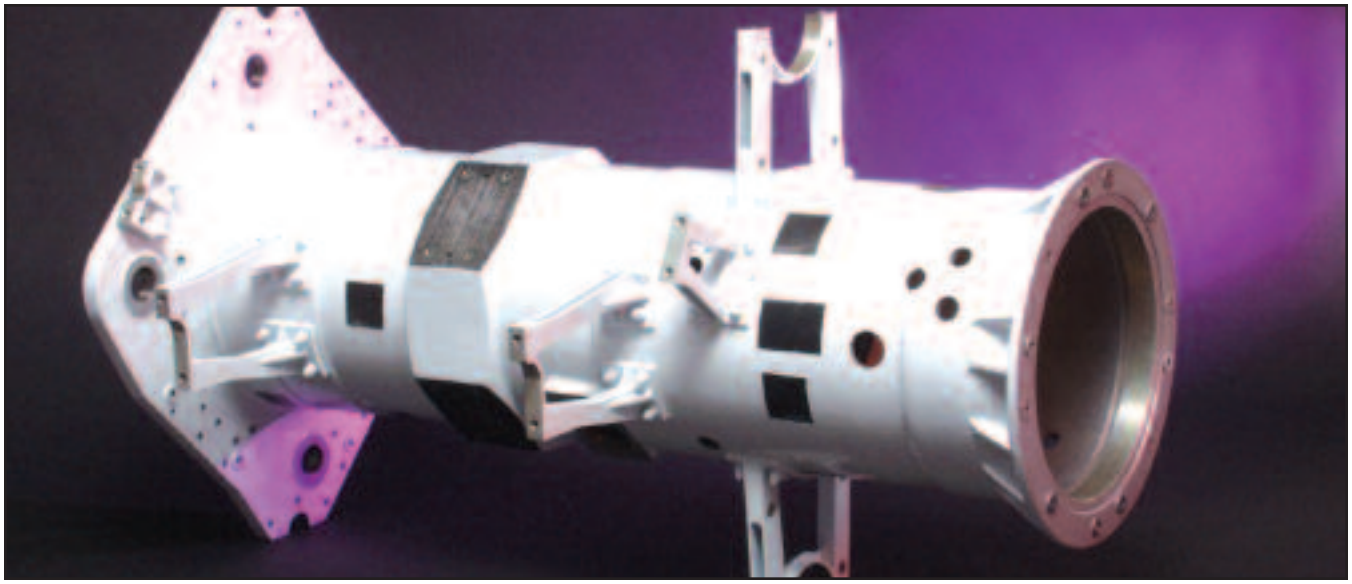
Spring 2006

Missile Defense Agency

TechUpdate

A Quarterly Newsletter for MDA Technology Transfer



▲ Vanguard Composites has developed an aft flange for a missile defense kill vehicle. The flange (pictured on the left end of this unit) exceeds structural requirements by 20 percent.

INSIDE

From Research to Reality

MDA-funded project leads to incorporation of advanced composites on missile interceptor.

by Scott Tillett/stillett@nttc.edu

A missile interceptor recently installed at Fort Greely, AK, now carries hardware developed under an MDA research program, and the companies responsible for developing the component expect that more of their MDA-funded technologies could be included in future interceptors.

The companies, Vanguard Composites Group, Inc. (San Diego, CA), and V System Composites, Inc. (Anaheim, CA), both wholly owned subsidiaries of DR Technologies, Inc. (San Diego, CA), co-developed an advanced composite aft flange design. Research and development funding came from MDA's Deputy for Engineering, Producibility (DEP), formerly Manufacturing Producibility.

The aft flange mounts the "fly away" interceptor—consisting of a main structure, divert maneuvering system, sensor, and electronic components—to the interface of the Boeing-manufactured booster. The divert assembly includes thrusters and associated "plumbing" used to maneuver the interceptor's Exoatmospheric Kill Vehicle (EKV)—the actual "hit to kill" portion of the interceptor that maneuvers to collide with the hostile threat during intercept.

The Vanguard/V System Composites aft flange was incorporated into the EKV architecture to satisfy Raytheon's requirement for a lightweight, stiff structure manufactured from space-qualified material—and that

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High-Tech Hopes

by Patrick Hartary/phartary@nttc.edu

America is facing tough times. Rising energy prices are putting the squeeze on consumers. Increased traffic congestion is damaging air quality, slowing commerce, and increasing energy consumption. Soaring health-care costs are forcing more Americans to decrease or even discontinue their coverage.

High-tech innovations funded by the Missile Defense Agency may address some of these issues. And their developers, companies like ZTEK, Blue Road Research, and Advanced BioPhotonics, hope to cash in by developing and marketing spinoff products for commercial markets.

Years ago, ZTEK developed solid-oxide fuel-cell technology for "Star Wars" power applications. Today, the company is leveraging this research to create high-temperature solid-oxide fuel-cell systems that could allow gasoline filling stations of the future to produce hydrogen and electricity, depending on demand. The hydrogen could be used in vehicles that use hydrogen fuel-cells or directly burn hydrogen, while the excess electricity could be sold to utilities.

With the help of MDA SBIR funding, Blue Road Research has improved its fiber-optic strain-measurement technology. Now, the company is using its technology to monitor the structural integrity of bridges. Its sensor systems have been shown to be sensitive enough to detect the presence of individuals jogging on a bridge, and to stratify the classes of motor traffic, distinguishing minivans from SUVs and small cars.

Advanced BioPhotonics is using MDA-funded research on quantum-well infrared photodetectors to bring enhanced imaging abilities to the surgical suite and to the patient's bedside. The device's most promising performance is currently in blood-flow studies related to surgeries and tissue integrity, but it also has exceptional future potential in monitoring cancer patients during chemotherapy and in discovering new drugs. Some of these applications could provide new capabilities and even decrease treatment costs.

Many of America's energy, traffic, and healthcare problems have been decades in the making, and their solutions may not come for years. With new technology born from MDA-funded research, some high-tech hopes could make a difference.

Free poster

For all who enjoy history, MDA has a free poster for you. It's a timeline chronicling the past 20 years of historical highlights of both MDA and the agency's top spinoff technologies. Technology transfer has played an important role at MDA, and the poster itself has a dual use. It will not only educate you, but it'll look great on your wall. To receive a free poster, call (703) 518-8800, extension 239, or send an e-mail to techapps@nttc.edu. Please provide us with your full name and mailing address.

NOTE: We were unable to print the Winter 2005/2006 issue, but it is available online at www.mdatechnology.com/update

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The MDA Technology Applications program sponsors publication of the *MDA TechUpdate* to encourage the transfer of missile defense technology to American businesses and other government agencies.

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The *MDA TechUpdate* is written and produced for MDA by the National Technology Transfer Center-Washington Operations. This project is sponsored by MDA. The content does not necessarily reflect the position or policy of the Government; no official endorsement should be inferred.

Approved for Public Release
06-MDA-1504 (17 APR 06)

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Q&A: Mike Zammit

by Patrick Hartary/phartary@nttc.edu

The Missile Defense Agency named Mike Zammit the new manager for its SBIR/STTR programs; he had served as acting manager since September 2005. Prior to this position, Zammit managed the SBIR program for MDA Advanced Systems. Before arriving at MDA, he served as the Standard Missile-3 program manager at the Naval Surface Warfare Center, Dahlgren Division.

In a recent conversation with Zammit, I asked him to share his program goals and to provide small businesses with some guidance for applying to MDA SBIR/STTR solicitations.

Q: What will you do differently in your new position from previous managers?

A: The MDA SBIR/STTR program is actively managing more than 400 contracts with small businesses. As a result, we receive dozens of phone calls and e-mails daily, requesting further assistance. Communication is key to improving our relationship with small businesses. Therefore, one goal is to communicate more effectively and in a more timely manner. Additionally, we will be attending more conferences and industry events than in previous years. A better informed and educated small business community is likely to submit stronger, more focused proposals and minimize mistakes. Plans are also in the works to get more MDA prime contractors to engage the program to improve the transition of technology to Phase III. We will be also developing an intranet capability for MDA personnel to access final reports.

Q: Many small businesses are interested in submitting an SBIR/STTR proposal to MDA. How do they get started?

A: First, I'd recommend that any small business join the DOD SBIR/STTR Announcement Listserv at http://www.acq.osd.mil/sadbu/sbir/solicitations/index.htm. They can receive information on MDA and other DOD solicitations via e-mail. To submit an MDA SBIR/STTR Phase I proposal, visit our Web site at http://www.winmda.com. Under the "Getting Started" tab, small business can find a step-by-step submission strategy. The first three steps cover guidelines, eligibility requirements, and deadlines. The next four address proposal research, including identifying if your proposal/technological idea matches an SBIR/STTR topic and registering your business to participate. Preparing and submitting the proposal are discussed in the last three steps.

Q: In some cases, SBIR/STTR companies have complained about not getting paid on time and/or delays in the contracting process. Can you address these issues?

A: When SBIR/STTR companies don't turn in their paperwork on time, payments will be delayed. For MDA contracts, we believe the use of Wide Area Workflow-Receipt and Acceptance (WAWF-RA) will largely alleviate any such problems in the future. WAWF-RA is a secure World Wide Web-based system that provides our industry partners with the ability to electronically submit invoices and receive/accept reports. The Defense Contract Management Agency first deployed this capability to those industry partners with the greatest volume of monthly receiving reports and invoices. The results showed that where WAWF-RA was used, it had virtually eliminated late payments and associated interest penalties. At the same time, it reduced administrative cost by eliminating manual processing and the impact of lost or misrouted documents. Additionally, use of WAWF-RA allows for total visibility of document status, a secure auditable trail for each transaction, elimination of mailing cost and lost documents, and the system is offered to our industry partners at no cost. We also recently made some changes to the contracting process that should reduce the time to get companies under contract. For example, our most recent Phase I companies received contracts within two months of their selection. Phase II companies selected in November 2005 should be under contract by the end of March 2006.

Q: To submit a Phase II proposal, a Phase I company must receive an "invite." How can a company improve its chances of receiving an invitation?

A: My best advice is to work closely with your technical monitor and MDA sponsor whose requirements/needs must be fully understood. If companies find the opportunity to brief their technology to a sponsor, their presentation must be clear and concise. Additionally, companies would greatly benefit from communicating with the topic authors (often a different person than the technical monitor) after their work has begun to ensure that their work is visible to the corresponding MDA programs. The names of topic authors are available on the presolicitation; however, these names are removed after the presolicitation period has ended. Finally, companies are more likely to be invited for a Phase II if they are working side-by-side with the Ballistic Missile Defense System (BMDS) integrators.

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Faster Imaging

High-speed cameras have pushed the limits of processing, so one company has put the processor in the camera.

by Michael Felton/mfelton@nttc.edu

Digital camera users know that touching up or altering images using a computer can be a time-consuming affair. Even high-end personal computers take seconds of processing time to run optimization tools. Now imagine having to process thousands of images per second. Manufacturers in many industries and the military are facing this very problem—how to find product defects, targets, or missiles, in the thousands of images per second that very-high-speed cameras can produce.

Addressing this issue, Salvador Imaging, Inc. (Colorado Springs, CO), has developed a solution that preprocesses the images inside the camera as they are generated, decreasing the need for large cables to transmit the images and reducing the computer power needed to spot defects or targets. Already, the technology is commercially successful, but it has even more untapped potential.

▲ Two high-speed cameras developed by Summit Imaging sit atop a piece of manufacturing equipment, inspecting glass panels used for computer monitors and big-screen televisions.

The brains

High-speed cameras are specially designed to produce thousands of images per second. To quickly capture images, Salvador Imaging uses a single charge-coupled device (CCD) that may be segmented into as many as 16 sections, with each section connected to an amplifier. Because amplifiers have slight variations in gain and offset, each amplifier has to be adjusted so the image can be analyzed effectively.

Although other high-speed cameras output the raw images to an external computer, Salvador Imaging works with customers to design cameras that use parallel processors to preprocess the data immediately after it is generated by the CCD. "The cameras are not just taking pictures, they have brains in them that are processing, adding nonlinearities or subtracting nonlinearities, or doing some bizarre data stretching or multiplication," said David Gardner, founder and CEO of Salvador Imaging. Between one and eight field-programmable gate arrays take the data from the CCD sections and apply algorithms to them in real time. The arrays and associated high-speed memories are supplied by outside manufacturers. Salvador Imaging writes the code for the arrays and designs circuits to connect all the components.

Designing camera circuitry may sound straightforward, but in high-speed, high-dynamic range applications, it's actually very complex. In order to maintain 12-or 14-bit dynamic range in cameras operating at hundreds of megahertz, signal timing and jitter must be controlled to within a fraction of a nanosecond. "When I was in college, they used to say, 'You're going to be dealing with circuit designs where 5 nanoseconds will make a big difference,' and I thought 'I'll never have to worry about that stuff,' " Gardner said. "Now, we worry about it every day."

Naive developers often don't anticipate the complications of operating CCDs at higher speeds. For instance, the circuits themselves can become antennas, affecting adjacent circuits. And timing jitter, not a problem with slow cameras, can turn a 12-bit camera into a 6-bit camera or, at worst, contribute noise that will bury any sign of a defect or target. "I'd like to say that one day we just sat down and designed it and it worked," Gardner said. "But we have had many, many years of doing it wrong to figure out [how] to do it right."

Inspecting flat panels

Salvador Imaging isn't Gardner's first foray into high-speed imaging. In 2002, Summit Imaging, a predecessor to Salvador Imaging that was founded and run by Gardner, received an MDA Phase I SBIR contract to produce a camera-based inspection tool for microelectromechanical systems. The camera, capable of preprocessing 3-D images, caught the attention of one of Summit Imaging's customers, Photon Dynamics.

Photon Dynamics watches over 70 percent of the world's big screens—that is, their systems inspect the glass panels used to make computer monitors and big-screen televisions. "Cameras scan a piece of glass that is the size of a king-sized bed," Gardner said. "They have about one minute to scan that entire piece of glass, looking for defects that are only a few microns in size."

There were two technical challenges that Photon Dynamics faced when developing its inspection system. First, the camera needed to be mounted on a gantry and moved

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over the panel. "If [Photon Dynamics] were to just output the data out the back of a camera by brute force, they would end up with cables about the size of a fire hose, making mechanical scanning nearly impossible," Gardner said. Second, the camera would be producing over a gigabyte of data per second, and computers fast enough to handle this would be prohibitively expensive.

"What we had to do was basically preprocess [the data] in the camera and reduce that data by a factor of 10 before they ever saw the data," Gardner said. "The reason preprocessing is important is that there is a lot of algorithmic processing that you have to do when looking at flat panels. It's a very low signal-to-noise-ratio application."

The cameras delivered to Photon Dynamics, based on Summit Imaging's MDA project, were 50 to 100 times faster than previous cameras, allowing Photon Dynamics' customers to inspect more flat panels in less time.

Cops, docs, and the silver screen

Although flat-panel inspection is currently the biggest commercial success of Salvador Imaging's technology, it may find

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Donating Profits to Charity

by Michael Felton/mfelton@nttc.edu

David Gardner's life has been a roller coaster. With plenty of ups and downs, Gardner has a new mission: donate all profits generated by Salvador Imaging to charity.

After working for six years on SBIR contracts that were not commercialized, Gardner, who had just purchased a house and whose wife was expecting their first child, quit his job in frustration. Because of a U.S. Air Force SBIR program manager who convinced him not to give up on SBIR contracts, Gardner started Silicon Mountain Design. And his company became very successful. It spun off a 1995 BMDO-funded Phase II SBIR project into an automated Papsmear system, won the prestigious Tibbetts Award, and was bought for more than $10 million by DALSA Corporation, a Canadian CCD maker.

Gardner initially joined DALSA but soon parted ways and considered a new career in real estate. But he was contacted by a former customer, Photon Dynamics, to start a new company to supply cameras to them, and Summit Imaging was born. On a business trip to Europe, Gardner contracted a life-threatening illness and doctors expected him to die in six months. Thankfully, he didn't and has since recovered. But that prognosis changed his outlook on life.

In 2002 Photon Dynamics acquired Summit and formed a camera design department within the company. In 2004, Gardner approached his employer about spinning off the camera group as a separate company. When the CEO asked why he wanted to do this, Gardner explained that he liked the dynamic and creative nature of smaller companies, and that he wanted to donate the profits to help those who are less fortunate in life. His CEO supported the idea and Salvador Imaging was born. Today, Salvador provides imaging solutions to many customers and continues to support Photon Dynamics in their flat-panel inspection systems.

One of the first projects to benefit from Salvador Imaging's profits was the construction of a water-purification system for a small village in Honduras. "They were slowly dying because they were drinking water from a polluted river," Gardner said. The village had access to a spring but could not afford the materials to transport the water to the village. "We donated about $2,500 worth of pipes and valves and a water purifier, and they did all the labor," Gardner said.

Salvador Imaging's profits have also helped improve working conditions, increase output, and provide more jobs at a tortilla factory in Honduras. Current projects include the development of a new computer lab and a hospital for malnourished children in the same region of Honduras.

▲ With a new perspective on life, David Gardner of Salvador Imaging is donating all his company's profits to worthy causes. One recipient, a tortilla factory in Choluteca, Honduras, used the money to buy new equipment, increasing output from 3,000 to 30,000 tortillas per day and creating 14 new jobs.

QWIPs in the OR

Highly sensitive photodetectors are bringing enhanced imaging abilities to the surgical suite and to the patient's bedside.

by Joan Zimmermann/jzimmermann@nttc.edu

Advanced BioPhotonics, Inc. (Bohemia, NY), which owns the exclusive worldwide license for using quantum-well infrared photodetector (QWIP) technology in biomedical imaging applications, has developed a QWIP-based device called the BioScanIR® that can be used in procedures in which Doppler ultrasound and other imaging modalities have traditionally reigned. Highly sensitive, relatively operator-independent, fast, and economical, BioScanIR's most promising performance is currently in blood-flow studies related to surgeries and tissue integrity, but it also has exceptional future potential as an adjunct device for monitoring cancer patients during chemotherapy, and as a tool in drug-discovery applications.

▲ BioScanIR is a functional imaging system that detects minute changes in blood perfusion through the capture of passively emitted infrared radiation that is produced by tissue. By analyzing this captured radiation, the system can help physicians and researchers differentiate between normal and abnormal tissue.

New domain

The QWIP was a groundbreaking technology that sprang from the collaboration of many agencies, including DARPA, NASA, and MDA back when it was still BMDO. MDA funding was instrumental in the early development of the QWIP at the Jet Propulsion Laboratory; the agency's main interest was in how well the QWIP could detect missiles while in non-boost phase. In addition, Advanced BioPhotonics received a Phase I SBIR to develop an integrated portable infrared camera system that could meet MDA's booster-typing needs as well as prod the next innovations in infrared medical imaging. The highly sensitive, gallium-arsenide QWIP detector can "see" the radiation range at which most room-temperature objects emit energy. This type of detector can pick out the warm silhouette of a living being in a room obscured by smoke, or the signatures of different chemicals in the atmosphere of a distant planet.

Here on Earth, however, QWIP technology has found a home in the medical domain, in the expanding field of infrared imaging. For blood-perfusion studies, BioScanIR also offers advantages over techniques such as CT, PET, and functional MRI (fMRI), whose limitations include exposure to ionizing radiation, lack of timely feedback, psychological limitations such as claustrophobia in the use of MRI, and high expense. By comparison, BioScanIR offers a much improved profile of time savings and financial advantage, in addition to its precise imaging abilities.

Helping surgeons

In the surgical realm, the organs and blood vessels look nothing like the neat pictures in *Gray's Anatomy*. Surgery is a highly skilled and visual business, and reconnecting blood vessels is a lot tougher than just wielding a needle and thread. The leakage of small blood vessels can easily go unnoticed in the obscuring matrix of tissue, and surgeons must spend a good deal of time confirming their handiwork before they decide to close up. In this instance, QWIP technology can provide a highly resolved picture of what the surgeon can't see with the naked eye. For breast reconstructive surgeries, doctors have used the BioScanIR to detect the presence of "feeder" or perforator vessels that nourish and provide oxygen to tissue. In the planning stage prior to surgery, the BioScanIR identifies vessels that perfuse the donor flap, or the area of skin and muscle that will form a new breast. Ordinarily, the Doppler ultrasound method, which is

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operator-dependent and time-consuming, is used to identify these vessels. With BioScanIR, this determination can be made in 20 seconds, with the better reliability of an objective measurement tool and no physical contact with the patient. After surgery, the mobile BioScanIR unit can be moved to the bedside to monitor post-surgical perfusion, to ensure that the vessels remain open, in turn ensuring a successful reconstruction. This method would replace an intensive period of visual inspection provided by a dedicated nurse who has been trained to look for pale or blue skin, which are at best subjective indicators of flap health. Determination of feeder vessels is also important in assessing the integrity of bypass grafts in heart surgery and in reattachment procedures in trauma cases.

In neurosurgery, direct infrared imaging can provide a better look at blood-flow-induced changes on the surface of the cerebral cortex, important in surgery for the treatment of seizure disorders and the excision of brain tumors. A number of monitoring techniques are used for this purpose—among them, the traditional electroencephalogram (EEG). However, EEG electrodes require contact with the brain surface, a procedure known to increase the risk of seizure and infection, and EEG-based analysis often requires multiple cranial surgeries. MRI scanning is also used for this purpose but it is very expensive and limited in application. It also restricts the surgeon to the use of nonmagnetic instruments. In a case study, BioScanIR has been used to successfully outline the margins of a brain malignancy. Determination of normal versus abnormal is especially critical in a region where the removal of excess tissue may cause irreversible loss of function. Furthermore, the same imaging technique was used to determine that a particular region of the brain "lit up" in response to physical stimulation of the hand and arm, allowing the surgeon to avoid that area and spare the patient's use of her limb.

In another case study in the monitoring of tumor progression, BioScanIR was used to follow the progress of chemotherapy. In this study, a woman with a moderately sized, aggressive breast tumor was administered the drug Adriamycin, an effective but potentially highly toxic agent, to shrink her tumor prior to surgery. The tumor site was imaged over three cycles of therapy and showed no significant changes in blood perfusion. The oncologist noted the lack of response and switched the chemotherapy to Taxol, and again proceeded with three cycles.

BioScanIR could flag a winning pharmaceutical candidate earlier in the pipeline.

▲ QWIPs enable BioScanIR to safely and frequently monitor tumor growth during chemotherapy, allowing doctors to choose more-effective drug regimens and sparing the patient unnecessary exposure to toxic agents.

Once again, the blood flow to the tumor remained stable, indicating no response and prompting the decision to proceed surgically. The rapid and straightforward determination of tumor response spared the patient the more toxic effects of the drug regimens, repeated biopsies, and numerous MRI studies, and likely also pointed the way to other more-effective post-surgical drug therapies.

Pilot programs

For development and refinement of cancer-related applications, BioScanIR has been installed in pilot programs at Harvard University's Dana Farber Cancer Institute, the University and Hospital Center at the State University of New York (SUNY) at Stony Brook, and the Millard Fillmore Hospital in Buffalo, NY. In addition, Advanced BioPhotonics has entered into an agreement with the Research Foundation of the SUNY at Stony Brook to investigate the use of the BioScanIR in cancer-drug discovery and breast-cancer diagnosis. Other potential uses of BioScanIR include assessment of limb integrity in patients with diabetes complications or other peripheral vascular disorders.

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Fuel Cells for Fueling Stations

Supplying fuel-cell vehicles with hydrogen requires infrastructure, but a new system may produce hydrogen at a fueling station near you.

by Michael Felton/mfelton@nttc.edu

▲ Could this machinery be a fixture at the filling stations of the future? ZTEK's technology, which extracts hydrogen from gasoline or natural gas, may allow hydrogen fuel-cell vehicles to refuel at gas stations.

The anticipated hydrogen economy raises a chicken-and-egg problem. Few consumers would buy a hydrogen-powered car with nowhere to buy hydrogen. Few companies would invest in hydrogen production and distribution without customers.

But ZTEK Corporation (Woburn, MA) has developed a possible solution—a high-temperature solid-oxide fuel cell and integrated steam reformer that could be installed at gasoline fueling stations to produce hydrogen and electricity from natural gas, gasoline, or diesel fuel. The hydrogen could then be sold to owners of hydrogen fuel-cell or hydrogen-burning cars. And, when hydrogen demand is low, electricity could be generated and sold to electric utilities.

Harvesting electricity

The core of ZTEK's system is a zirconia-oxide fuel cell that operates at 900º to 1000ºC. Air enters the cathodic compartment where electrons from the cathode split the oxygen molecule into oxygen ions. The oxygen ions travel through the solid-oxide electrolyte (zirconia) and react with the hydrogen or carbon in the fuel, forming water and carbon dioxide and releasing electrons. Steam and carbon dioxide exit the cell as exhaust, and the electrons are harvested as electricity through external loads.

To coproduce hydrogen, ZTEK developed a steam reformer that uses the fuel cell's waste heat. The reformer and fuel cell are colocated within a container and in close thermal contact. Most hydrogen used in the United States is produced through simple steam reforming. The process uses high temperatures, steam, natural gas, and a catalyst to promote the reaction of natural gas with water, which produces hydrogen, carbon monoxide, and carbon dioxide. Typically, the heat for the reaction and the production of steam is generated by burning additional natural gas. However, ZTEK uses the waste heat and steam from the fuel-cell reaction to increase the efficiency of the process and reduce the reformer's footprint and size. The fuel cell and reformer fit in a 10-foot cube.

Using this method, electricity and hydrogen are generated, providing a fueling station with two additional revenue streams—hydrogen and electricity—from the initial investment. In addition, ZTEK's system reduces the complexity of recovering and sequestering carbon dioxide, resulting in a system that is even more environmentally friendly.

ZTEK has also developed additional ways to use the excess heat in solid-oxide fuel cells. Like others in the field, the company has coupled high-temperature fuel cells with heating and cooling functions for buildings. But ZTEK has invented and patented the first integrated fuel cell and turbine in the world. "Our waste heat directly powers the turbine, and the turbine does not require any net input of fuel," said Michael Hsu, president and founder of ZTEK. According to Hsu, the fuel cell alone is approximately 40-percent efficient in generating electricity, but when combined with an integrated turbine, efficiency increases to 60 to 80 percent, depending on the unit's size.

Demonstrations

In 2002, ZTEK took its first steps into hydrogen production by becoming a member of the California Fuel Cell Partnership, which includes major automakers and energy companies. ZTEK delivered demonstration units for hydrogen production to Pacific Gas and Electric, and the two companies have partnered to open a hydrogen refueling station in San Carlos, CA, in 2006.

In January 2006, ZTEK entered an agreement with the U.S. Navy to collaborate on a hydrogen-fueling project at the U.S. Marine Corps Base Camp Pendleton near Oceanside, CA. When operational, the station will serve both military and commercial hydrogen vehicles in the area.

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Charging Up for a Long Life

Battery-management system could extend life of lithium-ion technology in space.

by Scott Tillett/stillett@nttc.edu

No one knows for sure whether a lithium-ion battery can fly successfully in space for longer than a decade. That's because the technology has been available commercially only since the 1990s, and there's still a bit of a question about how long lithium-ion batteries will survive in the harsh conditions of space.

Compared with nickel-hydride and nickel-cadmium batteries, lithium-ion batteries deliver the same amount of power with only about a third the weight and volume. Such energy density makes them ideal for space missions, since each additional pound sent into orbit can add thousands of dollars in launch costs. But although lithium-ion batteries have proven their mettle on the ground, they must be modified to ensure they can meet the demands of space.

Yardney's lithium-ion battery may last up to 15 years in space.

With MDA SBIR funding, Yardney Technical Products, Inc. (Pawcatuck, CT), is developing technology to enhance lithium-ion batteries for use in military and commercial satellites. The technology, which Yardney is developing through subsidiary Lithion, Inc., should maximize the lifetime of batteries in orbit. The company's work also could lead to enhancements for lithium-ion batteries used in terrestrial applications—in cell-phone towers, automobiles, emergency equipment, and uninterruptible power systems.

Key to Yardney's innovation is a sophisticated battery monitoring and equalization system. The electronics in the microprocessor-based system provide complete cell monitoring and balancing during charge; protection circuitry against overvoltage or undervoltage; monitoring and reporting for current and temperature; and calculation for batteries' states of charge and health. MDA originally funded this technology through two Phase II SBIR awards. Lighter, more efficient batteries with greater durability and longer lifespans could be used in a variety of space-based assets being developed for the Ballistic Missile Defense System.

Longer life

A sophisticated, space-qualified monitoring and equalization system is critical for meeting a battery lifespan goal of 15 years in space. To ensure battery cells function efficiently at all times during that life span, Yardney's system includes individual controls for each cell. This feature allows cells to be equalized at different voltage levels and at different charge/discharge rates.

"The technical side has been a challenge, especially for the development of the electronics," said Dr. Rob Gitzendanner, director of programs and applications at Yardney. "Getting into a 15-year-lifespace battery, radiation and some of the other space-environmental issues become a real concern for an electronics design."

The battery system's design will emphasize flexibility, according to Gitzendanner. He said a user might sometimes need extra power for a satellite—to make changes in orbit or perform other activities. "With the electronics that we're developing, users will have the ability to adjust to that higher voltage and maintain cell equalization," Gitzendanner said.

Yardney continues to work on cell/battery assembly and testing. The company also is investigating new electrode materials that offer increased stability and longer life.

Yardney is seeking new applications for its battery technology as well as subsystems and components that could enhance system capabilities. "We're always looking for good electronics houses, and we are looking for good materials that can increase the [battery] performance," Gitzendanner said.

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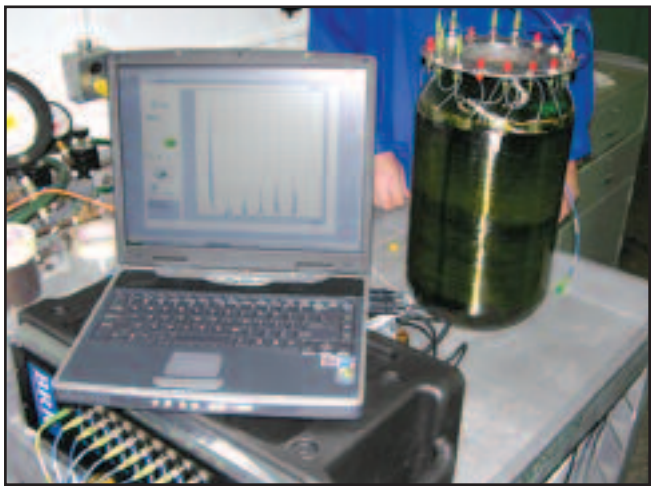
▲ Yardney is conducting MDA-funded research to extend the lifetime of lithium-ion batteries in space. The work could also lead to enhancements in lithium-ion battery technology for terrestrial applications.

No Strain, No Gain

A winning combination of sensor and software now offers a new way to rapidly and accurately assess the quality of materials, without destructive testing.

by Joan Zimmermann/jzimmermann@nttc.edu

Imagine being a manufacturer with a lot of wing parts ready to ship out, and relying on a 2-percent sampling of the lot as a quality-control measure. And to achieve that measure of confidence, you've had to haul your sample of parts to a test facility, and subject them to hours of expensive tests that can vary in accuracy. Conversely, imagine being able to "see" into every single part and within seconds determine its integrity, at less cost, and on-site. With its embedded fiber-optic systems, Blue Road Research, Inc. (Gresham, OR), can provide that alternative scenario.



▲ Robust, real-time fiber-optic sensors and associated software analysis can provide reliable and specific information about the integrity of structures. Blue Road Research is using such technology to monitor bridges.

Multiaxial sensing

Blue Road's expertise in fiber-optic technology has been honed in part by an MDA SBIR contract to detect strain in composite rocket motor casings for missiles. Nick Ortyl of Blue Road credits this SBIR, among others, for a cascading series of refinements that have enabled the company to become a top-notch supplier for both full fiber-optic systems and their individual components. The chief innovation in the MDA SBIR was the use of multiaxial fiber-optic strain sensors, with associated software analysis, to provide a real-time image of strain in composite pressure vessels, yielding more precise information about the location and severity of damage. Utilizing the approach demonstrated during the MDA SBIR, the structure can be monitored as required in service and the damage made by a foot-pound impact located to within a few centimeters of the actual strike. Robust, real-time fiber-optic sensing provides reliable and specific information about the integrity of structures, benefiting industries as diverse as aviation and civil engineering, automobile manufacturing, mining, chemical processing, and pharmaceutical plants.

Embedded fiber-optic sensors can determine wing integrity and fuselage status.

Blue Road's technology can be used in either a continuous or periodic manner to assess the integrity of structures such as roadways, bridges, adhesive joints in aircraft wings, and composite pressure vessels for the next generation of hybrid vehicles. Fiber-optic sensors can be combined with other sensing modes to provide a suite of capabilities, and they are immune to electromagnetic interference while producing none themselves. This means they can be used in hazardous environments where a spark might create an explosion. In addition, repair personnel need not be concerned with electrocution when cutting through optical fibers. Embedded in roadways, Blue Road's sensor systems have been shown to be sensitive enough to detect the presence of individuals jogging on a bridge, and to stratify the classes of motor traffic, distinguishing minivans from SUVs and small cars. Other applications are limited only by the imagination of materials manufacturers.

For composite structures, embedded fiber-optic sensors can also function as quality-control monitors during the manufacturing process, yielding valuable information about how fast and how well the composite material cures. Defects that could make the part more likely to fail can be detected before the part is ever incorporated into a product. Composites are used in countless manufactured items, including the jets that transport millions of passengers per day around the globe.

Improving aircraft safety

In the aviation industry, Blue Road's technology can provide an extra set of eyes for busy ground crews. The wings and body of an airplane are designed to withstand repeated cycles of strain and are regularly inspected. Routine maintenance procedures include visual assessments and other analyses such as x-ray, ultrasound, and infrared imaging.

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Cracking the Code of Legacy Systems

New tool provides 'blueprints' and a process for updating and programming software.

by Scott Tillett/stillett@nttc.edu

Imagine being an architect trying to renovate a skyscraper without the original blueprint. Some programmers today face a similar task when updating old software that, in many cases, was assembled in a piecemeal fashion—without a comprehensive, master diagram.

But a new tool, developed by CohesionForce, Inc. (Huntsville, AL), will allow programmers to more easily diagram and revamp existing software systems, enabling better management of future code modifications. The tool, developed with MDA SBIR funding, also will help programmers diagram and then build new systems from scratch.

CohesionForce calls its new offering a "Programming Support Environment" (PSE). The product is based on the nonproprietary Unified Modeling Language (UML), which allows a user to create an abstract model (a set of diagrams) of a software system.

The company's approach lets software engineers take existing source code and pull information into the PSE, so that programmers can use it to edit or enhance the system. "We start with the source code and walk backward to create these diagrams," said David Phillips, chief technical officer at CohesionForce. "It's for the purpose of getting the information necessary to do the editing that you want to do to that system." Also, in building new systems, CohesionForce's tool can reverse-engineer the final product and then compare it with the original design—to validate the system and see if programmers actually built what they set out to build.

MDA originally funded CohesionForce's UML-based PSE through a Phase I SBIR award. The technology shows promise in dealing with the complex task of upgrading software in legacy weapon systems or migrating software from prototype systems to actual systems in the field.

Looking back

The reverse-engineering or "backward-looking" aspect of the tool is unique, according to Phillips. Existing UML modeling tools allow the user to construct a design of a "new" system and then, in some limited cases, produce source code from the design, he said. But CohesionForce's tool can do the same while also delivering unique capabilities for understanding old or existing systems.

"CohesionForce's PSE concept focuses on supporting existing systems by transforming the 'structural and behavioral' information that is stored in the source code into knowledge about the application and allowing the software developer to manipulate that knowledge at a higher level of abstraction,"

Courtesy of stock.XCHNG

▲ Software can be more easily updated and even re-engineered using CohesionForce's new UML-based programming tool.

Phillips said. "We do this by making a blended model that contains information about not only the structure of the system, but also the behavioral aspects as well."

Also, competing tools usually support only a small set of programming languages, such as Java, C, and C++, according to CohesionForce. But many users, including Defense agencies and other large organizations, have a large bulk of existing software written in Ada and other languages that competing tools will not readily support. And even if language-level support is available (usually through third-party plug-ins), the source code still would need to be changed to support code generation from the tool. Although CohesionForce's tool was originally developed to work with the Ada programming language, Phillips said the technology can be easily adapted to work with other languages, including Java and C++.

Keying in on features

Phillips said the PSE revolves around four key features. First, it provides a graphical environment for analysis and modification of existing source code—in the form of a high-level model for the entire system or application. Second, it maintains a "pedigree," giving users a sophisticated capability to trace back to the original source code and to compare or control various versions of an application. Third, it provides software engineers and analysts with configuration-management tools at the modeling level (such as requesting and

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could meet tight delivery requirements to support the Initial Operational Capability mandate issued by President Bush for an operational missile defense system by September 2004.

"We were able to turn the design around in three months, and produce the first unit in roughly two weeks after manufacturing authorization was received," said Matt Thompson, vice president for missile defense business at Vanguard. In delivering the advanced-composite flange, the companies also exceeded Raytheon's requirements for structural performance by 20 percent, he said.

Coming soon

In addition to the aft flange, Vanguard is developing three other technologies that could work their way into future interceptors. Like the aft flange, the other technologies are polymer-matrix composite structures. The technologies are in various stages of development and assessment. Eventually, the interceptor could make use of material technology hardware being tested for potential inclusion in future interceptor configurations, according to Thompson.

Among the technologies considered for inclusion in the EKV are a sensor sunshade for optical sensors; enclosures and heat sinks for the electrical conversion unit; and a housing for the electronics unit. While these three technologies, as well as the aft flange, are based on polymer-matrix composites, the requirements for each have pushed them all in slightly different directions. For example, stability and permeability requirements have shaped decisions on materials for the sunshade, whereas conductivity and specific-heat issues have influenced the design of the composite for heat sinks.

▲ An advanced-composite aft flange developed by Vanguard Composites Group and V System Composites has been installed in a missile interceptor recently installed at Fort Greely, AK.

Future interceptors may include more Vanguard composite parts.

For missile defense applications, Vanguard officials describe the sunshade as the most promising of the three emerging technologies. In future interceptors, the sunshade, which prevents stray light from interfering with sensor optics, could replace a beryllium sunshade. Beryllium, though lightweight, is toxic if improperly handled and thus increases production costs. It also increases the complexity and lead time of designs. Vanguard's proposed sunshade, however, would offer low weight and stiffness comparable to the beryllium design—without the negatives—as well as offering the potential for additional radiation shielding. The company reports it can produce the sunshade for one-quarter of the cost of the current sunshade.

Meanwhile, the enclosures and heat sinks, as well as the EKV electronics unit housing, promise weight savings of around 35 percent when compared with competing beryllium components. The components also boast a significantly short lead time, reduced cost, and no special handling requirements.

Development path

Vanguard continues to perform qualification testing on the three emerging components, all of which have strong MDA SBIR legacies. "In each case, SBIR funding was key to development of those technologies," Thompson said. With the aft flange, MDA's DEP actually funded initial design and development of the component, followed by additional SBIR funds for continued development.

In developing the composite materials for the various EKV components, Vanguard and V System Composites have gone with a design-to-performance approach. Various details of the same component might require different fibers, according to Thompson. "We don't use just one particular fiber and one particular resin," he said. For example, high thermal conductivity might be needed in sidewalls, so the companies might select a graphite fiber with high thermal conductivity. Meanwhile, the lid might require a fiber exhibiting good stiffness and good heat resistance, with no specific needs for high conductivity. "So we can pick different resins, fibers, and even fiber product forms, to suit the different components as their functions require," Thompson said.

The companies already have two manufacturing patents related to their MDA-funded technologies. Even though the military application is the prime target for the technologies, Thompson said they could be applied to commercial uses as well. For example, makers of enclosures for commercial satellites and aircraft could find the technologies useful. Also, the composites being developed by the companies

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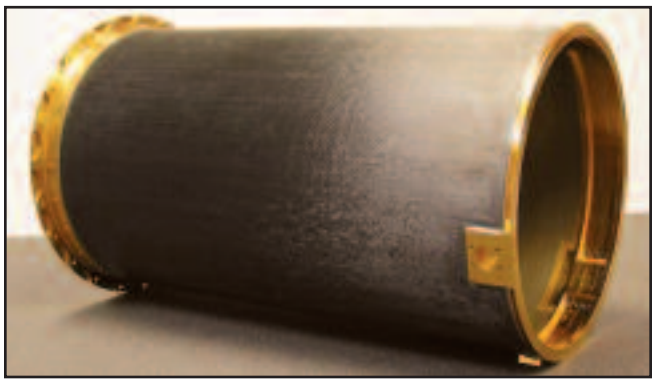
From Research to Reality from page 12



▲ Missile interceptors need sunshades to prevent stray light from interfering with sensor optics. Current sunshades are made with beryllium, which is more costly than other materials. Future versions may be based on Vanguard's advanced composite design.

could prove ideal for the automotive industry, which might use the materials to create multifunctional automobile structures or possibly embedded manifolds.

For Vanguard and V System Composites, challenges remain, however. Thompson said the companies still must seek sources of funding for validation testing. He said the companies continue to look for funding partners interested in investing in technologies that are at an intermediate maturity level.

DR Technologies plans to grow from its current $12 million in annual sales to $30 million over the next two years. Thompson said acquisitions might be part of the growth. "As part of our business expansion plans, we have considered acquiring technology capabilities in line with, yet complementary to, our business expertise," he said. "SBIR development opportunities, as well as the Ballistic Missile Defense System applications, continue to present themselves frequently, and make good use of small-company technology synthesis."

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Q&A: Mike Zammit from page 3

Q: For MDA-funded technology, the time between development and insertion can be quite lengthy. How can companies survive this "valley of death?"

A: To encourage transition of SBIR technology into the BMDS, MDA's Phase II Enhancement policy will match up to $500,000 of non-SBIR/non-STTR investment from a DOD acquisition program, DOD prime contractor, or private enterprise with SBIR funds to extend an existing Phase II project for up to one year to perform additional research and development, in accordance with DOD policy. All applications are subject to review based on the Phase II Enhancement statement of work, transition plan, and availability of funding. Companies need to work closely with the MDA sponsors and the BMDS integrators to develop a transition plan.

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applications in many other fields. Earlier camera developments by Gardner and his colleagues that were funded by MDA's predecessor, BMDO, have been used by Agilent Technologies to inspect circuit boards and by a major pharmaceutical lab to automatically examine Pap smear samples. Salvador is also working on a new medical application, which may be announced in late 2006.

The military and law enforcement communities remain interested in this technology because it can provide high-speed image acquisition without massive cabling. Salvador will soon provide cameras for experimental work in the Air Force's Predator unmanned aerial vehicle. In addition, Salvador Imaging's cameras have flown on an airship for an application related to homeland security, and others are being tested in gimbals placed in aircraft surveillance pods. These systems have fewer cables to encumber gimbal movement and the data can be sent wirelessly.

Salvador Imaging and its predecessors have successfully commercialized a number of high-speed cameras that originated under MDA funding. The company's largest customer continues to be in the flat-panel inspection business, but opportunities in defense, law enforcement, medicine, movies, and as yet unthought-of applications remain on the horizon.

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Fuel Cells for Fueling Stations from page 8

ZTEK is also marketing its hydrogen-production systems to industrial hydrogen users. "We want to sell hydrogen at a good price," Hsu said. "Our operating costs are very low because, compared to electrolysis, natural gas [the fuel for the hydrogen-producing reformer] at this point is the cheapest source of energy and our efficiency is high, so operating costs are actually very, very controlled."

The company's turbine technology will be demonstrated by AT&T to provide electricity for a phone-network switching station. A simple cycle ZTEK fuel cell is currently being demonstrated in Connecticut and previous versions have been demonstrated by the Tennessee Valley Authority.

ZTEK seeks potential customers for its hydrogen/electric and electric (200-kilowatt fuel-cell/turbine-powered electrical generation) systems. ZTEK is also interested in investors and sees opportunities in producing hydrogen for industry and the growing number of fuel-cell vehicles, as well as in the growing market for on-site generation of electricity.

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tracking changes to both the model and the software) that typically are reserved for only software developers at the coding level. And fourth, the PSE allows software developers or managers to "understand" the source code and customize the reports they generate, comparing results against the original design model.

The company continues to look for customers—specifically targeting organizations that have a strong need to verify their software models. Organizations working with older languages and large systems, therefore, are a prime target. Phillips said the tool might also prove useful in educational environments, giving software students a helpful way to view source code graphically as they learn.

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No Strain, No Gain from page 10

▲ According to Blue Road Research, its fiber-optic strain gauges can be used in either a continuous or periodic manner to assess the integrity of structures such as railroad trestles.

Sensors embedded in critical composite structures and joints of the aircraft can provide to maintenance crews an instant snapshot of wing integrity and fuselage status. In this way, fiber-optic sensors add another dimension to aircraft safety by reporting on the internal stresses that occur over time and accumulate to create structural fatigue and damage. Blue Road sensor systems can better locate these areas of damage and provide information on their magnitude.

In addition to its OEM niche, Blue Road also encourages the development of a smarter clientele, and it sells a repertoire of instructional videos and software packages that allow its consumers to learn more about the manifold uses of fiber-optic technology.

And in the future, the sky may not be the only limit for the company. NASA has recognized Blue Road's innovative spirit by honoring its commercial product line with a NASA TechBrief's Top 50 Products of 2005 award, and has expressed interest in the technology for its "Return to Flight" effort. NASA also awarded Blue Road's underlying technology with an Outstanding Poster Presentation at the "Moon to Mars" session at the National Space and Missile Materials Symposium in June 2005. Someday, when astronauts are roughly 35 million miles from the Blue Planet, orbiting a not-very-hospitable red planet, Blue Road sensors might just provide a little extra peace of mind.

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Turning Prototypes into Products

by Fred Patterson

What does it take to turn prototypes into products? "Commercialization requires a significant amount of money," said Fred Patterson, a veteran management consultant who runs SBIRcoach.com. "But it also takes more than money. If you think you're ready to commercialize, it's time to ask some tough questions about the technical, operational, and financial aspects of your business."

Below is a brief checklist that Patterson suggests small businesses should use to look ahead toward commercialization. Properly addressing the "No" answers can make the difference on whether or not you are successful.

	Yes/No	
TECHNICAL	❑	❑ 1. Is the prototype fully functional?
	❑	❑ 2. Will it meet customer needs?
	❑	❑ 3. Can we package it for use by the customer?
	❑	❑ 4. Can we truly produce this product in quantity with consistent quality?
	❑	❑ 5. Are suppliers available for all parts?
	❑	❑ 6. Is our technology difficult to copy/reverse-engineer?
	❑	❑ 7. Are we doing the right things to raise our technology readiness level?
OPERATIONAL	❑	❑ 1. Do we know how to distribute the product?
	❑	❑ 2. Do we have systems and staff in place to manage growth?
	❑	❑ 3. Are the founders equipped to manage the evolving organization—or willing to relinquish control to those who are?
	❑	❑ 4. Can the organization survive the inevitable culture change from a technical excellence culture to a "making the numbers" culture?
	❑	❑ 5. Are we willing to take on new partners who, only being interested in return on investment (ROI), will undoubtedly (and perhaps rightly so) insist on controlling the strategic decisions being made by the board of directors?
	❑	❑ 6. Do we realize that we must still complete all outstanding SBIR contract and grant obligations, even though our new partners are going to consider them a distraction from the ROI mission?
	❑	❑ 7. Will we continue to propose new SBIR business?
	❑	❑ 8. Are we doing the right things to raise our business readiness level?
FINANCIAL	❑	❑ 1. Do we have the financial resources to enable growth?
	❑	❑ 2. Can we maintain a healthy cash flow while we grow?
	❑	❑ 3. Do we know how much invested capital we need to accomplish the technical *and* operational objectives?
	❑	❑ 4. Do we know what sources of capital we will/can consider?
	❑	❑ 5. Will we have to build or acquire other businesses?
	❑	❑ 6. Do we know how much invested capital we should seek?
	❑	❑ 7. Can our pre-investment valuation be justified?
	❑	❑ 8. Is our exit plan (IPO, acquisition, etc.) supported by our business strategy?
	❑	❑ 9. Are we equipped to negotiate the right deals?

BIOGRAPHY

Fred Patterson is the founder of The Commercialization Funding Coach, Inc. His company's well-known registered brands include The SBIR Coach® and SBIR Playbook®. He is the former co-founder and executive officer of two of Texas' most successful SBIR-award-winning companies, SPEC and Radiant Photonics. Patterson teaches companies the SBIR "ropes" and guides them in the process of producing clearly articulated and reviewer-focused proposals. In 2005, he expanded his services to State emerging technology funds as The ETF Coach™, guiding clients through the grant application process for Texas' new $200 million dollar ETF. Patterson also offers coaching in government contracting and accounting, protection of intellectual property rights, Dealsmanship™, and the strategic planning process of raising a company's Funding Readiness Level™.

Tech Trivia

After reading this newsletter, you've stored a lot of new information in your brain. Play our Tech Trivia game to test what you just learned.

1

Tech Trivia

Advanced BioPhotonics' highly sensitive, gallium-arsenide QWIP detector has been successfully used in

A. breast reconstruction surgery
B. chemotherapy
C. brain tumor surgery
D. all of the above

2

Tech Trivia

Which company's product line won a NASA TechBrief's Top 50 Products of 2005 award?

A. CohesionForce
B. Blue Road Research
C. ZTEK Corporation
D. Yardney Technical Products

3

Tech Trivia

Yardney's lithium-ion battery system includes monitoring and equalization capabilities that are critical to meet a space lifespan goal of

A. 5 years
B. 7 years
C. 15 years
D. 35 years

4

Tech Trivia

David Gardner's first company, which he sold to DALSA for nearly $18 million, was named

A. Silicon Mountain Design
B. Summit Imaging
C. Photon Dynamics
D. Salvador Imaging

Answers: 1. D, 2. B, 3. C, 4. A

NOTE: We were unable to print the Winter 2005/2006 issue, but it is available online at www.mdatechnology.com/update

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