ARMY TECHNOLOGY

JULY/AUGUST 2014 | VOLUME 2, ISSUE 4

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FOCUS:

+PLUS

INTERVIEW WITH

DR. THOMAS RUSSELL
ARL DIRECTOR

JULY/AUGUST 2014 | VOLUME 2, ISSUE 4

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ACRONYM GUIDE

AFIRM	Armed Forces Institute of Regenerative Medicine
AMC	U.S. Army Materiel Command
AMRDEC	Aviation and Missile Research, Development and Engineering Center
ARDEC	U.S. Army Armament Research, Development and Engineering Center
ARL	Army Research Laboratory
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
CAD	computer-aided design
CERDEC	Communications-Electronics Research, Development and Engineering Center
CFD	Combat Feeding Directorate
DARPA	Defense Advanced Research Projects Agency
DMDI	Digital Manufacturing and Design Innovation
ECBC	Edgewood Chemical Biological Center
ManTech	Army Manufacturing Technology Program
MOLLE	Modular Lightweight Load-carrying Equipment
MPDL	Medical Prototype Development Laboratory
NSRDEC	Natick Soldier Research, Development and Engineering Center
PED	Production Engineering Directorate
REF	Rapid Equipping Force
RDECOM	Research, Development and Engineering Command
TIRM PMO	Tissue Injury and Regenerative Medicine Project Management Office
TRADOC	Training and Doctrine Command

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DIRECTOR'S CORNER: ADDITIVE MANUFACTURING

Just around the corner at the intersection of the future and the art of the possible lies a technology that may profoundly change Army logistics and supply. 3-D printing promises dramatic results that will benefit Soldiers.

Imagine the possibilities of three-dimensional printed textiles, metals, integrated electronics, biogenetic materials and even food. Army researchers are exploring the frontiers of an exciting technology.

One day, Soldiers will print critical repair parts at the point of need. With the logistics burden lifted, the Army will be able to lighten the load and provide more capabilities at less cost.

3-D printing is the process of making something from stock materials, such as metal or plastic powder, by adding material in successive layers. It's also known as additive manufacturing, or AM. In contrast, traditional manufacturing processes often work in the opposite way, by subtracting material through cutting, grinding, milling and other methods.

As we find stronger hybrid materials that will integrate into a Soldier's kit, we open opportunities to an untapped potential. Our engineers will create new designs not possible by any other manufacturing process.

This future is within our grasp.

However, material and process certification and qualification is a huge challenge. If you talk to anyone associated with AM, you'll find that for the industry to reach exponential growth there must be a level of trust and confidence in critical component parts.

The Army Research Laboratory is working closely with the Defense Advanced Research Projects Agency, or DARPA, to ensure the development of standards to include consideration of Army-specific requirements and applications.

This is one of the pillars of the RDECOM strategy for future AM research investments. We are focused on developing enhanced material performance and design-for-process based on Army needs.

We're also working to establish a comprehensive knowledge base. If we populate a government-owned database, we would have a list of parts indicating where AM is a viable alternative for tool, spares or repair.

Across the command, we have engineers and researchers working to develop rapid prototypes through innovative AM techniques. Organizations from across the government come to our centers and specify their requirements. Our prototype integration facilities use the latest 3-D printing technologies to assist in designing parts that meet fit, form and function.

To meet that mission, we're working closely with industry and academia to advance our machine technology and improve our materials. Some of our centers are actually beta testers for industry prototypes. This symbiotic relationship helps us meet our other goal of being able to transfer Army-developed technology to the domestic industrial base.

RDECOM has been a participant the public-private partnership known as America Makes. The institute, which began as a presidential initiative to jumpstart advanced manufacturing, lays the groundwork to help the nation and the Army as we adopts the digital manufacturing of the future.

Small business is another area where we see potential partners. We hope to partner with machine and material developers to collaborate on next-generation products that will benefit the warfighter.

Additive manufacturing is gathering speed as a viable alternative to traditional methods. The Army will continue to look for ways to embrace new technologies that save money, avoid costs, streamline processes and provide innovative solutions to empower, unburden, protect and sustain our Soldiers.

Dale A. Ormond
Director, RDECOM

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We're always looking for good ideas to help keep our Soldiers safe. If you would like to submit a research or business proposal, business idea, recommend improvements to existing equipment or have a revolutionary idea that may be of benefit to the U.S. Army, please contact:

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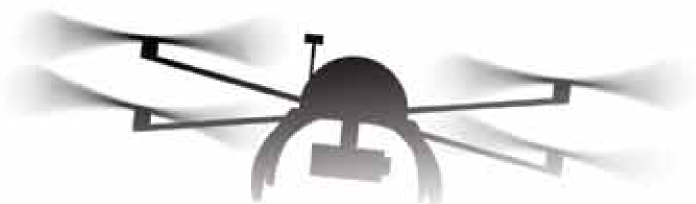

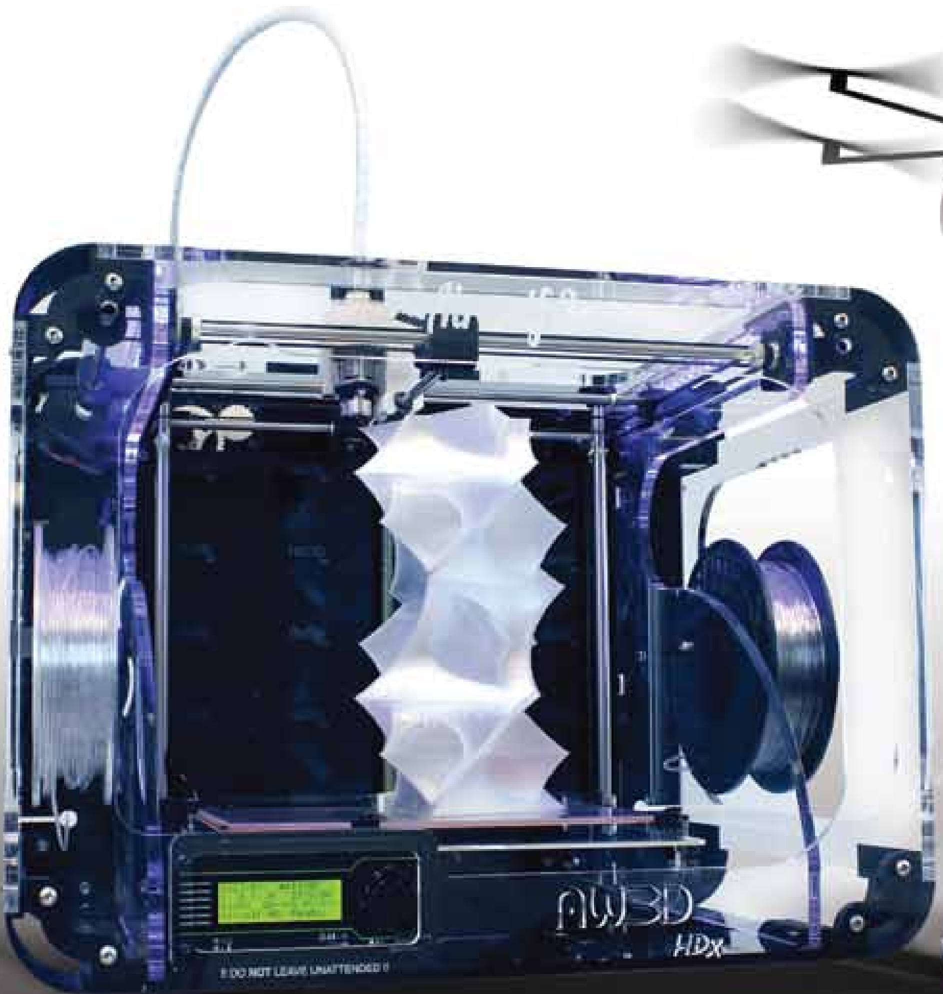

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Research Vision

***ARMY TECHNOLOGY*'S EXCLUSIVE INTERVIEW WITH DR. THOMAS RUSSELL, DIRECTOR OF THE ARMY RESEARCH LABORATORY**

Dr. Thomas Russell is director of the U.S. Army Research Laboratory at Adelphi, Md. Russell started his government career as a research scientist at the Naval Surface Warfare Center, White Oak Laboratory, Md. In 1994, he joined the Naval Research Laboratory where he worked in many leadership positions. In 2006, he moved to the U.S. Air Force where he became director of the Air Force Office of Scientific Research. He was responsible for the Air Force basic research program in aerospace, chemical and material sciences.

Russell has led the U.S. Army Research Laboratory since March 11, 2013. He holds a bachelor of science in chemistry from Muhlenberg College and a doctorate in chemistry from the University of Delaware. He has been a visiting scientist at the National Institutes of Standards and Technology, an adjunct professor at the Washington State University Shock Dynamics Laboratory and a part-time faculty member at Montgomery College.

His principal fields of interest are energetic materials, decomposition and combustion chemistry, detonation physics and chemistry, high-pressure chemistry and physics and spectroscopy. He entered the Senior Executive Service in 2006.

Q: What is the current research strategy for additive manufacturing and 3-D printing?

Russell: I think the vision for the lab is to do research guided by a long-term vision. What we want to do is the same kind of thing we're doing in material design, which is materials by design. In the case of additive manufacturing, it's really about how do we do structures by design. It's a voxel-by-voxel assembly of materials. What that would be in a 3-D structure is placing material location by location and building the fundamental building blocks to actually design structures. For ARL, a lot of it is about hybridization. If I've got to do hybrid materials, how do I actually improve strength, durability and things that are really directed more toward the Army's specific applications? In the commercial world, people are doing similar things, but the Army application typically puts our materials in extreme environments. It's a different set of material science where we're looking toward solving problems.

What 3-D printing and additive manufacturing does is give us a unique approach to begin to design those materials from the foundations as opposed to using traditional processing techniques.

Q: What is the potential of 3-D printing?

Russell: It's an exciting area at the moment. There's a lot of work you hear about in the press about plastics. A lot of people have actually talked about plastic guns and how you can design plastic guns, but there's a lot more than that pushing the frontiers. People today are beginning to do manufacturing of biological materials. In the future through additive manufacturing, we may be able to produce a heart and do transplants. For Soldiers, there are some medical benefits too. Many of the injuries Soldiers receive in the field are not traditional. A lot of the medical community sees this as a new approach to medicine. We can 3-D scan injuries. We can replicate what those injuries are. Surgeons and medics can practice on those specific types of injuries and provide better service to the warfighter.

Logistically there are benefits. One of our biggest challenges in the Army is that there is a huge logistics burden. If we could forward-deploy manufacturing capabilities, we would have the opportunity to manufacture parts in-theater, or repair parts. This is not just about manufacturing a new part, it's often about how we can repair something that has been damaged. We have the opportunity to do that in-theater and use local materials. It's an exciting area. I don't think we've realized its full potential.

Q: How is ARL advancing 3-D printing of super-strong materials?

Russell: One of the things that additive manufacturing does for you is that you can create complex structures that you cannot machine any other way. When you do that, you can create structures that have certain absorption characteristics that you wouldn't have in traditional materials. That would be one way of building protective materials. You take advantage of particular properties of strain and stress and have tetrahedron-type structures where when they get under loading there is a different loading mechanism that absorbs energy and reduces the transmission of that energy into the system. You can do the same thing with other structures with changes in Poisson's ratio so you can absorb acoustic waves and they would transmit in a direction, normal to the direction of loading. We're focused on those areas, but another area in which we're leading is in hybrid approaches and how we bring in dissimilar materials.

A lot of what you hear in the additive manufacturing world is really about a single material or two materials. A question might be, is there a way to begin putting in dissimilar materials so you can make true structures? One example might be if you had a helmet for a Soldier. We would like to put sensors on that. We can 3-D scan that today and get that topological overview of that helmet and then you can put flexible sensors or sensors on top of that surface. With 3-D printing, or additive manufacturing, you can do the same thing by designing the helmet itself. If you make a 3-D contour of that helmet we could then manufacture that helmet with different materials, then embed in that the sensing systems. It's not on the surface it's actually part of the helmet itself. That means you have to start thinking about how to manufacture dissimilar materials together because they are made with all different kinds of techniques. That's where I think ARL is helping to lead in this area, especially in applications of importance to the Army.

Q: Why do you think the Army Research Laboratory is uniquely qualified to research 3-D printing?

Russell: We do it in partnerships. We have joint programs, or joint collaborative activities with small businesses, and with the academic community. I think what we do is bring to bear a set of scientists and engineers, particularly with expertise in materials such as ceramics, polymers, metals, composites, and we understand the Army applications. Because it's a small business set, there really isn't a large commercial market in many of the application areas supporting the Soldier. Because of that, we kind of lead the team. We work with these other communities. We help them to identify the challenges and problems that Soldiers need us to address and we have this in-house expertise that helps coordinate that activity. It's really the best and brightest across the community, not just with ARL researchers, but with our partner researchers. What ARL does is, we're kind of the glue that holds all of that together. We maintain that expertise to support where the Army wants to go.

Dr. Thomas Russell (left), director of the U.S. Army Research Laboratory, discusses his organization's work with Gen. Dennis L. Via (right), commanding general of the Army Materiel Command, at Adelphi, Md., Feb. 7, 2014.

Q: What can Soldiers expect from additive manufacturing and 3-D printing in the next 10 to 15 years?

Russell: Ten to 15 years is actually a fairly short timeline. A lot of the S&T that we do today goes beyond that. I think the number one thing that the Soldier will recognize in the near future is that what we've done in the past is basically hang gear on everything. Whether it's on a tank or on a person, we're hanging things on like a Christmas tree. We treat those structures to be like that. I think what additive manufacturing will do for us is it will enable true integration into the structures. We'll get beyond this constant evolution where we're just hanging the next sensor or the next GPS device. What we'll do is start to integrate into the structures themselves. There will be a lot less weight, better performance, better characteristics of the materials and it will be more integrated as part of the total kit. I think that's what Soldiers will see in the next 10 to 15 years.

Q: Are you optimistic about the future of 3-D printing?

Russell: I'd say I'm optimistic. I agree it's not a silver bullet. There's no one technology that will solve all our problems. The question is, how do I add those technologies together to create the best solutions? Different manufacturing or processing capabilities will create different products. Some of those products will be better than what we generate from 3-D printing or additive manufacturing. But, there are some areas where the products we will produce from this area will be far superior to what you can get with traditional manufacturing techniques. One area in particular is these complex structures. There are many things that we can make today structurally using these techniques that are impossible using traditional manufacturing techniques. There is a place for it. It will solve a lot of problems. It may add a few problems as we go along as well. But that's part of what science and technology is all about. It's about learning where the edges of technology exist and how you probe that edge. I think that's what we're doing with additive manufacturing. We're really probing the edge of manufacturing technology. We don't know where that limit is at the moment. That limit will be different for different materials.

It's an exciting space of research. I do think the potential has not been fully realized. As we move forward, you'll see more and more advancements. Major advancements will come based on the hybridization of materials. It's really where those materials start to overlap and how we can assemble those dissimilar materials where we'll get our major gains over the next couple of years—or the next couple of decades. It's time to move on to the next phase. ■

THE FUTURE OF 3D PRINTING

The Army seeks to expand its role in innovating the advancement of 3-D technology

BY DAVID MCNALLY, RDECOM PUBLIC AFFAIRS

In past 30 years, 3-D printing has transformed from an immature technology with limited applications to being adopted by industry as an enabler for the next generation of products and systems.

In the next 10 to 15 years, experts expect the technology to revolutionize how commercial and defense products are designed, sourced and sustained.

"As the technology continues to mature, the Army must not only closely watch how industry is applying this game-changing manufacturing process, but also have an active role in shaping the technology, applications and reducing the barriers to implementation within Army systems," said Andy Davis, Army Manufacturing Technology program manager. "The benefits of actively participating in the advancement of 3-D printing to the Army are great."

Whether it is manufacturing parts on demand at the point of need, repair of high-value parts at a fraction of the cost and time, or realizing entirely new designs currently unobtainable through traditional manufacturing processes, the Army of the future will rely on this additive manufacturing process, he said.

ADDITIVE MANUFACTURING

Additive manufacturing is the process of building a 3-D structure by introducing material to a space that previously had none. This is opposed to traditional subtractive process, which starts with a block of material and subtracts material until arriving at a target final geometry.

Within additive manufacturing, there is 3-D printing. Davis said the terms are not synonymous.

"You could consider welding to be additive," he said. "You are introducing a filler material into a base material to join them and perhaps build up a surface. 3-D printing is specifically related to taking what looks like a printer, a print head, and you're extruding material, or you are using a laser to melt material and consolidate it, layer-by-layer into a three-dimensional form. It can be metal, plastic or organic materials."

Because 3-D printing is layer-by-layer building of parts, the process is flexible and enables users to produce almost any geometry conceivable.

"Coupled with the reality of being able to minimize or eliminate support tooling, 3-D printing has nearly limitless applications," Davis said.

NATIONAL INTEREST

In 2011, President Barack Obama initiated the National Network of Manufacturing Innovation. This network is part of a larger plan focused on strengthening the U.S. economy by investing in advanced manufacturing. As a result, the U.S. government, led by the Departments of Defense and Energy, established a series of manufacturing institutes, similar to the Fraunhofer Institute model seen throughout Germany.

"These are public-private partnerships focused on specific technology areas really aimed at research and technology development that can be commercialized," Davis said. "The first of the U.S. government-backed manufacturing institutes, known as America Makes, is focused on 3-D printing. The Army has been involved in America Makes from the start. It is a great opportunity to align our expertise, personnel and investments in 3-D printing with what's going on at a national level."

The Army's ManTech Program and Army science and technology community, through the U.S. Army Research, Development and Engineering Command, provides subject-matter experts, requirements, funding and leverages a much larger community of practice to include government, industry and academia.

THE ARMY'S VISION

Requirements drive the Army S&T community. The U.S. Army Training and Doctrine Command looks to the S&T community to inform the establishment of requirements. Army acquisition program managers often turn to the RDECOM community and seek help from Army researchers, engineers and scientists to help meet those requirements.

"3-D printing has been a technology and a capability that, by and large, has moved forward without requirements," Davis said. "It can do a lot of things. It can do everything, depending on who you listen to. Should it? No, it probably shouldn't do everything."

Future requirements under development at TRADOC may include the capability for a Soldier to download a part file out from a master parts library; print the part; take the part off the machine; put it on a system and accomplish his or her mission.

"That's the vision," Davis said. "The Army must focus on technology development and policy advances to achieve this vision. From a technology and processing standpoint, 3-D printing is limited based on material properties and structural strength of the end item being produced.

"Take the drive wheel on a tank, for example," Davis said. "It is forged from a very specific alloy of steel or aluminum, which gives it specific properties. This part has been tested and qualified and validated that the design, material and process are correct given the requirements. You may not be able to get those material properties and performance from a 3-D printing process."

If one starts with a powder versus a block of metal that is hammered into a final shape, the process is inherently different from the traditional manufacturing process.

"As a result, there are differences in what the end product will be," he said. "Policy also dictates some of the barriers to implementing 3-D printing as a viable manufacturing solution across the materiel enterprise. Specifically, part and process qualification rise to the top of the list of challenges. Set 3-D printing aside. If you want to change something that was an aluminum honeycomb structure to a composite structure, it is challenging and expensive. It is time-consuming and very costly to get through a flight certification process for a traditionally manufactured part. Now you're introducing not just a new part that's been made using traditional manufacturing processes, you're introducing a whole new manufacturing process that's not yet well-characterized. Our acquisition policy must reflect new ways of dealing with this challenge."

3D modeling artist Ryan Gilley (left) laser scans a protective mask as Rapid Technologies Branch Chief Rick Moore reviews the results on-screen.

3-D modeling artist Ryan Gilley displays some of the products he designed and printed using advanced manufacturing techniques at the Edgewood Chemical Biological Center, Aberdeen Proving Ground, Md. (U.S. Army photo by Tom Faulkner)

ARMY FOCUS AREAS

"The Army needs to be looking at the parts and the materials for our systems that go above and beyond commercial industry needs," Davis said. "We must develop the material data sets, processing parameters, and library of parts that are approved or qualified using a certain process. We need a central repository for the digital part and processing data necessary to build and maintain our systems. We need to have control over that so that there's not long-term uncertainty in sourcing those parts. We need to be able to disseminate this information to users in the depots and in the field.

"We have parts that come back from the field because they are slightly worn," he said. "Consider the main rotor shaft for a helicopter—to replace one can cost tens of thousands of dollars and may take several months depending on the supply chain. Imagine the savings to the Army in terms of operational availability and cost if those parts could be repaired, in the field or at a depot, using 3-D printing technologies."

RDECOM has teams working with Army depots to do just that, but more effort is required to qualify these processes, Davis said.

THE FUTURE IS NOW

The Army will get to a point where it can print and build parts using additive processes that are combined with subtractive processes, Davis said.

"Someday that will all be integrated. It will be the right part, right off the machine, all the time. But, that is a ways off," he said. "RDECOM needs to be looking at the materials sets and the requirements. We need to partner with the commercial and defense industrial base, with academia and with other government agencies to address technology and policy challenges.

"We also need an industrial base that is capable of making things for us. The future of an integrated additive-subtractive manufacturing industry that enables Soldiers to manufacture finished end-items at the point of need begins with the Army focusing on 3-D printing technologies and policies to enable the use of these technologies today."

3-D PRINTING BENEFITS FOR LOGISTICS

ARDEC investigates how 3-D printed metals could transform Army logistics

BY TIMOTHY RIDER, ARDEC PUBLIC AFFAIRS

A Soldier at a forward operating base needs the proper form to recommend an award for a fellow Soldier. He goes online, opens a form, fills in the blanks and hits "PRINT."

Easy.

Another Soldier at a FOB needs a part for a weapon trigger assembly. Spare parts are not in storage. He goes online, opens the computer-aided design, or CAD, file for the trigger assembly and hits "PRINT."

Impossible.

Not to quibble, but James Zunino, a materials engineer for the U.S. Army Armament Research, Development and Engineering Center, would say that printing gun parts is no problem; it's just not possible to print qualified gun parts to military standards...yet.

"We've made a lot of parts and prototypes," Zunino said during a discussion about printed metal parts. But none of the parts have undergone a rigorous process to determine whether they were suitable to replace actual weapons parts.

"In theory, if you have a certified operator, certified materials and a certified printer, you can make qualified parts," Zunino said.

In today's Army, certified materials and printers to make qualified parts don't exist. However, uses for additive manufacturing and 3-D printing continue to develop. Zunino explained that metal parts are made using additive manufacturing in the medical and aviation industries.

Those materials are too obscure and expensive for military application now, but Zunino and his colleagues at Picatinny Arsenal, N.J., are laying out steps that would make it possible for a Soldier to print qualified metal parts to get parts faster while saving the Army money.

Zunino's colleague, Elias Jelis, is working on a doctoral project to qualify and set the parameters for a specific steel alloy additive manufacturing process using what's known in the industry as 4340 steel.

"Once you establish the process of qualifying one material you can use it to qualify another," Zunino said.

ARDEC engineers may also qualify 4140 steel, another alloy used in gun barrels, warheads and munitions parts, and others. They would then make parts from the metals and compare them against existing parts.

In such a comparison, data would be built on the structural differences between printed and machined parts, which would contribute to the effort to eventually qualify parts made from a 3-D printer.

Additive manufacturing is defined as a process of making devices or objects with an additive process, where successive layers of material are added or laid down in different shapes, rather than conventional subtractive processes that include removal of material such as machining, cutting, drilling, etching and carving.

Additive manufacturing of metals is often accomplished with help from laser-induced heat, called sintering, which bonds metal particles together to form the object being printed.

Because of the way the material is applied in successive layers, printed materials have strengths in different orientations than from currently manufactured parts, Zunino said. Knowing these characteristics, engineers might orient the way the object is printed so that the qualities of the printed part are consistent with the strength characteristics of a functional, durable part.

The effort to develop additive manufacturing for the Army would be worthwhile. Zunino asserts that the technology may well have a significant impact one day on how the military provides specialty tools, custom parts and replacements for obsolete parts to deployed Soldiers, who are often at remote FOBs.

"If you are a Soldier in a FOB in Afghanistan, everything is different," Zunino said. "It's not as easy as running down to the Home Depot and picking up a screwdriver."

Today, to get a spare part or tool delivered to a forward-deployed Soldier, the part left a warehouse and was delivered to a shipping port or airport where it departed for an overseas journey. It was received, and then joined a convoy with security personnel or was taken by helicopter to the distant location.

In any significant deployment, an untold numbers of parts, tools and spares add up to comprise a military logistical tail.

"Those costs add up," Zunino said. "When you add all the transportation costs, fuel, security, it then might be cheaper to be able to print one."

An imaginative future with additive manufacturing might reduce the logistical tail to the raw materials the printers require to function.

Not all replacement parts are simple, one-piece metal items. Many parts are comprised of multiple materials and include electronic components.

Zunino points out that there are many ways that items can be produced using additive manufacturing. 3-D printers can also be used to make molds, which can be used to create plastic injection molds or metals casts for objects like exhaust manifolds, Zunino said.

Additive manufacturing processes may also be combined with subtractive processes such that a metal object can be printed and then machined to obtain a desired shape.

3-D printers can produce metallic shapes that are impossible or far more expensive to produce when using machine tools. Examples of such shapes include square holes, holes within cylinders and zigzag channels.

The boundless potential of the shapes made possible by additive manufacturing inspires design engineers.

"We're already getting CAD designers to think in 3-D," Zunino said.

Top: *James Zunino, Picatinny materials engineer, displays an object that was created by an additive printing process. 3-D printing gives engineers the flexibility to quickly print items of various shapes, materials and structure. (U.S. Army photos by Erin Usawicz)*
Above: *James Zunino, Picatinny materials engineer, displays a modular tool that can be added onto the Multi-Axis Modular Manufacturing Platform for additive manufacturing. Different tools allow the machine to perform different manufacturing techniques.*

Warhead designers attempt to create blast effects that meet specific criteria, explained Zunino. They may want blast fragments of specific sizes to radiate in specific directions such that their blasts can most effectively destroy desired targets.

"Once you get into detonation physics you open up a whole new universe," Zunino said.

The limits on what can be produced using machine tools limit warhead shapes. By lifting limitations through the expanded capabilities that come with additive manufacturing, space is used more efficiently.

"The real value you get is you can get more safety, lethality or operational capability from the same space," Zunino said.

Zunino and his colleagues are also developing manufacturing processes that bring together printed metals, printed energetics and other materials layered onto substrates into the many components that comprise an "initiation train" in munitions. The term describes how primers, fuzes and explosives are arranged to facilitate how a device goes from being safe, to armed and, ultimately, initiated.

Those efforts may transform a supply base that is ground in the industrial age. The current industrial base for these processes, think of traditional watches with springs and gears, were developed in the World War II era and before, according to Zunino.

"You can vastly simplify the manufacturing of energetic materials by printing them," Zunino said. "When entrepreneurs can begin to inexpensively produce their dreams, additive manufacturing will help revolutionize the industrial base and the manufacturing revolution will begin."

3-D COMPOSITES

Scientists break new ground with 3-D printing composites

BY T'JAE GIBSON, ARL PUBLIC AFFAIRS

When Army research and development investments in additive manufacturing pay off, future warriors who need hard-to-get devices, such as unmanned aerial vehicles or medical devices, may be able to print them on the spot.

Scientists from the U.S. Army Research Laboratory are searching for materials and technology to create multifunctionality. Larry R. "LJ" Holmes is the principal investigator for the lab's additive manufacturing material and technology development.

"DoD can't afford to wait for commercial industry to create this capability. Industry doesn't inherently understand our specific needs without ARL research informing them," Holmes said.

Holmes received a patent for a novel additive manufacturing technology used to create micro-composites, which can be tailored for specific end-use applications that require high-strength lightweight materials. The Field-Aided Laminar Composite, or FALCom process. Holmes worked in collaboration with the University of Wisconsin-Madison to address the defense science and technology community's need for agile manufacturing of systems.

The process uses electric fields to align and orient particles within a polymer system at any location and desired orientation during the additive manufacturing of a three-dimensional object. FALCom allows for a high degree of design freedom, especially with weapon systems like rotorcraft, which are tight on space. Holmes said the process is used to support personnel protection programs and has garnered interest from the Rapid Equipping Force. The REF harnesses current and emerging technologies as solutions to deployed Soldiers' urgent needs.

"FALCom can be used to make multi-functional parts," Holmes said. "Anytime we can add multifunctionality, we are helping with space and weight savings. Embedded sensing, embedded heat-sinks and embedded electronics – all of these things help with trade space. FALCom offers a way of making these types of things with regard to 3-D printing," Holmes said.

Historically, 3-D printing has relied on commercially available materials like polymers, and it was used primarily for prototyping. For years, trends have moved toward total manufacturing, like building engine parts and robotic components with 3-D printing, said Dr. Jaret Riddick, a team lead within the ARL Vehicle Technology Directorate.

Riddick and Holmes, along with research engineer Ed Habtour, are among a cadre of scientists and engineers at Aberdeen Proving Ground, Md., investigating the development of materials and technologies that could be transitioned to industry or military program managers who make decisions about Soldiers' equipment.

"We can 3-D print structures with wiring, sensors or energy storage embedded in the structure," Habtour said. "It reduces weight."

Habtour uses 3-D printing to develop and transition technologies to other military organizations and small businesses based on the maturity of the technology.

Riddick said if these materials are to be used to manufacture real parts, as opposed to prototypes, the material properties must be well understood.

"The actual process of 3-D printing changes the properties," Riddick said. "For some processes involving metals, the temperature, spot size where the printer's laser points to melt the metal or the architecture, how the object is built one layer at a time, horizontally versus vertically, changes the material properties and performance."

Last fall, Army and Purdue University researchers, created a structure using brittle 3-D-printed materials with pseudo-ductile behavior, "which is somewhere between brittle and flexible," Habtour said.

Exploiting the pseudo-ductile behavior of logical structures, known as topologically interlocked structures, researchers showed improvements in energy absorption and dissipation, productivity and lower maintenance costs. The team developed computer models using commercial and open source code to provide an automated process for auto-generation of the geometries, models, materials assignments and code execution, Habtour said.

"The benefit for the Soldier is an aftereffect," Habtour said. "[It] would provide an excellent energy absorption and dissipation mechanism for future vehicles using additive manufacturing."

Army researchers used the fused deposition modeling 3-D printing process to create a structure with good energy absorption from materials that do not exhibit good absorption.

"Now we have a modeling tool, which wasn't available before," Riddick said. "We're planning to ultimately reduce maintenance and logistics burdens by being able to deploy the capability to produce the products for repair on-the-spot, rather than transporting them from far-off locations."

Riddick said a collaboration with Howard University is under way to build upon these results by measuring dynamic response of 3-D printed polymer materials fabricated with this process.

The Army Research Office funded Howard researchers to investigate high strain rate properties of materials. Results of testing show that dynamic response of the structures can be manipulated by 3-D printing.

"The challenges of moving additive manufacturing from a prototyping technique to an actual manufacturing capability are rooted in basic scientific research and fundamental advances," Riddick said.

"Additive manufacturing has the strong potential to increase the military's agility and efficiency but this is not exclusive to America," said Dr. Jeffrey Zabinsky, chief of ARL Materials and Manufacturing Science Division.

Zabinsky said 3-D printing may also provide adversaries with capabilities they have not had in the past.

"We will need to close the gaps and stay several steps ahead of our adversaries," he said.

OPEN MANUFACTURING

DARPA seeks advanced manufacturing standards

BY DAVID MCNALLY, RDECOM PUBLIC AFFAIRS

Since the early 1970s, the Defense Advanced Research Projects Agency, known as DARPA, has been making investments to jump-start additive manufacturing. However, rapid adoption of advanced manufacturing techniques continues to face steep barriers as the industry seeks confidence that critical parts will perform as predicted. This led DARPA to focus on how to ensure that the technology meets the technical expectations of the marketplace.

“We looked at setting up the Open Manufacturing program to see if we could build more confidence in these manufacturing technologies so that we can actually realize their potential,” said Michael "Mick" Maher, DARPA Open Manufacturing program manager.

Maher said metallic parts created through additive manufacturing, known as AM, have typically been used for rapid prototyping, not for the actual manufacturing of products.

”Improved build capabilities and expanded material palette have led to enhanced focus on using metals AM for rapid manufacturing of optimized parts intended for actual use in platforms, including rotating turbine engine components and critical load-bearing aircraft structures. But, metals AM still faces barriers to gaining acceptance,” he said.

For the past two years, DARPA has been developing a methodology and framework for building confidence in these new manufacturing technologies. The agency set up and funded two manufacturing demonstration facilities, known as MDFs.

The MDF located at the Pennsylvania State University Applied Research Laboratory focuses on additive manufacturing.

“At Penn State, they actually assess the technologies,” Maher said. “There are a lot of different types of additive manufacturing. Penn State has the capability to assess the strengths and weaknesses of each approach. They are also the facility that curates our process models. As people begin to develop new modeling techniques, they always want to know: Where do I use this? Why is this one better than the other? Penn State becomes my trusted agent that allows me to do that assessment.”

The other MDF, located with the U.S. Army Research Laboratory at Aberdeen Proving Ground, Md., supports a bonded composites effort.

“What is particularly important to the additive community is that the ARL MDF is also the place where we store our material and process data,” Maher said. “For a long time, government agencies would buy material analysis. We wouldn't buy the actual raw material data and the pedigree that goes with it. The ARL MDF becomes a facility that now, whenever the government is generating data, they will be able to store it and make it available for other government agencies.”

DARPA hopes to help create a definitive knowledge base for the entire industry. “One of the things we have been doing is working with the America Makes manufacturing institute,” Maher said. “They are utilizing our framework and our database as the basis for what they're doing.”

America Makes is the presidential initiative to create a publicprivate partnership to create advanced manufacturing techniques and empower the U.S. economy.

DARPA is also working with industry to develop rapid qualification methodologies and frameworks.

“With Open Manufacturing, we are highly optimistic,” he said. “We are coming out of our phase one and looking at the results that we are getting from our performers. Honeywell is working with the direct metal laser sintering process, and Boeing is working with the electron beam additive manufacturing process. In both cases, we are extremely pleased with the results, which we see as being able to predict performance based on our probabilistic models and the rich material and process information.”

Building confidence in critical parts created with new technologies and rapid qualification of these procedures are still major challenges.

“From a DARPA perspective, we invest in revolutionary, high-risk, high-payoff programs. The last investments in additive manufacturing, before doing the Open Manufacturing program, were probably 10 to 15 years ago. We got back into it because we saw there were challenges that needed to be addressed.”

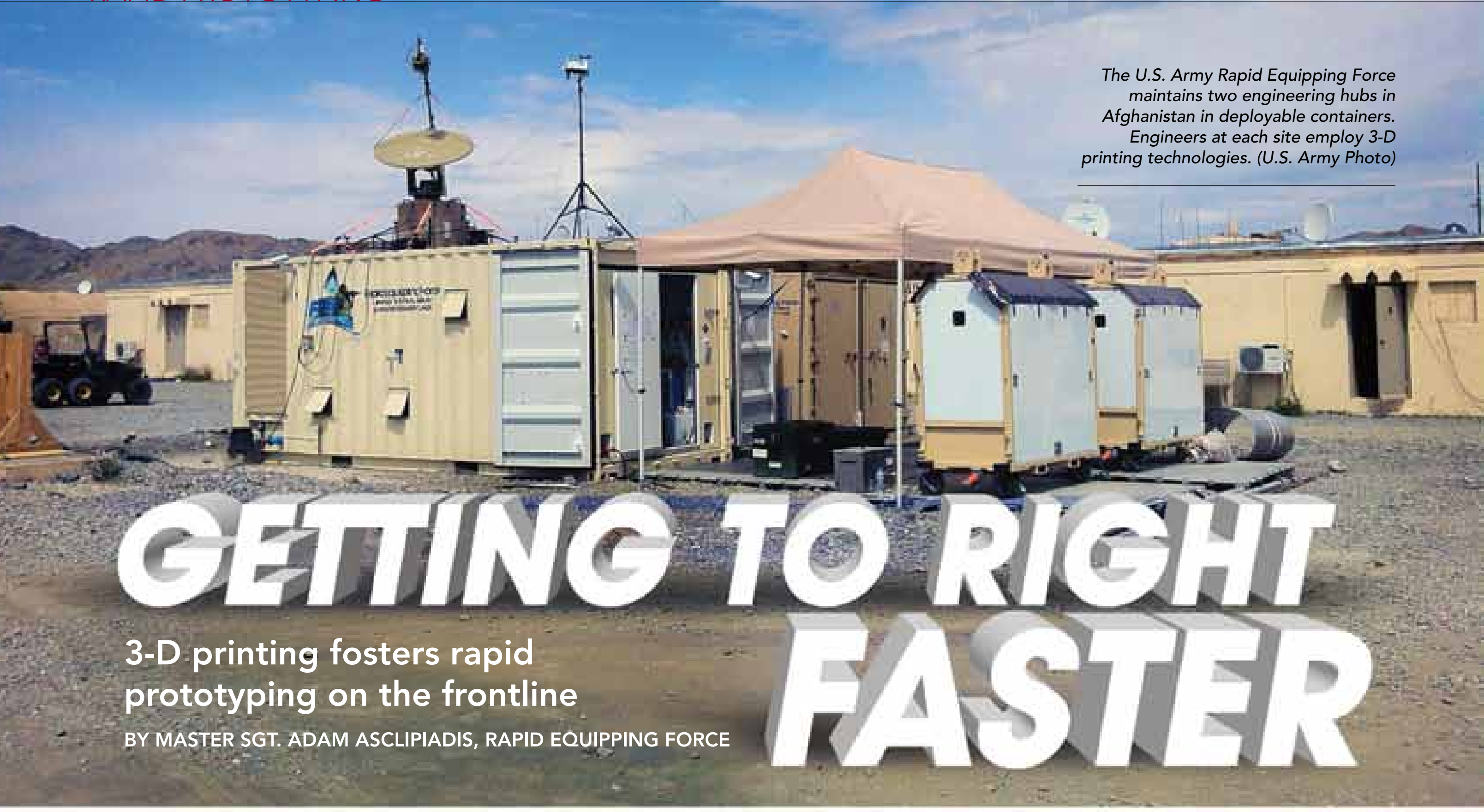
In the future, DARPA hopes designers and manufacturers will embrace the new capabilities afforded by additive manufacturing and the actual production process will become transparent to the end user.

The DARPA Open Manufacturing program will continue its quest for two more years during phase two.

“To fully implement, we have a plan that goes out another yearandahalf after that,” Maher said. “One of the things we’re doing to ensure that we get adoption of the technology is by including an expert panel to provide some informal feedback for the Open Manufacturing program.”

The expert panel includes members from the Service science and technology communities, certification authorities, the U.S. Army Manufacturing Technology Program, Federal Aviation Administration, National Aeronautics and Space Administration, and U.S. Army Evaluation Center.

“They know what’s coming down the road and they are aware of our capabilities and what we’re doing with the technology,” he said. “That’s one of the reasons we’re very confident that people are going to adopt these techniques in the future.”



The U.S. Army Rapid Equipping Force maintains two engineering hubs in Afghanistan in deployable containers. Engineers at each site employ 3-D printing technologies. (U.S. Army Photo)

GETTING TO RIGHT FASTER

3-D printing fosters rapid prototyping on the frontline

BY MASTER SGT. ADAM ASCLIPIADIS, RAPID EQUIPPING FORCE

Combat frequently presents unexpected challenges, demanding rapid solutions. When faced with unique problems, Soldiers often devise quick fixes out of readily available materials. Whether minor changes to procedures or small modifications to equipment, adaptation routinely occurs at the tactical level on the battlefield.

Additive manufacturing, an evolving technology to create 3-D objects by printing layer-upon-layer of thin material, demonstrates the potential to empower such Soldier innovation and foster frontline agility. One organization, the U.S. Army's Rapid Equipping Force, known as REF, found a practical way for deployed units to take advantage of additive manufacturing technology in Afghanistan.

EXPEDITIONARY PROBLEM SOLVING

As part of its mission to equip, insert and assess emerging technologies and rapidly address capability shortfalls, the REF deploys small teams of Soldiers and civilian engineers to forward locations. These teams interface with deployed units, canvass the battlefield for emerging requirements, facilitate solutions and oversee REF products in theater. Before 2012, teams created solutions for Soldiers in workshops located on large forward operating bases; however, engineers faced a limitation. Each hour spent traveling to units in remote locations represented lost design and engineering time.

The REF inserted two, 20-foot, containerized mobile Expeditionary Labs, or Ex Labs, to deploy to units in isolated locations. Just like REF headquarters, the labs support requirements, solutions and limited development or integration efforts. Each lab includes a Stratasys Fortus 250mc 3-D printer, a computer numerical control milling machine, an array of fabrication tools, electrical diagnostic equipment, software programs and a global communications system to connect forward teams directly with REF leadership and other partners.

"The idea with the labs is that REF brings scientists and engineers to the Soldiers, even those in austere locations," REF Director Steven Sliwa said. "Any Soldier can come to the lab with a problem, and our experts will help them determine a path forward. Perhaps there is piece of kit in the REF inventory that will work; perhaps the lab can design and prototype a solution; or the Soldier may need to submit a 10-liner requirement document so that REF can procure a corresponding off-the-shelf solution."

The 3-D printers and modeling software, both critical Ex Lab components, allow REF engineers to quickly design and validate a solution concept prior to any manufacturing decision.

First, REF engineers work directly with the Soldier to understand the challenge. Then, they virtually design a prototype solution, incorporating the Soldier's unique ideas and concept for operations. The REF engineers 3-D print plastic mock ups and deliver them to the requesting unit for immediate feedback. This allows Ex Lab personnel to ensure proper form, fit and function with the end user up front.

As solutions are being worked daily downrange, the labs use their reach-back support to provide weekly updates to both REF HQ and the Army Test and Evaluation Command for guidance and oversight. Most solutions require three to five iterations before reaching the final prototype. By using forward 3-D printers, the engineering teams are able to print, assess and turn around follow-on plastic prototypes, sometimes in only a few days.

When multiple iterations are required for a customer in a remote location, this prototyping method saves time and money when compared to other options.

PARTNERSHIPS TO PRODUCE SOLDIER-INSPIRED SOLUTIONS

The REF owns five 3-D printers—the two in Afghanistan and three at their headquarters at Fort Belvoir, Va.—all of which print solely in plastic polymers, suitable for prototyping. While the labs can create one-off, low-volume orders for simple, plastic components, REF prototypes are typically the first step and often require external validation and manufacturing.

For example, when a unit approached the lab for help with the Mine Resistant Ambush Protected vehicle, REF partnered with two key organizations to solve the challenge. The tire inflation systems on the MRAP deflated when rocks or fixed objects damaged the valve stem. The solution began as a simple cap made using the 3-D printer and, by the fifth and final version, it morphed into a metal cover that could easily attach to existing bolts on the wheels. To meet the number of incoming requirements, REF needed more valve stem covers than the lab could quickly produce with a single CNC machine, so they also worked with the forward-deployed Research, Development and Engineering Command Field Assistance in Science and Technology Center to quickly fabricate 25 sets.

In concurrent discussions with Project Manager MRAP, REF learned that a wheel redesign effort was already under way; however, it would take more than a year to outfit all vehicles in theater. PM MRAP recommended REF continue to bridge the immediate need until the long-term solution could be implemented. From beginning to end, the entire design, manufacture and delivery took less than five weeks.

"You can see how the printer allowed us to get to right faster," REF lead scientist Dr. Karen Harrington said. "We were able to print it, try it and then get it right, while bypassing all of the shipping time and costs associated with trying to iterate from across the ocean."

3-D PRINTING IN SUPPORT OF FORCE 2025

REF Ex Labs demonstrate the ability to containerize, deploy and operate these systems in a combat environment. While the 3-D printing is a key asset, the REF director emphasized that it is the staff—two engineers, a senior operations advisor and a noncommissioned officer—and not the fabrication tools that are the key to its forward success.

"The Army's most valuable assets are Soldiers and in the REF Ex Lab, the people are the greatest advantage," Sliwa said. "When you combine an experienced NCO with talented designers, you can empower a Soldier and take his good idea and turn it into a solution in real time…that's pretty powerful. The 3-D printer is important, but it is just one important tool in the toolbox."

There are known limitations and unanswered questions with regard to future Army widespread use of 3-D printers. Small solutions can take several hours to produce, and some printing materials require stable, sterile environments and specific material handling during transportation and storage. The established polices for testing, training, contracting and intellectual property impact how this technology can be used in the field today. Extending the use of 3-D printers to unit-level for design and manufacturing will only exaggerate these issues. The Army will have to reexamine existing policies to maximize 3-D printing benefits in the future.

Over the past two years, REF adjusted to these limiting factors while executing Ex Lab initiatives. The organization collaborates with the Department of Defense Manufacturing Technology Program; Department of Homeland Security; Department of Energy; and the Armament Research, Development and Engineering Center on these issues at the lower levels. REF is supporting an active ARDEC initiative to establish an Army catalog for 3-D modeling files, and will upload more than 70 original files from the Ex Lab projects in the coming months. They are also partnering with other government agencies, such as DHS, for support. Though these efforts are in the early stages, if realized, the approach could promote interagency information sharing on emerging technologies, prototypes and 3-D printable files.

During missions, an exposed valve stem could cause tires to deflate when damaged by rocks or fixed objects. Using 3-D printed prototypes, engineers fine-tuned a solution, which was then milled using traditional manufacturing techniques. (U.S. Army photo)

REF officials believe additive manufacturing is a proven and rapidly improving capability that will become even more valuable as more readily available systems provide greater printing capabilities at lower costs. The next generation of Soldiers will grow up with this technology in their schools and universities and will expect the capabilities that 3-D printing provides.

The Army must be prepared to empower our greatest asset, the Soldier, particularly those deployed, who have the greatest understanding of warfighter challenges and how to solve them, Sliwa said.

"I think the question is not if the Army wants to use this technology, but how does it plan to employ it in the future?" Sliwa said. "REF is not the lead organization for the Army on 3-D printing, but we are here to support our partners. We have valuable lessons learned from nearly two years of printing in theater that can aid the doctrine, organization, training, materiel, leadership and education, personnel and facilities discussions that must take place today if we are considering widespread use by Force 2025."

As one of the first organizations to take 3-D printing to combat, the REF believes there will be long-term applications for this capability on the battlefield in the future.

When the Army transitions from Operation Enduring Freedom, REF will continue to support rapid innovation and deployed units globally with the Ex Lab and its 3-D printing capability. ■

Medical Applications for 3-D

Army invests in 3-D bioprinting to treat injured Soldiers

BY DAN LAFONTAINE, RDECOM PUBLIC AFFAIRS

A team of scientists scans the surface of severely burned skin, creates a three-dimensional map of the wound with a laser, and then prints skin cells onto the patient using a 3-D bioprinter.

Medical specialists are developing methods to transition this research from the laboratory to clinical trials.

The U.S. Army is a significant proponent and investor in regenerative medicine and 3-D bioprinting, according to officials. Scientists are aiming to advance this new research area to help injured service members recover from the wounds of war.

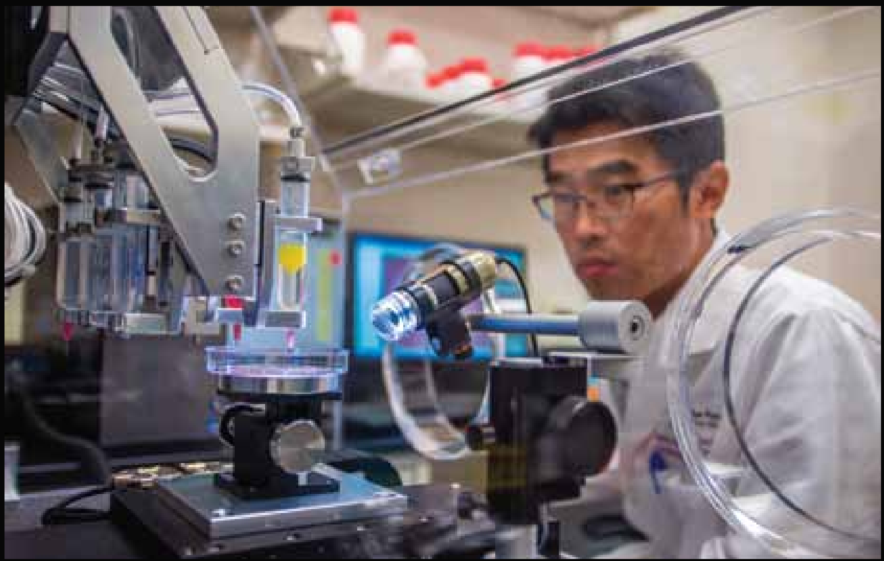
Dr. Michael Romanko, who provides science and technology management support for the Tissue Injury and Regenerative Medicine Project Management Office with the U.S. Army Medical Material Development Activity, said that improvements in body armor, vehicle design and advanced medical care during the past decade led to Soldiers suffering injuries that would have caused fatalities in previous conflicts.

Blasts from improvised explosive devices have increased the number of Soldiers experiencing the loss of limbs, catastrophic injuries to the face and severe burns.

"There was an increasing need to deliver therapies for wounded warriors. We saw a spike in the severity of the trauma that these Soldiers were receiving. As we increased the quality of battle armor, the injuries they were surviving were that much more debilitating," said Romanko, who holds a doctorate in molecular medicine.

The Department of Defense, in turn, established the Armed Forces Institute of Regenerative Medicine in 2008. Regenerative medicine aims to replace or regenerate human cells, tissues or organs to restore or establish normal function.

The AFIRM is a multi-institutional, interdisciplinary network of universities, military laboratories and investigators under the framework of a cooperative agreement, Romanko said. The network is designed to promote integration of development, from basic science research through translational and clinical research, as the best means of bringing regenerative medicine therapies to practice.



Research fellow Dr. Young Joon Seol works on a project to print experimental muscle tissue for reconstructive surgery. (Photos courtesy Wake Forest Institute for Regenerative Medicine)

The success of the first five years of the AFIRM led to the competition of a new cooperative agreement in 2013, he said.

3-D bioprinting is one tool that scientists are developing in the field of regenerative medicine. It is an early discovery technology being used to address extremity injury and skin, genitourinary and facial repair by AFIRM investigators.

Skin repair is the most robust focus area addressed in the regenerative medicine portfolio, Romanko said.

"The scars that Soldiers develop as a result of burns constrict movement and disfigure them permanently. The initiative to restore high-quality skin that is elastic and complete with sweat glands, appropriate pigmentation and hair follicles is incredibly important," he said.

***Left:** Scientists at the Wake Forest Institute for Regenerative Medicine print ear, finger bone and kidney structure scaffolds using a 3-D printer.*
***Right:** A 3-D printer prints a kidney structure.*

Romanko described how researchers are currently using 3-D bioprinters for skin repair research.

In translating this technology to the clinic, scientists will take healthy cells and, using a device similar to an inkjet printer, load the cartridges with two types of skin cells—fibroblasts and keratinocytes—instead of ink. Fibroblasts make up the deep layer of skin, and keratinocytes compose the top layer.

After the team completes a scan of the burn and constructs a 3-D map of the injury, the computer tells the printer where to start printing and what type of cells to use, depending on the depth of the injury and the layer being reconstructed. The bioprinter deposits each cell precisely where it needs to go, and the cells grow to become new skin.

Early research results are promising, and scientists hope this could be a viable solution in the future, Romanko said.

Addressing the need for skin repair is important because burns account for 10 percent to 30 percent of battlefield casualties. The precision available through 3-D bioprinting allows for a custom solution for each patient.

"Everyone has a different type of injury, and not everyone's skin injury looks the same. Skin bioprinting would provide a scalable form of personalized medicine," Romanko said.

An additional goal in regenerative medicine is bioprinting organs, limbs and vascular systems. Other early discovery 3-D bioprinting projects within AFIRM have focused on the generation of complex tissue components with bone and muscle.

3-D bioprinting is still in the early stages, Romanko said. More laboratory research is necessary, and several federal regulatory steps must be completed before patients could enroll in clinical trials.

About 30 universities, hospitals and additional partners, led by the Wake Forest Institute for Regenerative Medicine, make up the consortium of AFIRM researchers. Romanko works with the TIRM PMO, which supports AFIRM and other regenerative medicine programs.

AFIRM receives funding from the U.S. Army, the Office of Naval Research, Air Force Surgeon General's Office, Veterans Health Administration, National Institutes of Health and the Office of Assistant Secretary of Defense for Health Affairs. AFIRM investigators also bring in funding from other federal, state and private sources.

Leveraging experts from across academic and medical research organizations allows the Army to pull together the range of specialties needed for this type of complex technology, Romanko said.

Engineers work with bioimaging experts to develop the actual bioprinters and technology to scan the topology of injury sites, like the skin, or recreate the 3-D structures of other organs. In turn, biologists and physicians who specialize in the specific organ or tissue being produced oversee the process to ensure the appropriate placement of cells and construction of tissue. They all work together as a multidisciplinary team to advance bioprinting research.

Expanding the technology to a greater number of potential patients will also help to ensure its long-term viability, Romanko said.

"This has very widespread use, not only to the military audience, but also to the civilian population. We need a larger commercialization audience in order to be a self-sustaining technology," he said.

For additional information on AFIRM, go to: http://www.afirm.mil.

ADDING ADDITIVE MANUFACTURING PARTNERSHIPS

Maryland Del. Mary-Dulany James (right) tours Edgewood Chemical Biological Center's Rapid Technologies Branch to learn about additive manufacturing March 10, 2014. (From left) ECBC engineering technician Brad Ruprecht, ECBC Director Joseph Wienand, ECBC Rapid Technologies Branch Chief Rick Moore and ECBC Acting Engineering Director William Klein. (U.S. Army photos by Conrad Johnson)

Chemical-biological center builds additive manufacturing partnerships

BY ECBC PUBLIC AFFAIRS

Additive manufacturing continues to generate a buzz across the nation, while sparking the economy with new design and manufacturing techniques.

The U.S. Army Edgewood Chemical Biological Center at Aberdeen Proving Ground, Md., is one of a handful of government organizations working with additive manufacturing to provide concept-to-product warfighter solutions faster and for less money.

"We've had 3-D printing and 3-D laser scanning capabilities here since the mid-1990s," said Rick Moore, branch chief of ECBC's Rapid Technologies and Inspection Branch. "These capabilities help us get equipment in the hands of the warfighter more quickly. It also provides access for other engineering and science groups to design products with multiple design iterations or changes before fully investing critical funds into full production of that item."

Additive manufacturing is the process of making a three-dimensional solid object of nearly any shape from a digital model. Having this capability has increased the speed of collaboration and innovation as designers work with partners to deliver products to the warfighter or bring them to market.

Additive manufacturing has proven to be ideal for proof of concept testing which facilitates cost-effective design iterations during the design phase, Moore said.

As the benefits of additive manufacturing gain attention, the state of Maryland is looking to capitalize on the revolution. Gov. Martin O'Malley signed a bill into law May 15 to establish the Northeastern Maryland Additive Manufacturing Innovation Authority, a consortium of private business, educational institutions, government agencies and APG representatives.

By partnering with the U.S. Army, Maryland legislators hope the law will facilitate the future of manufacturing, bring jobs into the area and ensure the state is at the forefront of innovation. An overarching Cooperative Research and Development Agreement between NMAMIA and ECBC will provide industry, academia and other non-federal partners with streamlined access to the center's expertise and capabilities in additive manufacturing, 3-D printing and computer aided design. Projects under the overarching CRADA will be documented by separate Joint Work Statements in order to protect data and other intellectual property from release to unauthorized personnel. Each JWS will describe the scope of work to be performed, the roles of the parties, and the amount of funds needed for ECBC and other federal laboratory support to be provided.

NMAMIA will leverage these world-class federal assets and help U.S. industry gain a competitive advantage in the international marketplace.

The Army's additive manufacturing credibility comes from many high-profile uses for the new technology at APG. One recent example was the joint mission between the Organisation for the Prohibition of Chemical Weapons and United Nations to destroy Syria's chemical agent stockpile. The center's Advanced Design and Manufacturing Division used a reverse modeling technique during the development of the Field Deployable Hydrolysis System, a new weapons of mass destruction-elimination technology developed to destroy chemical agents.

Reverse Engineering played an integral role in the production and manufacturing of the FDHS by generating 3-D virtual models through reverse modeling techniques," Moore said. "These models could be adapted at a moment's notice during the design phase, where the biggest challenge was creating a workable system that could fit into 20-foot shipping containers for transport."

Army engineers used the computer-aided design to create a physical scale model of the system for presentation purposes.

"The model was used as a communication tool to help explain the system to stakeholders," said Brad Ruprecht, engineering technician and model maker with the Rapid Technologies Branch. "Our branch is best known for additive manufacturing, we also provide high fidelity prototyping, model making and urethane plastic casting, and can respond quickly to customer requests."

ECBC officials said they will continue to be a resource for the community and will support the initiative through several upcoming STEM events, including summer camps.

"CERDEC's summer camp will feature ECBC engineers and technicians who worked with the Hollywood movie industry to learn additive manufacturing processes and techniques to produce special effects props such as the Iron Man suit," Moore said. "These engineers and technicians brought back concepts and applied them when creating the Future Soldier model for the STEM recruitment asset."

Moore said their initiatives in additive manufacturing are highlighted by a desire to engage the science and technology community with solutions.

ECBC Director Joseph Wienand (left) explains how 3-D printing allowed researchers to rapidly develop the Field Deployable Hydrolysis System, a new weapons of mass destruction-elimination technology developed to destroy chemical agents.

"Helping the next generation of scientists and engineers fosters the necessary skills for the technical excellence required for future of work," Moore said. "It will lead to improved products and services to meet the evolving needs of the warfighter."

SPEEDING UP THE DESIGN PROCESS

Medical researchers turn to 3-D printing for rapid prototypes

BY DAN LAFONTAINE, RDECOM PUBLIC AFFAIRS

To quickly design, fabricate and deliver prototypes of medical equipment to the field, the U.S. Army is employing futuristic 3-D printing technologies.

Mark Brown, chief of the Medical Prototype Development Laboratory, said 3-D printers have improved each step of his team's work.

"3-D printing speeds up the whole design process. The turnaround time has come down considerably," he said. "A challenging issue we've had is communicating ideas. This definitely fills in that gap by being able to communicate ideas with our coworkers—biologists and chemists—so we can be on the same page in terms of product development."

The lab's mission is to build prototypes of field medical equipment that are simple to operate, yet functional. They must also be compact, lightweight, transportable, ruggedized and easy to assemble with no tools.

MPDL is part of the U.S. Army Medical Materiel Development Activity.

Brown and engineering technicians Jay Bartlett and Mark Easterday begin the prototyping process by discussing ideas with the scientist, engineer or Soldier requesting the equipment. They develop drawings using computer-aided design software, and once an initial concept is agreed upon, the team proceeds to 3-D printing.

"Biologists or chemists can't necessarily put on paper exactly what they want. They know their part of it, and we know this part," he said. "This helps marry those two areas together so we can build what they want.

"In the design process, we'd like to get it as straight a line as possible.

Mark Brown, chief of the Medical Prototype Development Laboratory, shows a 3-D-printed prototype (left) of a litter handle adapter to mount litters into C-130 aircraft. (U.S. Army photo by Conrad Johnson)

Top: *Mark Brown, chief of the Medical Prototype Development Laboratory, demonstrates a 3-D-printed prototype of the Environmental Sentinel Biomonitor, which allows Soldiers in the field to monitor water for toxic chemicals. (U.S. Army photo by Conrad Johnson)*

It's not always linear. It's a lot of ups and downs. This helps smooth those bumps out."

Having a 3-D-printed prototype available for the requestor is beneficial because it allows for a comprehensive review and inspection before moving to the more time-consuming and expensive aspect of manufacturing, he said.

Brown emphasized that 3-D-printed parts are used for communicating ideas but not for building the end product. Once a design is finalized, the team can then fabricate parts from traditional materials such as aluminum, stainless steel and plastics using conventional manufacturing techniques.

The MPDL prototypes medical equipment for all the services, and Brown described two recent Air Force Special Operations projects for litters, also known as stretchers.

The team developed a new lightweight litter stand that is collapsible and fits into a backpack. They 3-D printed the joints, and most importantly, the three-degrees-of-freedom joint.

These assemblies have individual parts with complex geometry that can be challenging to visualize. As a result, 3-D printing was ideal for these types of parts and assembly, Brown said.

Another project was to design a litter handle adapter to mount litters into C-130 aircraft. At the request of the Air Force, the lab created two styles of adapters that provide a more robust mounting arrangement by gripping on the metal adapter instead of the plastic litter handles.

Brown and his team also design prototypes for test kits such as the Environmental Sentinel Biomonitor, which allows Soldiers in the field to monitor water for toxic chemicals.

David Trader, a research biologist with the Army Center for Environmental Health Research, said the current prototype size and weight could be reduced if they changed to smartphone-based software and used an ultraviolet-light emitting diode chassis.

"This is in the conceptual stage, but one way 3-D printing has accelerated this process is by having the prototype in hand and seeing if the reagents and workstations will fit in the chassis," Trader said. "It gives us the ability to visualize how the product could be used and how we can make the design more useful."

The greatest benefit to using 3-D printing for medical equipment is delivering more efficient solutions, Brown said.

"The time and costs associated with our development efforts are greatly reduced," he said. "Products get to the field faster.

"I'm interested in where this technology is headed. I think it has a lot more potential. It has a capability of revolutionizing manufacturing as we know it."

Presidential KICK-START

Presidential initiative to kick-start digital manufacturing

BY RYAN KEITH, AMRDEC PUBLIC AFFAIRS

President Barack Obama greets guests in the Blue Room before a Manufacturing Innovation Institutes announcement in the East Room of the White House, Feb. 25, 2014. (Official White House photos by Pete Souza)

As additive and other advanced manufacturing technologies continue to emerge, the digital thread connecting design, engineering, manufacturing and maintenance systems evolves as well. This is especially true for the Department of Defense, where today's two-dimensional technical data packages are flat, and proprietary computer-aided designs can be inefficient and ineffective.

President Barack Obama announced the selection of the team to lead the Digital Manufacturing and Design Innovation Institute Feb. 25, 2014. The public-private partnership is a consortium of 73 companies, universities, nonprofits, and research labs managed by UI Labs in Chicago.

Under the management of the U.S. Army Research, Development and Engineering Command, the institute will link promising information technologies, tools, standards, models, sensors, controls, practices and skills, and then transition these capabilities to the industrial base for full-scale application.

"DMDI will focus on using digital technology and data management to help manufacturers turn their ideas into real world products faster and cheaper than ever before," Obama said.

"We want suppliers to be able to collaborate with customers in real time, test their parts digitally, cut down on the time and money that they spend producing expensive prototypes," he said. "We want our manufacturers to be able to custom design products tailored to each individual consumer. We want our troops to be able to download digital blueprints they can use to 3D print new parts and repair equipment right there in the field."

Dr. Greg Harris with RDECOM's Aviation and Missile Research, Development and Engineering Center at Redstone Arsenal, Ala., is the DMDI Institute program manager. He is leading the Army effort, with participation from the Air Force, Navy and nine other federal government agencies including the Departments of Commerce and Energy, the National Science Foundation, and NASA. The institute is funded with a $70 million federal investment, which was more than matched by non-federal partners.

"This is exactly the right time for the Government to do a public-private partnership," said Harris, who co-authored the initial DMDI proposal with the Army Research Lab's Paul Wong. "We have a lot of great stuff happening, but on a lot of different islands out there. Companies are doing their own thing. There are significant hurdles today, including establishing true interoperability, the effective and balanced management of intellectual property interests, maintaining network technology and security, as well as advancing machine intelligence, workforce skills, and new organizational cultures that embrace and leverage the digital thread."

DMDI's focus will be to accelerate research, development and demonstration in the integration of Advanced Manufacturing Enterprise, Intelligent Machines, and Advanced Analysis in a secure and trusted cyber physical system, Harris said.

Advanced manufacturing encompasses agile and robust manufacturing strategies and integrated capabilities that dramatically reduce the cost and time of producing complex systems and parts. This includes the development and implementation of modeling and simulation tools to allow faster time to market and efficient production of complex systems. It also includes a focus on tools and practices to minimize multiple designs, prototypes and test iterations typically required for product or process qualification, all connected via the 'digital thread' to enable designer, analyst, manufacturer and maintainer collaboration.

President Barack Obama meets Dr. Greg Harris from the U.S. Army Aviation and Missile Research, Development and Engineering Center at Redstone Arsenal, Ala. Harris is the Digital Manufacturing and Design Innovation Institute program manager.

DMDI will develop and integrate smart sensors, controls and measurement, analysis, decision and communication software tools for self-aware manufacturing providing continuous improvement and sustainability. Intelligent machines realize the first part correct philosophy by allowing equipment plug-and-play functionality and allowing equipment to use manufacturing knowledge while planning and processing components, including 'big-data' analytics.

DMDI will capitalize on advances in high-performance computing to develop physics-based models of material performance with 'design for manufacturing' in mind. This includes developing and integrating smart design tools to help reduce over-design in order to reduce manufacturing cost.

"It is the integration of these technologies from which the step-function improvements in manufacturing competitiveness will occur," Harris said.

The nature of digital manufacturing and design makes the deliverables of DMDI different from other institutes. Harris said the DMDI will produce components of networks, digital information flow, and software and hardware outputs.

In this way, DMDI promises to significantly impact advancements in additive manufacturing. Harris anticipates future projects with America Makes, DMDI's sister institution, which is focused on this technology.

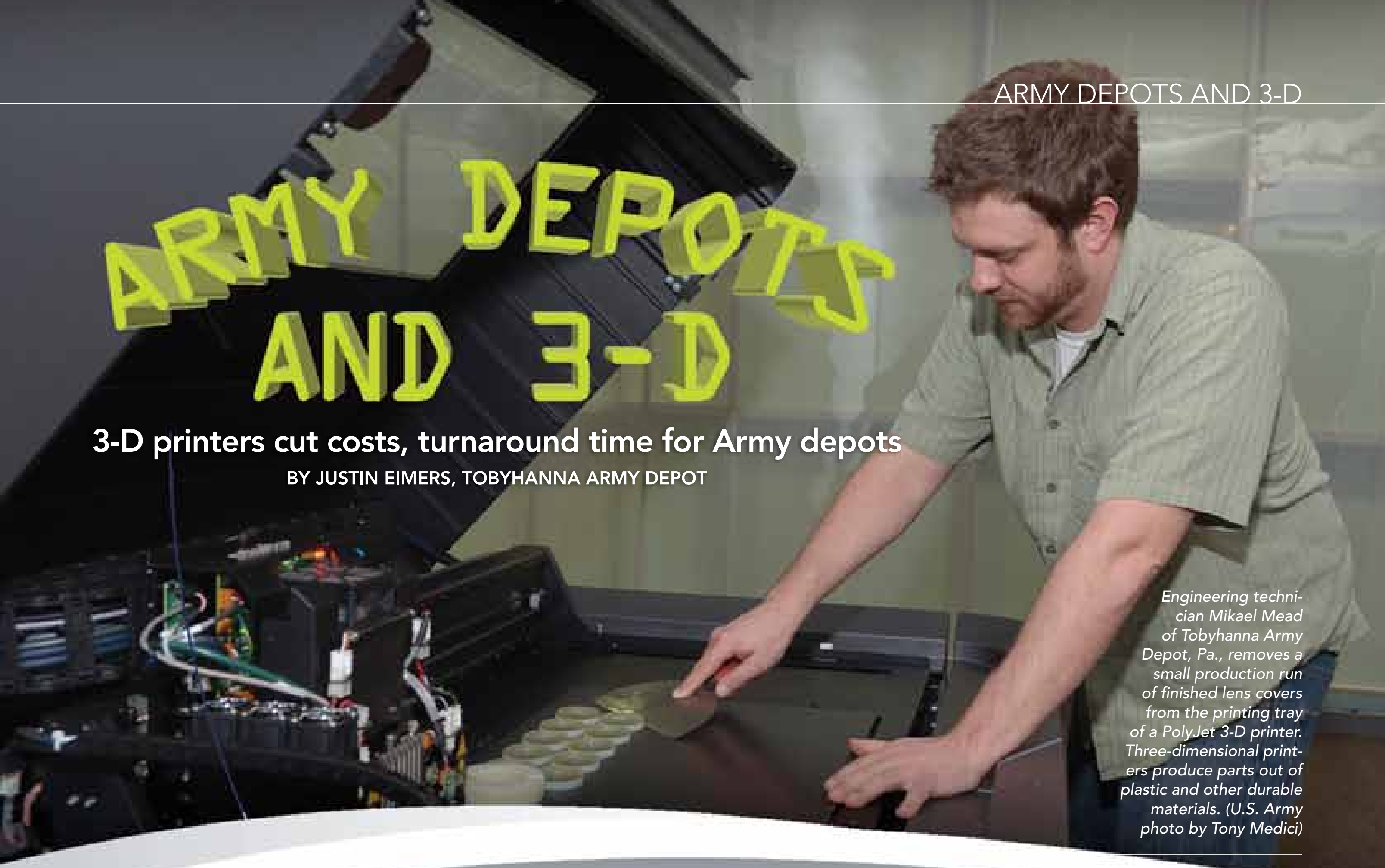
"They're no longer going to worry about the models that they have to have to drive their products," Harris said. "They're going to worry about the additive portion. Up until now, they had to deal with both sides. So now we're focused on the models, the 3-D models, the digital data, getting to machine the right way, all those types of things. Hopefully very soon we will be able to work out several projects where America Makes is the executer of the models that we're making. That's going to be exciting—when we can start showing the network working.

"The expected outcomes of the institute are an increase in the successful transition of digital manufacturing and innovative design technologies through advanced manufacturing; the creation of an adaptive workforce capable of meeting industry needs; further increases in domestic competitiveness; and the fulfillment of participating defense and civilian agency requirements," he said.

ARMY DEPOTS AND 3-D

3-D printers cut costs, turnaround time for Army depots

BY JUSTIN EIMERS, TOBYHANNA ARMY DEPOT



Engineering technician Mikael Mead of Tobyhanna Army Depot, Pa., removes a small production run of finished lens covers from the printing tray of a PolyJet 3-D printer. Three-dimensional printers produce parts out of plastic and other durable materials. (U.S. Army photo by Tony Medici)

Engineers and technicians at Tobyhanna Army Depot in Tobyhanna, Pa., use a highly innovative, cutting-edge fabrication process to significantly cut costs and reduce turnaround time.

The depot's additive manufacturing process uses two 3-D printers to produce parts out of plastic and other durable materials. Unlike traditional design methods where a part is made from a block of material and the excess is discarded, additive manufacturing uses only material necessary for the part, saving money and minimizing waste.

Corey Sheakoski, electronics engineer in the Production Engineering Directorate's Mission Software Branch, said the benefits and potential of this process are nearly unlimited.

"Tobyhanna has the ability to make any type of plastic part, as long as we have a 3-D model for it and it fits within a certain set of dimensions," he said.

Recently, a structural issue with heat sink components in Detector/Cooler Bench assemblies of Long Range Advanced Scout Surveillance Systems caused the parts to break, requiring replacement. Engineering tech Mikael Mead designed a plastic prototype using one of the depot's 3-D printers.

Within a week, based on Mead's prototype, four iterations of the heat sinks were produced using aluminum. Normally, the process would have taken several weeks had the parts been made in a metal shop. The aluminum heat sink replacements cost less than $1,000 to produce compared to the $52,000 price tag of replacing an entire unit.

Mead, who works in PED's Design and Development Branch, said the decision to make the heat sinks at the depot not only saves a substantial amount of money but also precious turnaround time.

"Our main focus when looking to improve a process using additive manufacturing is how it will impact our customers and the warfighter," Mead said. "Because we are able to produce heat sink coolers here, we can save hundreds of thousands of dollars each year depending on how many we produce, while continuing to provide timely and effective support to Soldiers."

Tobyhanna has been using additive manufacturing since the arrival of the first 3-D printer in the fall of 2006. The process begins with a computerized 3-D model that is programmed into one of two high-tech printers. The machine then builds a part, layer by layer, based on the model's design.

The depot's first 3-D printer, a fused deposition modeling machine, or FDM, is capable of making parts out of ABS plastic within a 10- x 10- x 12-inch area. The second machine, a polyjet printer, was purchased in April 2012, and can make parts out of hundreds of composite materials within an 8- x 16- x 19-inch area.

The FDM produces parts accurate to one one-hundreth of an inch of the computerized model, while the PolyJet printer is accurate to two-thousandths of an inch. This capability also allows depot engineers to print parts to use as prototypes for form, fit and function as well as test pieces.

Sheakoski added that the future of additive manufacturing and 3-D printing technology holds a lot of promise.

"When you look at some of the benefits of 3-D printing, the cost savings, reduction in turnaround times, reliability, it's exciting to think where it can go from here," he said. "Additive manufacturing is helping the depot cut costs during tough times while continually supporting the warfighter with high-quality products." ■

3-D Food

Chow from a 3-D printer? Natick researchers are working on it

BY JANE BENSON, NSRDEC PUBLIC AFFAIRS

Army researchers are investigating ways to incorporate 3-D printing technology into producing food for Soldiers.

The U.S. Army Natick Soldier Research, Development and Engineering Center's Lauren Oleksyk is a food technologist investigating 3-D applications for food processing and product development. She leads a research team within the Combat Feeding Directorate.

"The mission of CFD's Food Processing, Engineering and Technology team is to advance novel food technologies," Oleksyk said. "The technologies may or may not originate at NSRDEC, but we will advance them as needed to make them suitable for military field feeding needs. We will do what we can to make them suitable for both military and commercial applications."

On a recent visit to the nearby the Massachusetts Institute of Technology's Lincoln Laboratory, NSRDEC food technologist Mary Scerra met with experts to discuss the feasibility and applications of using 3-D printing to produce innovative military rations.

"It could reduce costs because it could eventually be used to print food on demand," Scerra said. "For example, you would like a sandwich, where I would like ravioli. You would print what you want and eliminate wasted food."

IT'S ALREADY HAPPENING

"Printing of food is definitely a burgeoning science," Oleksyk said. "It's currently being done with limited application. People are 3-D printing food. In the confectionery industry, they are printing candies and chocolates. Some companies are actually considering 3-D printing meat or meat alternatives based on plant products that contain the protein found in meat."

A printer is connected to software that allows a design to be built in layers. To print a candy bar, there are cartridges filled with ingredients that will be deposited layer upon layer. The printer switches the cartridges as needed as the layers build.

"This is being done already," Oleksyk said. "This is happening now."

A FOOD REVOLUTION

"It is revolutionary to bring 3-D printing into the food engineering arena," Oleksyk said. "To see in just a couple of years how quickly it is advancing, I think it is just going to keep getting bigger and bigger in terms of its application potential."

Oleksyk believes her team is the first to investigate how 3-D printing of food could be used to meet Soldiers' needs. The technology could be applied to the battlefield for meals on demand, or for food manufacturing, where food could be 3-D printed and perhaps processed further to become shelf stable. Then, these foods could be included in rations.

"We have a three-year shelf-life requirement for the MRE [Meal Ready-to-Eat]," Oleksyk said. "We're interested in maybe printing food that is tailored to a Soldier's nutritional needs and then applying another novel process to render it shelf stable, if needed."

Oleksyk said they are looking at ultrasonic agglomeration, which produces compact, small snack-type items. Combining 3-D printing with this process could yield a nutrient-dense, shelf-stable product.

"Another potential application may be 3-D printing a pizza, baking it, packaging it and putting it in a ration," she said.

GET YOUR DAILY REQUIREMENT OF VITAMIN YOU

Currently, most 3-D printed foods consist of a paste that comes out of a printer and is formed into predetermined shapes. The shapes are eaten as is or cooked.

Army food technologists hope to further develop 3-D printing technologies to create nutrient-rich foods that can be consumed in a Warfighter's specific environment on or near the battlefield.

Nutritional requirements could be sent to a 3-D food printer so meals can be printed with the proper amount of vitamins and minerals, thus meeting the individual dietary needs of the Warfighter.

"If you are lacking in a nutrient, you could add that nutrient. If you were lacking protein, you could add meat to a pizza," Oleksyk said.

Scerra said individual needs could be addressed based on the operational environment.

"Say you were on a difficult mission and you expended different nutrients...a printer could print according to what your needs were at that time," Scerra said.

FORAGE AND CREATE A 3-D PRINTED PORRIDGE

In the future, making something from scratch may have a completely different meaning.

"We are thinking as troops move forward, we could provide a process or a compact printer that would allow Soldiers to print food on demand using ingredients that are provided to them, or even that they could forage for," Oleksyk said. "This is looking far into the future."

Oleksyk, who was skeptical when she first heard that 3-D printers could be used to engineer food, now marvels at the possibilities.

"I've been here long enough to see some of these 'no ways' become a reality. Anything is possible," Oleksyk said.

NSRDEC Uses 3-D

Natick puts rapid in prototyping

BY JANE BENSON, NSRDEC PUBLIC AFFAIRS

Natick engineers use 3-D printed prototypes to perfect Soldier equipment, including the pack frame for the Modular Lightweight Load-carrying Equipment system and fabric attachments for the pack. (U.S. Army photo by David Kamm)

Army engineers are working to create 3-D solid models and prototypes from computer-aided design data. These prototypes enable researchers to evaluate and detect component and system design problems before fabrication.

The U.S. Army Natick Soldier Research, Development and Engineering Center Computer-aided Design and Rapid Prototyping Laboratory uses an additive manufacturing process of selective laser sintering, known as SLS. The printer relies on lasers to sinter, or melt, powdered, nylon materials layer upon layer into a prototype.

Over the years, researchers have created numerous prototypes and product components. NSRDEC engineers created prototypes for the pack frame of the Modular Lightweight Load-carrying Equipment system and fabric attachments for the MOLLE pack itself. Engineers also created a battery case, as well as the individual electronic components contained in the case, which were later tested and used in the field.

"We've built components that could interface with unique equipment like chemical gear," NSRDEC engineer Gary Proulx said.

Engineers also use the lab to develop testing tools and meters, some of which aid in testing of equipment in Natick's climatic chambers.

Rapid prototyping helps engineers find design issues early on and strive for continuous prototype improvement, Proulx said.

"With some items, it is how it feels," NSRDEC engineer Karen Buehler said. In the case of a snap-type closure buckle on your backpack...it's about how it snaps. Just a little bit off on a dimension can really change how it feels or how it works. If you have four or five ideas, you can pop them in there and make a couple of each and go try it and touch it and test it. Then you can make important changes that make sense."

"It's much easier to do things with this process than to mold it and build it," Proulx said. "You can build something one day and put it in someone's hand the next and then make your changes and then reiterate. It's a short cycle to do so, and it's relatively inexpensive."

The results are high-quality rapid prototypes.

"It provides a better way to interface with industry," NSRDEC engineer Matthew Hurley said. "We can give them parts that are 80 to 90 percent ready to be produced."

The engineers also create prototypes and scale models for illustrative purposes.

"We do a lot of prototyping of emerging concepts for demonstrations," Hurley said. "We're bridging the gap between concept and field-ready equipment."

"So many people are visual in terms of understanding information," Buehler said. "You touch it. You see it. It's not necessarily words that get through. 'Oh, I get it now. I've seen that. It looks like this. I can envision what the future looks like. Or at least now I have an idea of what it can do.'"

In the near future, engineers hope to add a new 3-D printer with will add multi-material stereolithography capabilities. The process uses ultraviolet cured liquid resin to form layers that comprise the prototypes.

"With the new machine, we can mix hard and soft materials," Buehler said. "We will be able to make a button. Or I can make something where I can press something and make it turn on and off."

"We will be able to produce more types of models to find errors in different applications because we have that wide range of mechanical properties," Hurley said.

WEARABLE 3-D

Future Soldier may wear 3-D printed garments, gear

BY JANE BENSON, NSRDEC PUBLIC AFFAIRS

Researchers at the U.S. Army Natick Soldier Research, Development and Engineering Center wear many hats and create many products.

"We cover a range of items: field clothing, combat clothing, dress clothing, chem-bio protection, body-armor systems, gloves, hats, helmet covers and experimental garments using new textiles," said Annette LaFleur, Design, Pattern and Prototype team leader.

The team uses a 2-D design program, and LaFleur is excited about the possibilities that 3-D printing capabilities hold for her industry, in general, and possibly for Soldiers.

"It could improve flexibility," LaFleur said. "You could incorporate hard and soft materials together into one design. So, maybe you have some sort of clothing or protective item that has rigid areas that move into soft areas, where your body needs to flex. That could be really exciting because that is hard to accomplish with a regular textile."

3-D printing would also eliminate or reduce the number of seams necessary to make a garment.

"The fewer seams you have, the more comfort you can achieve. Seams can cause a hot spot with rubbing," LaFleur said. "Seams can cause discomfort in high heat and humidity, especially when you layer with body armor. Reducing seams on chem-bio gear would be huge."

Ballistic materials could one day be incorporated into 3-D printing, allowing designers to produce shapes for armor and making it less expensive. The technology could also be used to make custom clothing or equipment.

"We could create something that is a totally perfect fit and reduce weight, maybe reduce bulk. A lot of the neat textiles that are being 3-D printed, even out of these synthetics, have a 3-D structure to them," LaFleur said. "That makes you think about spacer-type materials where you have air flow, which is so important if our Soldiers are going to be somewhere hot again, whether it is jungle or desert."

The nine-member team designs concepts and patterns for clothing and prototypes and relies heavily on computer-aided design, or CAD.

Designers can start from scratch, or they pull from NSRDEC's extensive CAD archives of fielded, historical or experimental items.

"CAD is fundamental," LaFleur said. "We can go into the CAD system and pull up a flat pattern. Say we are designing a new coverall. We already have an existing one that fits really well and that Soldiers like. We can go in and take off the design features like the collar or the cuffs, so you have a basic silhouette in a certain size, and start from there to design a new garment."

The CAD system also contains more than 300 tools to alter patterns.

"We use the system to size out all the patterns to the different sizes and lengths that are needed," she said. "We work really closely with the anthropometric group here to help determine what sizes are needed for different items."

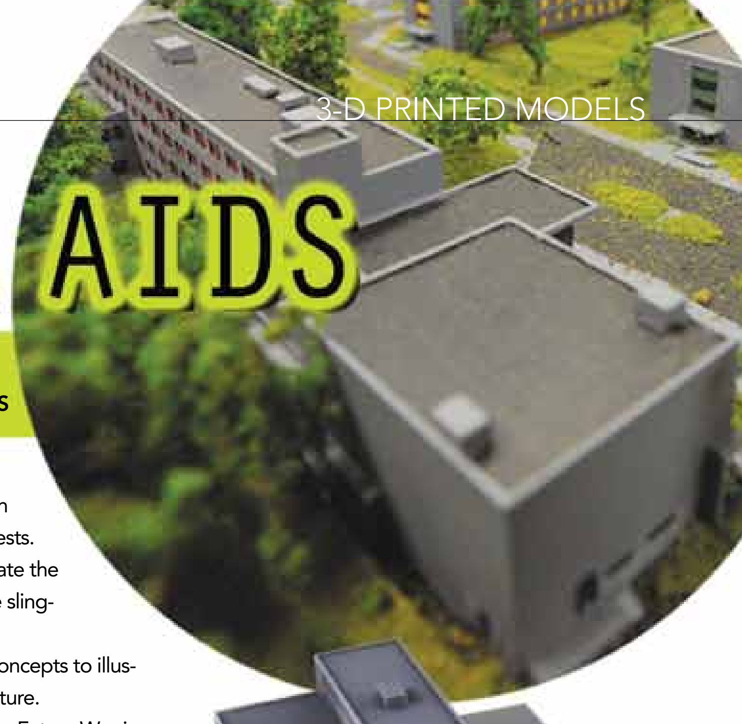
Although LaFleur is enthusiastic about the possibilities of 3-D-printing technology, she said human insight will always play an important role in the design process.

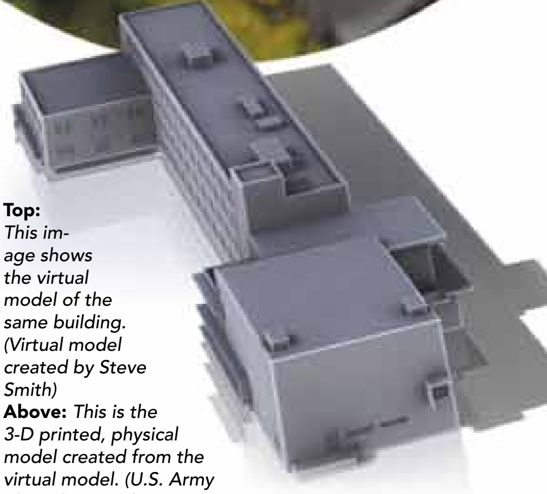
"I see 3-D printing as a tool,"LaFleur said. "Work processes have always evolved and changed, but you still need a designer to understand what's possible."

Annette LaFleur, team leader for NSRDEC's Design, Pattern and Prototype Team, uses a 3-D design program, but she is excited about the possibilities that 3-D printing capabilities hold for her industry and possibly for Soldiers. (U.S. Army photo by David Kamm)

3-D VISUAL AIDS

Natick improves understanding with 3-D printed models BY JANE BENSON, NSRDEC PUBLIC AFFAIRS





Top: *This image shows the virtual model of the same building. (Virtual model created by Steve Smith)*
Above: *This is the 3-D printed, physical model created from the virtual model. (U.S. Army photo by David Kamm)*

Welcome to Steve Smith's world. It's a place where big is small, small is big and anything is possible.

Smith works as a graphic designer at the U.S. Army Natick Soldier Research, Development and Engineering Center. The 3-D-printer guru uses the medium to design, make and improve displays. He works closely with NSRDEC scientists and engineers to create something visual and tangible so the average person can garner a better understanding of NSRDEC-developed products and concepts.

"The models help (subject matter experts) explain themselves to their audience more clearly," Smith said. "People have something they can pick up and see how it works. They can see what the physical science is behind it. It definitely helps a lot of people to see things in a concrete form."

Smith uses Computer-aided Design, or CAD, to create virtual, working models before they are sent to a 3-D printer. The printer uses a liquid polymer exposed to ultraviolet light to create the actual models.

The scientists and engineers tell him what they envision, and he develops the models. The process can sometimes give scientists and engineers a little bit of added insight.

"It can help point out when something doesn't work. We need to find a different footprint for this shelter. Or sometimes I can see that parts are colliding," Smith said. "I'm not an engineer by any means, but there is definitely some back and forth. You can pick up some problems before it even gets to the printing stage."

Although Smith uses 3-D printing primarily for model creation, he sometimes uses it to create prototypes.

"We have our own prototype facility, but I've done some occasional small jobs. For example, I did an electrochemical cell for a group in the food lab," Smith explained. "So, I can produce functional things, but a lot of it is conceptual. Most of what I do is illustrative."

Smith creates scale models of architecture and existing machinery. For example, he created a scale model of the layout of the Natick Soldier Systems Center and created a 1:8 scale Humvee, which included a way to insert an accelerometer for wind-tunnel tests. The model will be used to simulate the wind effects on the vehicle while sling-loaded under a helicopter.

He also works on notional concepts to illustrate what can be done in the future.

"Instead of building an entire Future Warrior that has to be worn, we can make a 'GI Joe'-scale figure and configure him with different equipment and that kind of thing."

In addition to being able to scale down large products and conceptual ideas to a small size, Smith's work can also provide an exploded view of items that use nanotechnology, focusing a magnifying glass to help people see the big picture.

"Think about things that are at the nanoscale," Smith said. "You can't take people on a tour of material that is at nanoscale, but you could build a big model that represents how this thing works at the nanoscale."

The process of using 3-D printing to create models has some advantages over older methods.

"In some ways 3-D printing is easier (than casting and making molds)," Smith said. "There is so much digital material out there in the public domain, either for free or that you can purchase. I wouldn't have to sculpt a human figure from scratch. If you wanted to make a human figure, you could find one and then modify it to your own needs. There is no mess involved. There is an undo button."

Just as with every technological advance, however, much is gained but something is lost.

"It can cut down on the amount of time someone spends making the actual model," Smith said. "Right now, there is still something lost in the process, artistically speaking. From an aesthetic purist point of view, it is kind of like comparing vinyl to CDs. It looks faux realistic, but it doesn't look like a human being made it by hand. It loses that kind of charm. "

Smith believes that 3-D printing may also prove to be a way to manufacture multifunctional materials. It could be used to create modular shelters. In the private sector, it is already being used to create common replacement parts, such as nuts, bolts and washers.

"It's going to get interesting, because they are starting to work with metals. So, you can print with metals," Smith said. "It will be interesting to see the effect on manufacturing. If people can do the manufacturing here (in the United States) at a fraction of the cost, there won't be the need to go overseas. There are still a couple of stumbling blocks, technologically speaking. Again, producing stuff out of metal is going to be a big leap."

Also, 3-D printers are getting faster all time, and some of the newer models have the ability to mix materials. The technology and its applications are becoming more and more commonplace.

"It's really a blossoming field. There are so many different avenues. It could go into art, manufacturing and biological devices," Smith said. "These printers have been around for a long time, but the cost of the machines was prohibitively high. Now, it is kind of like when the VCR and the camcorder got to the point when most people could afford to purchase them. It's gotten to that level." ■

Army, University of Maryland Baltimore County agree to research partnership

The U.S. Army signed an agreement with the University of Maryland Baltimore County June 6 to spur scientific research in areas of mutual interest.

Senior leaders from the U.S. Army Research, Development and Engineering Command and the university entered into a cooperative research and development agreement, known as a CRADA, on the UMBC campus.

RDECOM Director Dale A. Ormond said he was impressed with the school's emphasis on science and engineering as he formalized the CRADA with UMBC President Dr. Freeman A. Hrabowski III. The organizations share a common goal of furthering the boundaries of science and engineering, Ormond said.

"I don't think there's any discipline you can teach that we don't use someplace in this command," Ormond said as he described his workforce of 11,000 scientists and engineers spread across seven organizations.

The formal agreement provides a framework for RDECOM and UMBC researchers to work together on projects while sharing facilities, equipment and other resources. RDECOM now has 263 total CRADAs and 20 with universities.

RDECOM signed CRADAs with two other Maryland institutions—Morgan State University and the University of Maryland College Park—in 2010.

Hrabowski discussed his students' successes and how UMBC and Army researchers will fit together well.

"We have the highest percentage of students in science and engineering in the state," Hrabowski said. "Almost half are graduating with degrees in science or engineering. Many are interested in working for their country.

"Large numbers of students at UMBC have families in the military because they retired in this area. They really understand the nobility of the work."

The agreement now allows the organizations to enter into joint work statements that focus on specific topics. Immediately following the CRADA signing, Suzanne Milchling, director of program integration at RDECOM's Edgewood Chemical Biological Center, and UMBC Vice President for Research Dr. Karl V. Steiner finalized the first JWS.

ECBC scientists will partner with the university's chemistry department on developing next-generation systems for detecting hazardous compounds, according to Milchling.

UMBC will also be a valuable partner to the command as a large percentage of its workforce nears retirement age, Ormond said.

"Over the next 10 to 15 years, we're going to have a huge changeover in our workforce. About 50 percent of our scientists and engineers are in their early to mid-50s," Ormond said. "I need smart, bright people who have STEM degrees to come work for us so we can continue to push the leading edges of science and engineering."

Hrabowski said the university is poised to meet the Army's scientific and engineering needs.

"We are producing a lot of really smart people. I'm looking forward to seeing so many UMBC students [at RDECOM], that you come to think of us as a major partner," he said.

Ormond extolled the virtues of his employees' efforts in enabling the success of Soldiers as well as the unique opportunities afforded by working as an Army researcher.

Read more at: www.army.mil/article/127575

Natick researchers mentor high school robotics team

When the Natick High School robotics team was approached by the town's fire department in March 2012 to develop a remotely operated vehicle, or ROV, that could assist in search and rescue dives, they first turned to the Natick Soldier Research, Development and Engineering Center for technical expertise and guidance on their project.

Two years later, Natick InvenTeam leaders Katelyn Sweeney, 17, and Olivia Van Amsterdam, 16, found themselves presenting their team's work to President Obama at the fourth annual White House Science Fair.

Olivia Van Amsterdam, 16, and Katelyn Sweeney, 17, from the Natick High School InvenTeam, display poster boards of the remotely operated vehicle. (U.S. Army photo by David Kamm)

InvenTeams are comprised of high school students, teachers and mentors that seek to invent technological solutions to real-world problems in their communities.

"In our meetings with firefighters, we kept hearing about how dangerous ice-diving was," said Sweeney, a senior who will attend MIT this fall. "So we decided we wanted to try to tackle that."

Armed with a $10,000 grant from the Lemelson-MIT Program, to which they were selected as one of 16 teams nationwide, students set to work on an underwater vehicle that can assist firefighters searching for people or objects trapped under the ice.

With an initial scale model made from Legos, the team continued to refine their prototype with technical guidance from NSRDEC scientists and engineers.

"They made that small prototype turn into a reality," said Van Amsterdam of the NSRDEC mentors. "They asked a lot of questions and if we didn't have their input during the brainstorming phase, we would've gone through prototype after prototype after prototype."

"It was actually excellent that we failed so many times," said Van Amsterdam, a junior, who also serves as the technical lead for the team. "Fail early and fail often is what (Natick High School robotics teacher) Mr. (Douglas) Scott always says, and that was an important part of the process."

"With a team, it is easy to get either completely polarized or stuck on a single idea," said Sweeney. "Everybody had a different perspective on how to make the machine work, so we had to learn how to combine them to make something that was better than any singular idea."

Read more at: www.army.mil/article/127749

RDECOM command sergeant major lauds greening program

About 30 U.S. Army civilians are set to undertake a week-long course to better understand what it means to be a Soldier.

Command Sgt. Maj. Lebert Beharie said he has been impressed with the commitment of Army scientists and engineers during his two-and-a-half years as senior enlisted advisor of the U.S. Army Research, Development and Engineering Command.

"I tell all the senior leaders of the Army, 'I'm convinced now that I've been a part of RDECOM, not all of our Soldiers wear [Army Combat Uniforms]. We have Soldiers who wear civilian clothing,'" he said.

Beharie spoke June 5 during the greening-course kickoff. The group will train at Gunpowder Military Reservation and two APG locations—Lauderick Creek Training Site and Aberdeen Test Center—starting June 9 on tasks such as squad movement, land navigation, radio protocol and driving Mine-Resistant Ambush-Protected vehicles.

RDECOM's Communications-Electronics Research, Development and Engineering Center organized the course for civilian employees from across APG.

Beharie said his first appreciation for the Army's scientific and engineering talent came on a 2012 trip to RDECOM's forward deployed prototype integration facility in Afghanistan. Soldiers and Army civilians worked side-by-side to develop rapid technological solutions in theater.

Read more at: www.army.mil/article/127516

Robotics and 3-D printing popular topics during Picatinny tour

Josh Weston, honorary chairman of Automated Data Processing, and three representatives of the Yuval Education Services of Israel, visited Mt. Olive High School in Mount Olive, N.J., and Picatinny Arsenal's innovation lab and 3-D printing facility on May 29.

At Mt. Olive High School, the Yuval Education Services representatives and Weston were introduced to FIRST robotics. For Inspiration and Recognition of Science and Technology robotics (FIRST) is an international program that aims to foster high school students' interest in science and technology by hosting robotic competitions that provide real-world engineering experience.

The representatives and Weston also learned about 3-D printing in the classroom as well as the importance of engineer and scientist mentors in after school clubs, such as FIRST, which allow students to apply their education to hands-on activities and potential science, technology, engineering, or mathematics careers.

Later, at Picatinny, Ralph Tillinghast, director of the arsenal's innovation lab, discussed how Picatinny engineers find inspiration in commercial products and how using these "off-the-shelf" items for problem solving can reduce overall costs in development.

At the arsenal's 3-D printing facility, James Zunino, a materiel engineer, explained how additive manufacturing can reduce research and development time cycles by designing, developing, testing and redesigning components without the need for prototype production.

Visitors also discussed how additive manufacturing can be incorporated into K-12 classrooms to help reinforce the core curriculum and connect the educational lessons to modern, real-world engineering and design careers.

Read more at: www.army.mil/article/127213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my nephew's first time on base
I love baseball. I gave my nephew his first glove at four. But it wasn't until he was seven when he finally stepped out onto the diamond. Now I don't miss a game, even if I have to miss my season ticket seats at the stadium. Wearing flame-resistant clothing seems like a small thing until I think what it might be like if I missed just one of his innings.
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STRENGTH OF THE NATION

RONALD POLCAWICH

ARMY RESEARCH LABORATORY

Dr. Ronald Polcawich, team lead for Piezoelectric-Micro Electro-Mechanical Systems Technology at the U.S. Army Research Laboratory in Adelphi, Md., met President Barack Obama at the White House April 14, 2014, for the presentation of a Presidential Early Career Award for Scientists and Engineers. Polcawich represented the U.S. Army as one of 102 scientists and engineers honored.

“Before I worked for the Army, I had no idea how hard Soldiers have to work,” Polcawich said. “Now I understand just a snippet of what warfighters juggle on a routine basis. I’m simply here to make their jobs easier.”

Scan the QR code or go to **http://www.army.mil/article/125477** to read more.