehicles



A new breed of lightweight emergency vehicle designed to address tight budgets and tight spaces also brings a need for new power-generation products.

Relevant Scenarios

- Fires
- Hurricane response
- Tornado response
- Mining accidents
- Earthquakes
- Mobile hospitals
- Extraction
- Command centers
- Terrorist attacks

After United Airlines Flight 93 crashed in a field near Shanksville, PA, on Sept. 11, 2001, one of the first vehicles on the scene was a mini-pumper from nearby Stoystown. Such equipment is prominent among local emergency agencies. Mini-pumpers are relatively affordable equipment that can respond quickly, reaching spots that might prove challenging for larger trucks to reach. But with the rise of the small mini-pumper, the big need for electricity at a disaster scene has not changed. During a fire or other emergency, power is essential to run lights and equipment such as pumps. Powerful generators that can be operated with smaller vehicles are becoming a new necessity for budget-challenged agencies.

The Tool

Raven Technology, LLC (Brunswick, ME), has developed a generator that connects to a vehicle's engine and works without the use of inverters, instantly providing up to 5 kilowatts (kw) of household-type current regardless of the speed of the shaft to which the generator is belted. Raven refers to its patented technology as AC-Direct. The first commercial product to use the AC-Direct technology is Raven's Blackbird™, which generates up to 5 kw of 120-volt, 60-hertz, single-phase AC power.

The Blackbird™ converts mechanical energy to electrical energy with up to 90-percent efficiency. Operating with control circuitry with very low (approx-

mately 200-watt) power input, the unit modulates a patented alternator's electromagnetic field to control output voltage. The system does not switch live current. Moreover, it weighs only about 75 pounds, compared with competing 5-kw generators that can weigh up to 250 pounds and can take up an entire storage compartment in an emergency vehicle. The Blackbird™, however, mounts under a vehicle's hood, saving important compartment space for critical gear such as hazmat suits or other rescue equipment. The under-the-hood system, unlike many other emergency generators, also does not require users to keep it filled with gasoline, since it is powered by a vehicle's engine.

Its Status

In 1997, BMDO awarded an SBIR Phase I contract to Dirigo R&D, Inc., (which created Raven in 1998) to demonstrate a practical method of efficiently producing 60-Hz AC power using resonant circuit techniques to excite the field of a specially designed high-frequency alternator for mobile applications. Commercially, Raven now

is targeting fire and emergency services as its initial market. The company now sells a beta version of its product and expects to make its technology widely available in 2004.

Contact

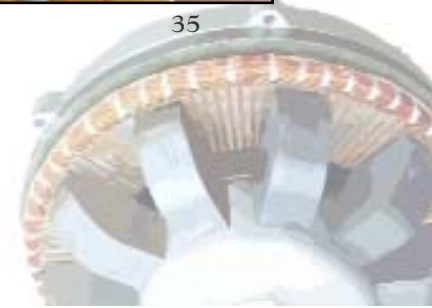
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Raven's technology can quickly provide up to 5 kilowatts of household-type current regardless of shaft speed.

■ Internal view of Raven's alternator.



35



This report has been written and produced for MDA by the National Technology Transfer Center-Washington Operations.

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This project is sponsored by MDA. The information presented does not necessarily reflect the position or policy of the Federal Government; no official endorsement should be inferred.



Some of the images in this publication were acquired from the Web sites of the Federal Emergency Management Agency and the U.S. Coast Guard. The MDA Technology Applications program greatly appreciates the use of these images.

105:

The number of disaster declarations issued by the Federal Emergency Management Agency in 2002, including wildland fires, tornadoes, floods, earthquakes, and tropical storms.

6,316,000:

The number of police-reported motor-vehicle traffic crashes in 2002.

1.7 million:

The number of fires reported in 2002.

15,111:

The number of transportation-related incidents involving hazardous materials reported in 2002.

*Sources: Federal Emergency Management Agency, National Highway Traffic Safety Administration,
National Fire Protection Association, Bureau of Transportation Statistics*

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