TECHNOLOGY FOR TODAY

Enhancing America Through Federally Developed Research and Technology

robotics
aviation
agriculture
oceanography
communications
nanotech
biochemistry
physics
medicine
energy
engineering
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mathematics
biology
environment
space

1440 AD — The Printing Press
1620 AD — The Submarine
1700 AD — The Piano
1790 AD — The Sowing Machine
1793 AD — The Cotton Gin
1817 AD — The Bike
1825 AD — The Camera
1885 AD — The Modern Automobile
1952 AD — The Polio Vaccine
1981 AD — The Space Shuttle
1991 AD — The World Wide Web
1996 AD — The MP3 Player
2003 AD — The Human Genome Map

Whats Next?

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Enhancing America Through Federally Developed Research and Technology

Advancing Federal Research and Technology

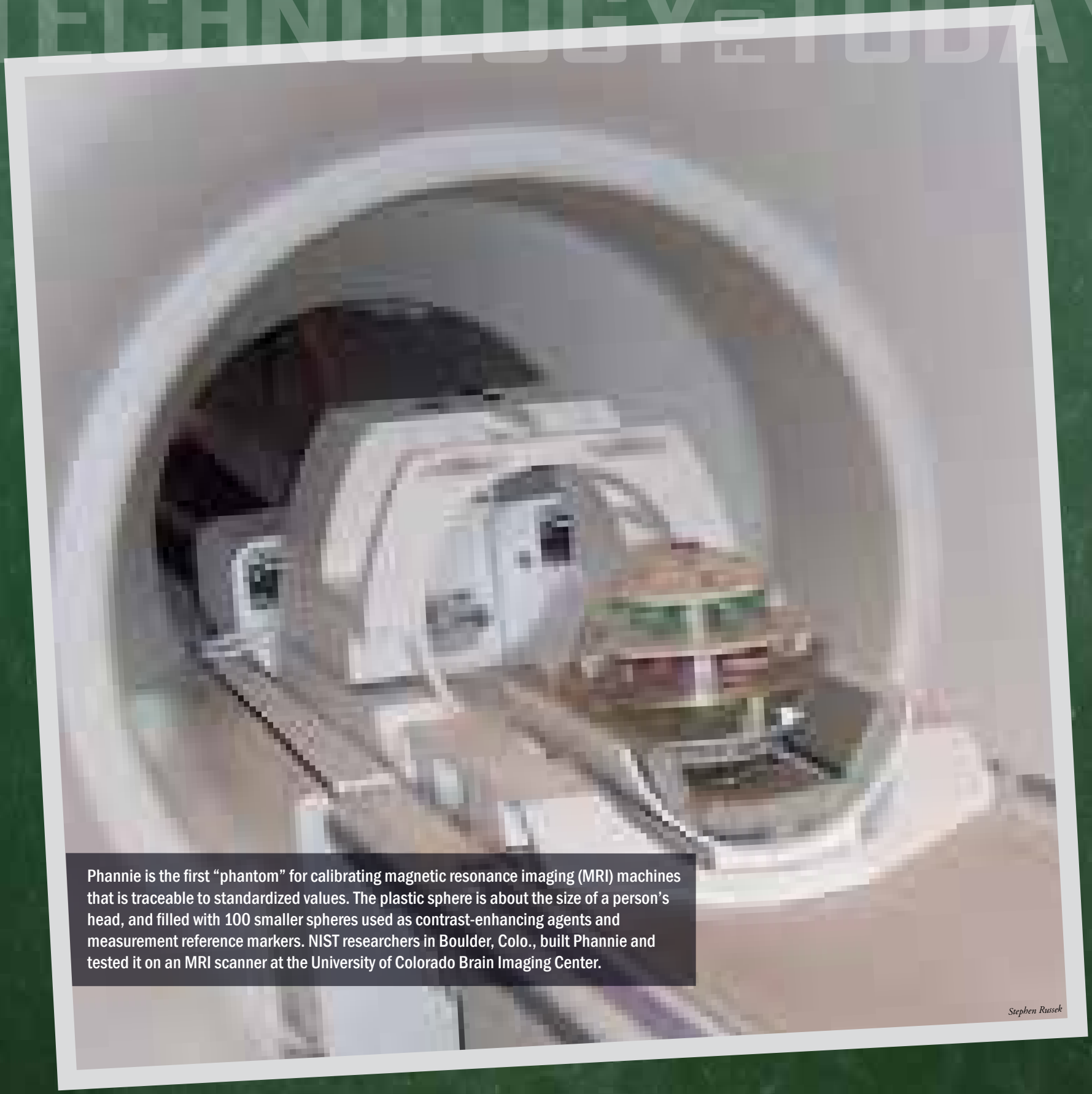
Welcome to the exciting world of federal technology transfer. Every day, hundreds of federally funded laboratories apply their research and development expertise to the advancement of science.

More than 300 laboratories and research centers—representing almost all federal departments and agencies—conduct over $100 billion in research and development annually and employ more than 100,000 scientists and engineers. Their science has the capacity to enrich our lives by making them safer, more convenient, and more fulfilling. From medicine to transportation to communications, these research facilities investigate everything that is known and extract knowledge from the previously unknown. The effort, desire, and creativity of these scientists are unparalleled.

But all of this work is for nothing if the "genius" is not let out of the bottle. It is essential that the fantastic developments happening behind laboratory doors be transferred from the theoretical to the practical. To capitalize on the nation's investment in federal research, the expertise and technology must be brought to the marketplace. This commercialization enhances not only the nation's socioeconomic well-being in the global marketplace, but also ensures its security and prominence. The transfer is accomplished through the outstanding work of scientists, agency representatives, and technology transfer professionals.

This achievement requires a vision, a plan, and a methodology. It is with great honor that the members of the Federal Laboratory Consortium for Technology Transfer (FLC) assist with generating this vision, plan, and methodology. Since its organization in 1974 and its formal charter through the Federal Technology Transfer Act of 1986, the FLC has developed tools and services to ensure that the efforts of federal engineers and scientists are not left on a shelf. This publication is only a small representation of how cutting-edge federal laboratory expertise becomes prevalent in our everyday lives through the execution of technology transfer.

Dr. J. Scott Deiter
FLC Chair



Phannie is the first "phantom" for calibrating magnetic resonance imaging (MRI) machines that is traceable to standardized values. The plastic sphere is about the size of a person's head, and filled with 100 smaller spheres used as contrast-enhancing agents and measurement reference markers. NIST researchers in Boulder, Colo., built Phannie and tested it on an MRI scanner at the University of Colorado Brain Imaging Center.

Stephen Russek

NIST's Standard Phantom Designed for Calibrating MRI Machines

Magnetic resonance imaging (MRI), a widely used medical tool that relies on magnetic fields and radio waves to visualize the body's internal structures, especially soft tissues, may soon become even more useful.

The National Institute of Standards and Technology (NIST) has developed the first "phantom" for calibrating MRI machines that is traceable to standardized values. The prototype, named Phannie, was developed in collaboration with the standards committee of the International Society for Magnetic Resonance in Medicine (ISMRM).

Traceable MRI calibrations are expected to enable accurate, quantitative measurements of tumors and other disease markers that can be reproduced across many different patients, scanners and clinics over time and potentially reduce medical costs.

The NIST phantom is a plastic sphere about the size of a person's head, filled with water-bathed grids of 100 small plastic spheres containing various salt solutions that become magnetized in a magnetic field. By making MRI scans of Phannie, users can evaluate the image contrast, resolution, and accuracy of distance and volume measurements.

A machine's performance can be compared to standards, to other MRI machines, and to itself over time.

The new phantom is intended to generate more accurate and consistent images, validate disease mechanisms and treatments, and reduce medical costs by improving image quality and reliability. The phantom will assist multisite clinical trials that use quantitative MRI to test the efficacy of novel drugs.

NIST's is the first phantom designed to ensure that MRI system properties and image data are traceable to international system of units (SI) standards.

The ISMRM Ad Hoc Committee on Standards for Quantitative Magnetic Resonance (SQMR) defined the phantom requirements and values. NIST modeled and built the prototype device, and assured the accuracy of measured quantities.

NIST also developed and tested various solutions used in the mini-spheres as contrast-enhancing agents and measurement reference markers.

Stephen Russek, the physicist leading NIST's part of the project, says the phantom is intended to be not only accurate and traceable, but also physically stable and affordable, so that it can become as widely used in MRI machines as seatbelts are in cars.

He demonstrated the durability of the mini-spheres by bouncing one on the floor. "If it's accurate, reliable and affordable, then you have a way to measure the accuracy of MRI scanners all across the country," Russek said. "If used routinely, it will allow us to get a complete snapshot of the quality and consistency of scanning."

Phannie is undergoing testing at biomedical imaging sites across the country under the guidance of the ISMRM Ad Hoc Committee on SQMR. Materials for Phannie cost $10,000; however, it is hoped that in mass production it will reduce the cost per phantom to $2,000, Russek said.

> *"The phantom is intended to be not only accurate and traceable, but also physically stable and affordable, so that it can become as widely used in MRI machines as seatbelts are in cars."* *Stephen Russek, NIST physicist*

National Institute of Standards and Technology
Gaithersburg, Maryland

About NIST

NIST, an agency of the U.S. Department of Commerce, was founded in 1901 as the nation's first federal physical science research laboratory. Over the years, the scientists and technical staff at NIST have made solid contributions to image processing, DNA diagnostic "chips," smoke detectors, and automated error-correcting software for machine tools. A few of the other areas in which NIST has had major impact include atomic clocks, X-ray standards for mammography, scanning tunneling microscopy, pollution-control technology, and high-speed dental drills.

www.nist.gov

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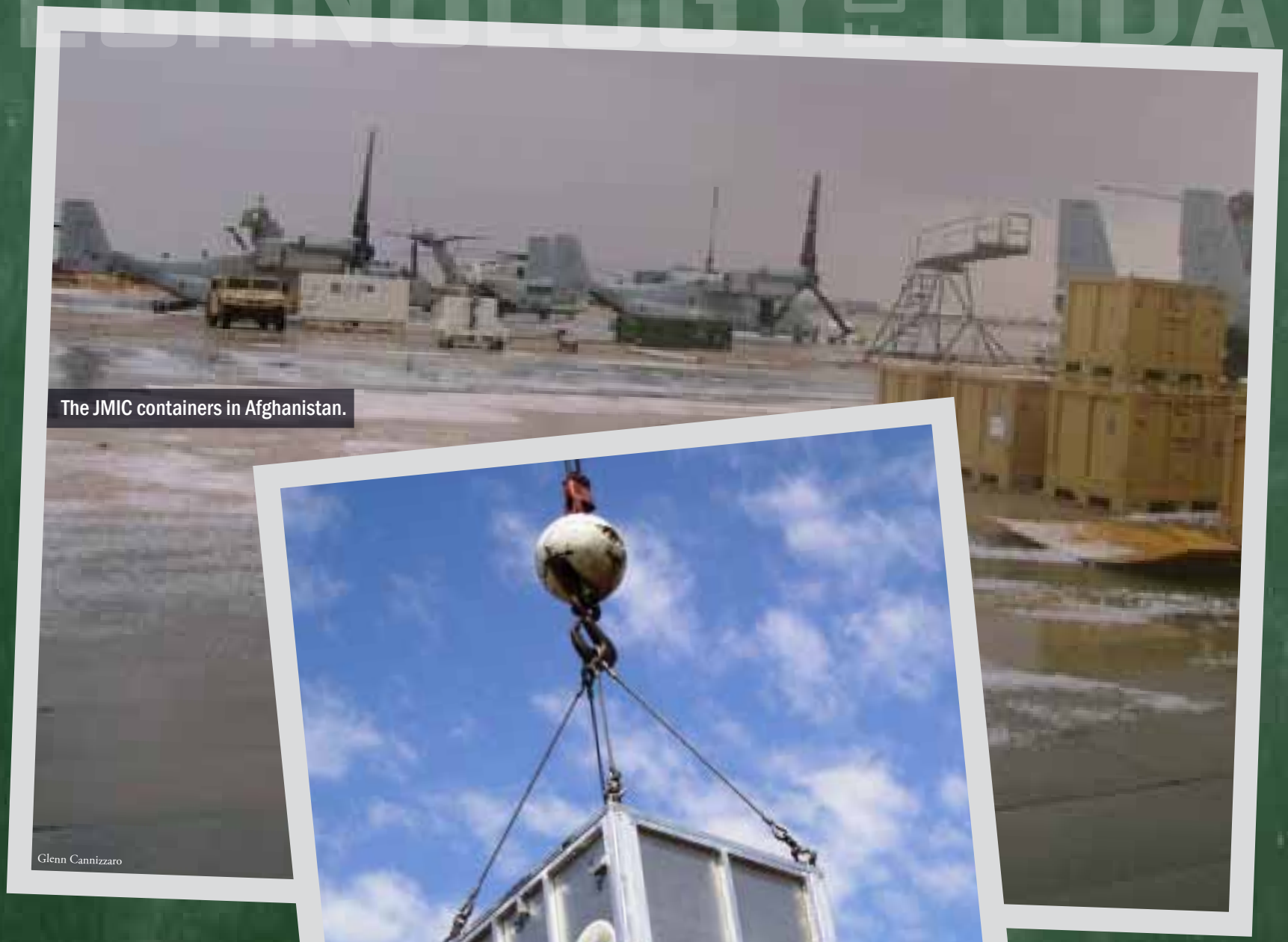


The JMIC containers in Afghanistan.

Glenn Cannizzaro

JMIC crane lift from pier to ship.

Glenn Cannizzaro

Navy Packaging Innovation Solves Shipping Challenges

With thousands of units in the field and commercial development underway, the award-winning Joint Modular Intermodal Container (JMIC) is on the cusp of transforming how cargo is packaged for shipping worldwide.

The technology was invented by Mark Heinrichs, a Navy engineer with the Naval Packaging, Handling, Storage and Transportation (PHST) Center at Naval Weapons Station Earle, and transferred to NextGen Containers of Birmingham, Ala., by the Naval Surface Warfare Center Indian Head Division (IHDIV) via a partially exclusive Patent License Agreement (PLA).

The JMIC functions as a pallet hybrid. Its unique "building block" modular design offers unprecedented flexibility, resulting in a more secure, convenient and, ultimately, lower cost alternative to more than 100 different pallet and container designs now in use by the military and commercial markets.

The JMIC can be loaded from either the top or the side, then shipped as a single unit or in multiple units locked together on a secured platform. Multiple units can also be locked to truck, railcar, ship and other surfaces equipped with interlock fittings.

When not in use for shipping, the containers can be used as secure storage units or collapsed to one-third their size and stored.

The PHST Center began working on the technology several years ago to create a better packaging solution for shipping munitions. Little had changed in shipping packaging for more than 50 years, and the inherent challenges in traditional packaging were getting more costly and labor-intensive.

The widely used, inexpensive wooden pallets, for example, handle small and odd-sized cargo; however, they require significant palletizing (wrapping/banding), as well as blocking and bracing.

In addition, they are susceptible to damage and not conducive to automation. International shipping containers offer the benefits of standardization, but are far too large for most military and commercial shipping.

JMIC, on the other hand, streamlines handling issues and offers the benefits of standardization, such as more efficient shipping configurations.

For example, 16 JMIC units fit into the standard 20-foot shipping container, filling it to capacity. Field use shows that compared to a typical partially full containerload of unstackable pallets, JMIC delivers a cost savings of 35 percent.

Standardization is also critical for automation and robotics, both key to rapid distribution, whether it is getting technology and equipment to the warfighter in the field as or moving commerce.

"Because of the advantages, JMIC containers are now being used to ship all types of cargo. More than 6,500 JMIC units are in use throughout the Department of Defense, with thousands more on order."

Because of the technology's many advantages, JMIC containers are now being used to ship all types of cargo. More than 6,500 JMIC units are in use throughout the Department of Defense, with thousands more on order.

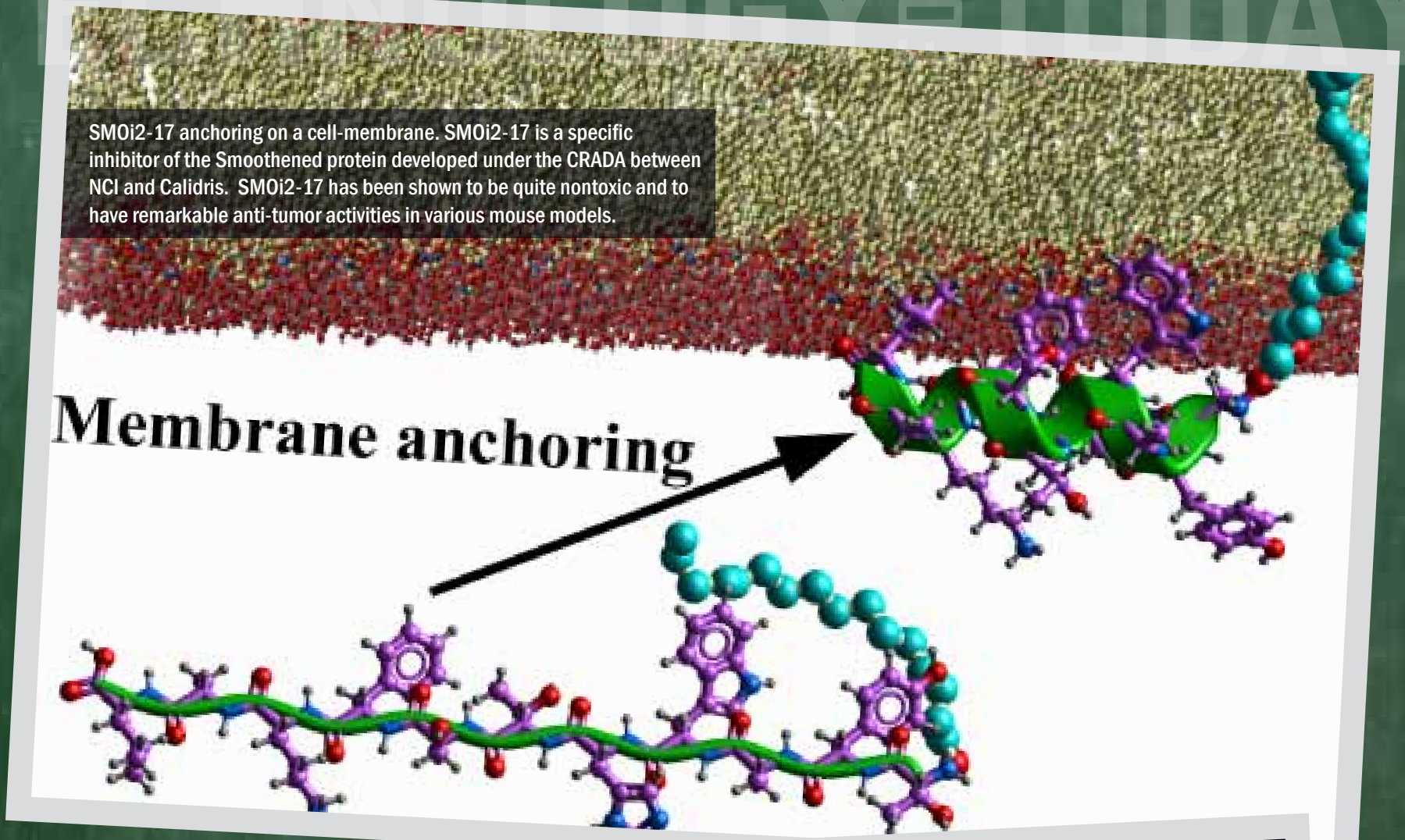
Commercially, NextGen Containers is marketing JMIC prototypes for commercial shipment of ammunition and medical equipment. In the meantime, IHDIV continues to seek licensees for the fields not covered by NextGen's PLA.

Naval Surface Warfare Center-Indian Head
Indian Head, Maryland

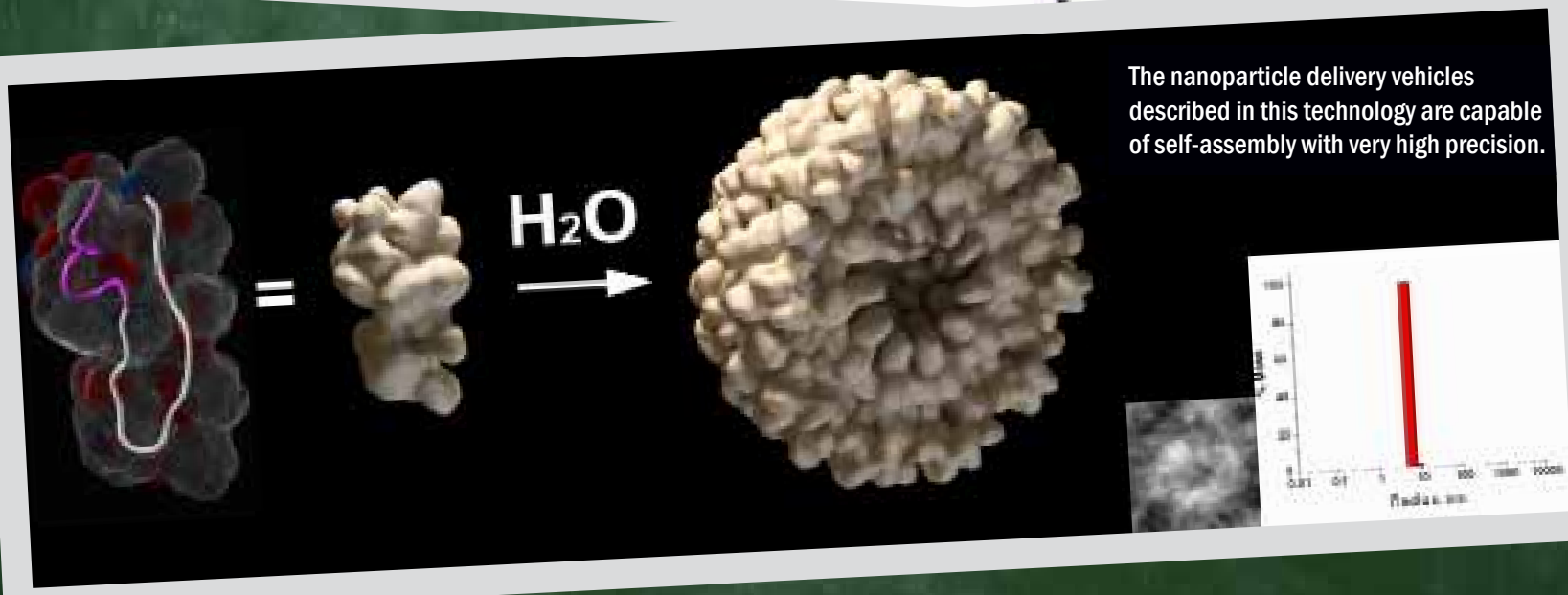
About NSWC Indian Head

The NSWC provides primary technical capability in energetics for all Warfare Centers through engineering, fleet and operational support, manufacturing technology, limited production, industrial base support, and secondary technical capability through research, development, test and evaluation for energetic materials, ordnance devices and components, and related ordnance engineering standards to include chemicals, propellants and their propulsion systems, explosives, pyrotechnics, warheads, and simulators. The NSWC also provides support, including special weapons support, explosive safety and ordnance environmental support to all warfare centers, military departments and the ordnance industry; executes other responsibilities as assigned by Commander, Naval Surface Warfare Center.

www.navsea.navy.mil/nswc/indianhead



SMOi2-17 anchoring on a cell-membrane. SMOi2-17 is a specific inhibitor of the Smoothened protein developed under the CRADA between NCI and Calidris. SMOi2-17 has been shown to be quite nontoxic and to have remarkable anti-tumor activities in various mouse models.



The nanoparticle delivery vehicles described in this technology are capable of self-assembly with very high precision.

NCI Develops Therapeutics for the Treatment of Cancer, Psoriasis, and More

Cancer is caused by the improper regulation of cascading signals, or pathways, within the cell.

One of the most prevalent means of fighting cancer involves the development of drugs and biologics that target and bind the specific proteins that disrupt the proper regulation of the pathways.

The Hedgehog pathway is normally involved in embryonic development, and it is also improperly activated in many different tumor types. Smoothened (SMO) is a protein that plays an integral role in the regulation of this pathway.

To reduce the growth of tumors, the National Cancer Institute (NCI) has developed novel drugs that disrupt the Hedgehog pathway by inhibiting the activity of the SMO protein.

These inhibitors belong to the class of drugs known as peptidomimetics (PMDs), which are synthetic drugs created by altering naturally occurring proteins.

To help the PMDs enter the tumor cells and deliver the drug directly into the cells, separate technologies needed to be developed. NCI is working on developing self-assembling nanoparticles that can incorporate PMDs. The resulting PMD nanoparticle delivery vehicle can permeate tumors and deliver the PMDs directly to cancer cells. This technology platform overcomes many of the specificity and stability issues associated with these types of drugs. The PMD technology, in conjunction with the nanoparticle delivery system, allows researchers great flexibility in developing a variety of cancer treatment options that can be used on "undruggable" proteins that are considered too difficult to be therapeutically targeted by existing therapeutics.

Transfer of this technology involved a Cooperative Research and Development Agreement (CRADA) between NCI and Calidris Therapeutics, a start-up company, and a license to the NCI technology. The CRADA is designed to accelerate pre-clinical development of the PMD technology. This CRADA/licensing approach allows for continued development of the technology under the CRADA, while the license will allow Calidris to secure background rights in the technology and help to attract potential investors.

"The resulting PMD nanoparticle delivery vehicle can permeate tumors and deliver the PMDs directly to cancer cells."

In addition to the technology transfer agreements in place with Calidris, the National Institutes of Health (NIH) has exclusively licensed the Hedgehog technology to Lee's Pharmaceuticals for the development of psoriasis therapeutics. Lee's Pharmaceuticals is an established Asian company that focuses on several indications, including dermatology, gynecology, and cardiovascular and infectious diseases. The license allows Lee's to expand its dermatology portfolio to include psoriasis treatments and to leverage its resources to bring products to market in Asia, a region where the NIH has not traditionally capitalized. By separating the field of use and geographical territories, the NIH is ensuring that its technologies are having a maximal impact promoting public health and stimulating economic development worldwide.

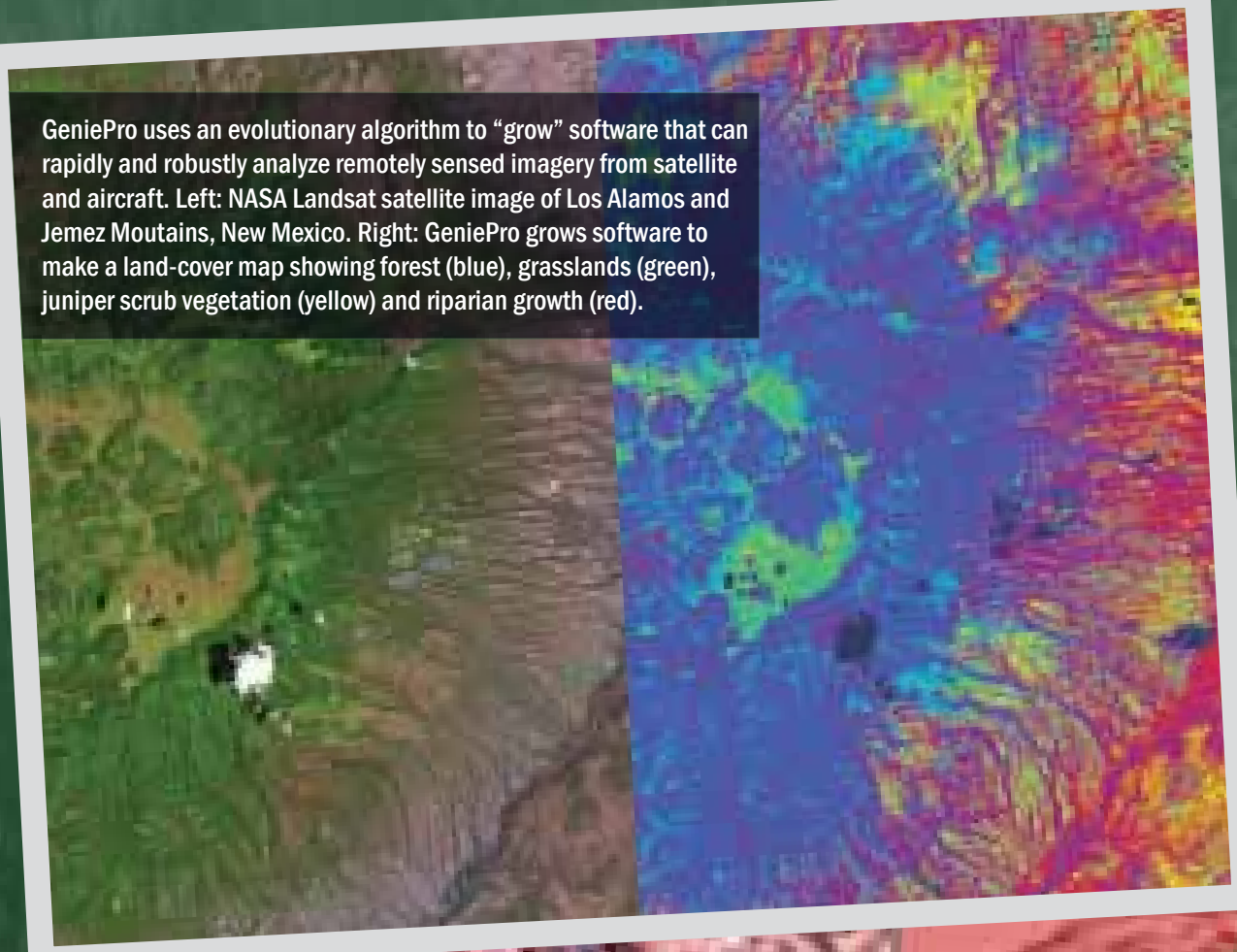
The potential benefit of this technology transfer effort extends beyond the development of a single therapeutic. The parties are attempting to establish the framework for creation of a new therapeutic field and a new generation of drugs that are highly specific, potent, and applicable to a multitude of diverse diseases. The inventors refer to these new therapeutics as "synthetic biologicals" because they possess the high specificity and reduced side-effects associated with many protein therapeutics.

National Cancer Institute
Bethesda, Maryland

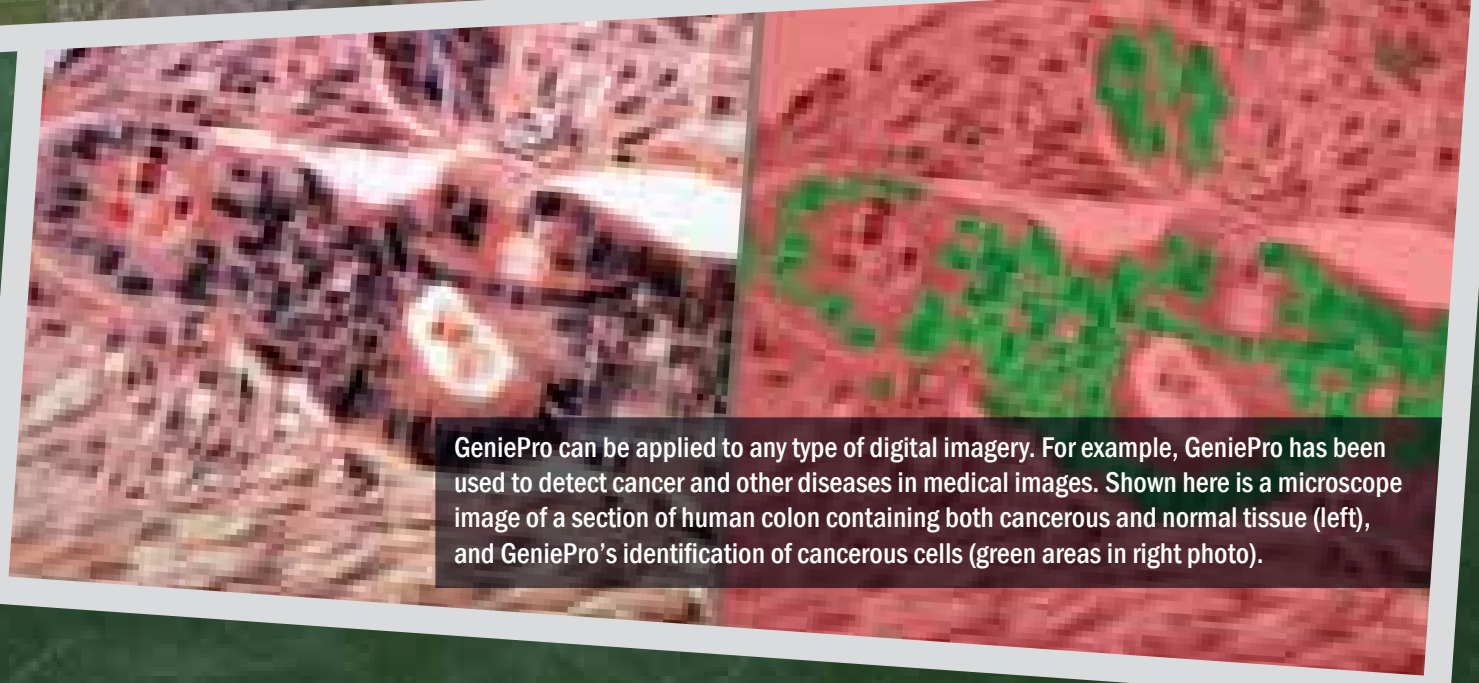
About NCI

Creation of the National Cancer Institute (NCI) was authorized by the U.S. Congress in the National Cancer Act of 1937. In this landmark legislation, NCI was given a mandate to engage in certain fundamental activities: conducting and fostering cancer research; reviewing and approving grant-in-aid applications to support promising research projects on the causes, prevention, diagnosis, and treatment of cancer; collecting, analyzing, and disseminating the results of cancer research conducted in the United States and in other countries; and providing training and instruction in the diagnosis and treatment of cancer. Over the years, NCI has evolved into the world's pre-eminent cancer research organization.NCI's advancements have helped define our understanding of human physiology, genetics, and cell biology; how normal cellular and physiologic functions can be subverted during the malignant process; and our ever-improving ability to use this knowledge to prevent, diagnose, and treat cancer.

www.cancer.gov



GeniePro uses an evolutionary algorithm to "grow" software that can rapidly and robustly analyze remotely sensed imagery from satellite and aircraft. Left: NASA Landsat satellite image of Los Alamos and Jemez Moutains, New Mexico. Right: GeniePro grows software to make a land-cover map showing forest (blue), grasslands (green), juniper scrub vegetation (yellow) and riparian growth (red).



GeniePro can be applied to any type of digital imagery. For example, GeniePro has been used to detect cancer and other diseases in medical images. Shown here is a microscope image of a section of human colon containing both cancerous and normal tissue (left), and GeniePro's identification of cancerous cells (green areas in right photo).

Los Alamos Tech Takes Imagery Analysis to the Next Level

Los Alamos National Laboratory's (LANL) GeniePro software is a general purpose, interactive, adaptive tool for automatically finding and labeling areas of interest in image data.

Rather than having to teach the program how to find areas of interest, the user has merely to provide examples of these areas.

GeniePro then designs, tests, and perfects its algorithms to produce consistent and accurate image recognition.

The software uses techniques from statistical machine learning theory and evolutionary computation theory to perform robust and customized automatic feature extraction in multispectral, hyperspectral, panchromatic, and multi-instrument fused imagery.

Genie was first used during the Cerro Grande fire to track the path of the wildfire for the Burned Area Emergency Rehabilitation team.

It was used again just after the September 11 terrorist attacks in New York City to track the cloud of ash and soot from the collapse of the World Trade Center towers.

Originally developed to analyze multispectral satellite data, GeniePro works with satellite data, aerial imagery, and medical images.

It has been applied to a variety of tasks, including crop and terrain mapping; road, railroad, river, and communications network mapping; broad-area search for vehicles and buildings; and cancer cell identification in histological images.

The GeniePro system incorporates many tools for manually optimizing results that can be easily exported in a variety of raster or vector formats for use by other software packages, such as commonly used image formats (NITF, GeoTIFF, ERDAS HFA, etc.), and it runs on both Windows and Linux systems.

GeniePro represents a significant technical advancement beyond the simple image classification algorithms found in popular geographic information system (GIS) packages.

For example, GeniePro is able to distinguish between features that share similar spectral characteristics (asphalt roads vs. asphalt roofs) because it processes the spatial context of each pixel, enabling it to produce precise results for tasks that would defeat traditional classification algorithms.

GeniePro, the most recent version of the software, was transferred to two firms through exclusive, field-of-use licenses.

Observera, Inc., licensed the technology from LANL for remote sensing and geographic information system applications. Observera's release of a commercial version of the software, GeniePro 2.0, marks the beginning of a line of new geospatial products.

Aperio Technologies, Inc., a global leader in digital pathology for the healthcare and life sciences industry, obtained an exclusive license to GeniePro for all digital pathology applications and has incorporated the code into its Spectrum digital pathology information management software, enabling it to be used as a pre-processing engine for various tissue-scoring algorithms such as finding tumor regions in digital immunohistochemistry slides.

In addition, whereas traditional analysis techniques require considerable hands-on time by the investigator to manually identify regions for analysis, the GeniePro software allows entire studies to be analyzed objectively and consistently without manual intervention.

Genie Pro may be applied to oncology, ophthalmology, diabetes, neurology, hematology, nephrology, cardiology, toxicology, and microbiology.

"GeniePro may be applied to oncology, ophthalmology, diabetes, neurology, hematology, nephrology, cardiology, toxicology, and microbiology."

Los Alamos National Laboratory
Los Alamos, New Mexico

About LANL

Los Alamos National Laboratory (LANL) is a premier national security research institution, delivering scientific and engineering solutions for the nation's most crucial and complex problems. Its primary responsibility is ensuring the safety, security, and reliability of the nation's nuclear deterrent. The Los Alamos of today emphasizes worker safety, effective operational safeguards and security, and environmental stewardship, while outstanding science remains the foundation of the Laboratory. In addition to supporting LANL's core national security mission, its work advances bioscience, chemistry, computer science, earth and environmental sciences, materials science, and physics disciplines.

www.lanl.gov

Air Force Pararescue Jumper (PJ) in Free Fall with MK 14 MOD 0.

NSWC Crane and Sage International Enhance a Proven Tool of Battle

Through technology transfer initiatives at Naval Surface Warfare Center, Crane Division (NSWC Crane), experts from the Warfare Center and Sage International, Ltd., signed an exclusive licensing agreement to commercialize upgraded features and technologies used on the M-14 battle rifle.

Because of a request from Naval Special Warfare, Sea, Air, and Land (NSW SEALs) for a more compact configuration of the M-14 rifle to better support arctic warfare missions, NSWC Crane engineer David Armstrong developed basic design features and concept sketches for a shorter barrel and a telescoping stock. Armstrong configured several prototype stocks, including one that integrated a Sage shotgun butt-stock, which was selected for further refinement.

The project later expanded to include all Naval Special Warfare commands, not just SEAL requests. Design modifications included incorporating multiple rails for attaching accessories, which would improve the overall accuracy and versatility of the system.

Armstrong worked with Sage International to design and produce a chassis stock system.

The replacement chassis stock system replaces the rifle's standard stocks, made of fiberglass or plastic, with aluminum. The incorporation of the aluminum creates a more rigid, durable and maintainable system. The metal-to-metal contact of the receiver to the chassis provides improved accuracy without the need for added bedding operations. The design also incorporates four forward rails that allow for easier mounting of sighting devices and accessories, such as day/night optics, lasers, lights, bipods and grips.

In addition to the improved accuracy, ergonomics and mounting capabilities, a key benefit to the warfighter is the ability to operate the system from vehicles and fight in close-quarter settings because of the shorter barrel and telescoping stock.

"These improvements not only provide the military with an enhanced battle rifle that is easy to carry and adjust in combat, but can be applied to other firearms and users," said Armstrong.

The stock system is currently used by Navy, Army, Air Force, Marine Corps, and Coast Guard personnel. To date, more than 8,000 have been produced for military use.

Sage International now holds an exclusive license for commercial sales and markets the system to law enforcement personnel and civilians.

The license has produced more than $55,700 in royalties, and approximately 5,000 systems have been sold commercially. The system also is available for the M1 Garand, the Mini-14, and M1A type commercial versions of the M-14 rifle.

"This partnership is the perfect example of what we strive to do through our technology transfer program at Crane," said John Dement, NSWC Crane Technology Transfer Program manager. "We not only provide the warfighter with the best technologies available, but also stimulate growth for our partners through commercial sales."

"We not only provide the warfighter with the best technologies available, but also stimulate growth for our partners through commercial sales."

John Dement, Program Manager, NSWC Crane

Naval Surface Warfare Center Crane
Crane, Indiana

About NSWC Crane

NSWC Crane supports the Warfighter in the areas of special missions, strategic missions, and electronic warfare/information operations by: providing full spectrum acquisition, engineering, logistics, and maintenance; sustaining systems; procuring hardware; operations support; technology insertion into critical components; extensive failure analysis; reverse engineering & obsolescence analysis; enhancing fleet's maintenance capability; and robust test capability. Partnerships with industry, academia and other government activities leverage the strengths of each to meet the needs of the Department of Defense. NSWC Crane and its partners are becoming known for world-class technical leadership to virtually every ship, submarine, aircraft, and missile system fielded by the Navy.

www.navsea.navy.mil/nswc/crane

TECHNOLOGY FOR TODAY

Dr. Charles Onwulata and his team in the lab working on the corn soy blend.

Agricultural Research Leads to Innovation to Fight World Hunger and Aid Emergency Relief

USDA Agricultural Research Service (ARS) researchers have developed an innovative food product to assist in the fight against hunger and malnutrition.

Dr. Charles Onwulata, Lead Scientist working at ARS; Dean Jensen, Operations Chief working at the USDA Foreign Agricultural Service (FAS); and Dr. Talari Jude, Food Technologist and FAS Manager of Domestic Programs have collaborated to deliver a novel emergency aid product for needy populations all over the world.

The FAS and the United States Agency for International Development (USAID) have consulted with Dr. Onwulata for over 15 years on resolving some of the problems associated with uncooked corn soy blend (CSB).

Over the last 50 years, the Food-for-Peace program, through Title II of Public Law 480, has distributed foods to people overseas at risk of hunger and malnutrition, providing nutritionally balanced meals in times of emergency.

The USDA FAS administers the Food-for-Peace program, buying U.S.-grown commodity products, which are in turn handed over to the USAID, which distributes the foods through non-governmental organizations (NGOs). The meals are supplied as uncooked fortified corn- or wheat-soy blends, with oil, vitamins and minerals.

These uncooked CSB meals have had many problems ranging from off-flavors (products going stale due to rancid fats); segregation of particles, which intensifies malnutrition (vitamins and mineral settling to the bottom of the bag); and off colors (as vitamins and iron react with starch, protein, and fat under high temperatures in tropical countries), just to name a few. To combat these issues, the team created an instant corn soy blend (ICSB), a CSB powder that makes porridge without cooking.

Not intended as a replacement for regular CSB, ICSB is being offered as a performance--based, "value-added," processed grain product alternative of choice that utilizes the exact same ingredients, formulations, vitamins and minerals utilized in the current CSB, with the major difference between the two formulations being that ICSB does not require cooking.

In summary, the ICSB product is balanced in nutrition, provides food to people in difficult situations, eliminates the problems faced by FAS with food quality issues, and helps to protect the environment.

Also, ARS and FAS are working jointly with a minority company that provides work for the disabled to manufacture ICSB in Baltimore, Maryland.

The ICSB process and product have been demonstrated to multiple U.S. aid agencies and the United Nations High Commission for Refugees. The FAS issued formulation specifications bids in 2010 under the $2 billion/year Public Law 480 program using this process to request a product that is fully cooked and ready to eat.

"The ICSB product is balanced in nutrition, provides food to people in difficult situations, eliminates the problems faced by FAS with food quality issues, and helps to protect the environment."

Agricultural Research Service HQ
Washington, D.C.

About ARS

The Agricultural Research Service (ARS) is the U.S. Department of Agriculture's chief scientific research agency. ARS's job is to find solutions to agricultural problems that affect Americans every day, from field to table. ARS has 1,200 research projects within 21 national programs employing over 6,000 employees, including 2,100 scientists. ARS conducts research to:

- Ensure high-quality, safe food, and other agricultural products
- assess the nutritional needs of Americans
- Sustain a competitive agricultural economy
- Enhance the natural resource base and the environment, and
- Provide economic opportunities for rural citizens, communities, and society as a whole.

www.ars.usda.gov

TECHNOLOGY FOR TODAY

Sgt.Lynn Randall King of the Brook Army Medical center felt that the existing training tools didn't sufficiently recreate the stress and difficulty of real-life hemorrhage control in the field. To address this he developed the Field Expedient Bleeding Simulation System (FEBSS™). Pictured here, an Army medic trains during a simulated excercise.

Army Veteran Invents Simulated Bleeding System for Wound Training

What started as an idea of how to make training more realistic for medics has developed into a commercialized product in use by numerous military and civilian organizations in the U.S. and abroad.

Effective training of medics is vital, given that a high percentage of fatalities and disabilities result from delays in effective hemorrhage control.

Realistic training prepares medics for what may be a shocking first sight for some, preparing them to take appropriate action with minimal delay in the line of duty—a difference that could mean life or death in some cases.

Army medics learn to treat wounded warriors to prevent such casualties during Combat Medic Training at Fort Sam Houston, Texas.

However, Army veteran Sgt.Lynn Randall King felt that the existing training tools didn't sufficiently recreate the stress and difficulty of real-life hemorrhage control in the field. To address this he developed the Field Expedient Bleeding Simulation System (FEBSS™) while he was an Army medic trainer at Brooke Army Medical Center (now San Antonio Military Medical Center) to better prepare medics for real-life blood loss treatment emergencies on the battlefield. The FEBSS™ simulates several concurrent wounds, either mild or severe, from a venal nick to a pulsing arterial hemorrhage.

Units are suited for retrofitting of typical manikins, or the systems can be worn by personnel in a role-playing exercise.

When worn by personnel, the device is camouflaged under their uniform and the added element of surprise occurs when, during training and battle simulations, the personnel becomes "wounded," screaming and bleeding unexpectedly.

An exclusive patent license agreement (PLA) to Skedco, Inc., allowed the small U.S. business to commercialize the FEBSS™ Army technology, which was first enhanced under a Cooperative Research and Development Agreement (CRADA), and is now the subject of several U.S. and foreign patents. Both the CRADA and PLA were negotiated by the U.S. Army Medical Research and Materiel Command's Office of Research and Technology Applications.

Since its commercialization in spring 2008, FEBSS™ has been purchased and is in use by several military and civilian medic training organizations in the U.S. and abroad. In 2009, the FEBSS™ was one of 30 products named to the *Journal of Emergency Medical Services* hot products list.

Reviewed by emergency medical service providers, products that make the list are deemed as the most innovative, functional, and potentially life-saving products to come to market in the past six months.

While statistics have yet to be compiled on how effective the use of FEBSS™ is during training, there is a documented case of an Army soldier who was able to react quickly after a fellow soldier was hit by sniper fire in Iraq.

Despite the soldier not being a medic, his quick reaction allowed him to stop the bleeding of a femoral artery injury in time to save his comrade's life. Prior to deploying the soldier had received training via the FEBSS™, and he attributed this to his quick thinking and actions.

In 2010, both the president and vice president of Skedco and Army veteran/inventor King traveled to Iraq to provide training to combat soldiers and medics using the FEBSS™. A trip to Afghanistan is slated for summer of 2011.

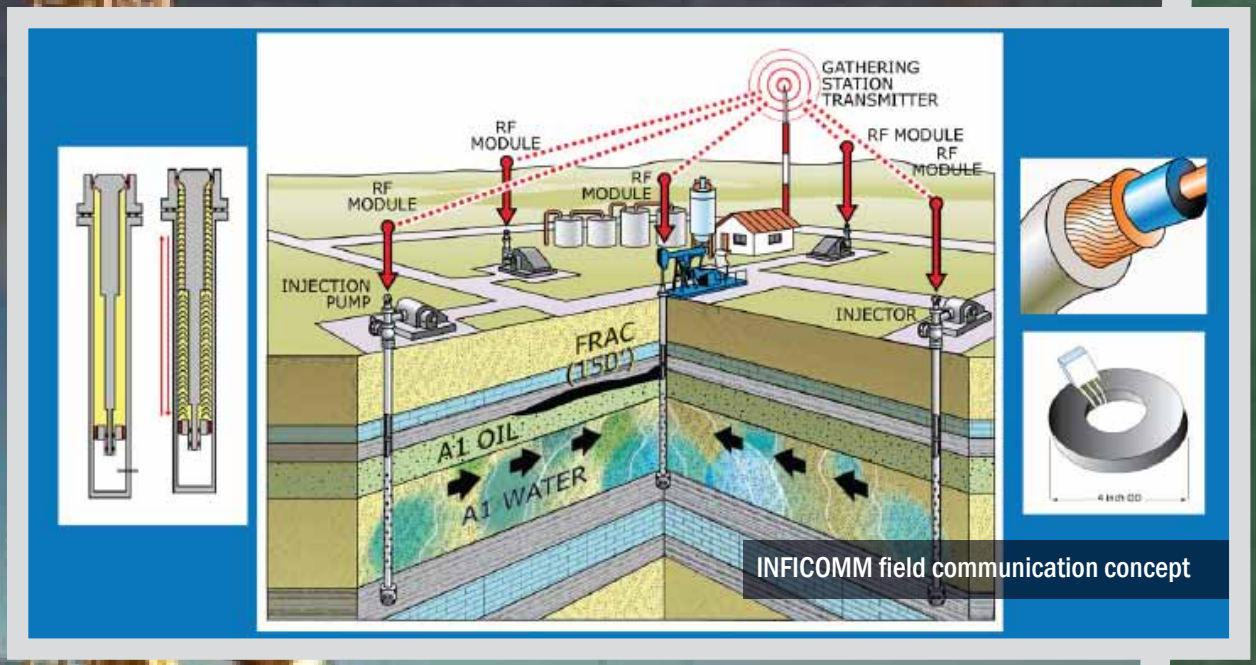
"An Army soldier who was able to react quickly after a fellow soldier was hit by sniper fire in Iraq. Despite the soldier not being a medic, his quick reaction allowed him to stop the bleeding of a femoral artery injury in time to save his comrade's life."

U.S. Army Medical Research and Materiel Command
Fort Detrick, MD

About USAMRMC

The U.S. Army Medical Research and Materiel Command is the Army's medical materiel developer, with responsibility for medical research, development, and acquisition and medical logistics management. The USAMRMC's expertise in these critical areas helps establish and maintain the capabilities the Army needs to fight and win on the battlefield. Ensuring our armed forces remain in optimal health and are equipped to protect themselves from disease and injury, particularly on the battlefield, is the job of the U.S. Army Medical Research and Materiel Command. Six medical research laboratory commands execute the science and technology program to investigate medical solutions for the battlefield with a focus on various areas of biomedical research, including military infectious diseases, combat casualty care, military operational medicine, medical chemical and biological defense, and clinical and rehabilitative medicine.

https://mrmc.detrick.army.mil



INFICOMM field communication concept

Dawn breaks on INFICOMM deep well test.

Turning Production From an Art to a Science

As scientists at Los Alamos National Laboratory were working to create a wireless communications technology that would enable our troops to communicate in combat zones, they had no idea that this would lead to additional benefits to national security by applying it to the oil and gas industry.

The ability to have broadband down-hole communication has been elusive in the oil and gas industry. Down-hole environments are not suited for current technologies. Temperatures, pressures, and mechanical issues limited data gathering for short periods of time, and often on an annual basis. Both wired and wireless communications have never been practical.

A general lack of understanding of the current down-hole environment makes production from a well more of an art than a science. Estimates from the industry suggest that as much as 50% of the reserves in a reservoir are never extracted; this is known as its "economic limit." By obtaining accurate and current data from a well on the temperature, pressure and fluid levels, the art of production will quickly become the science of production.

INFICOMM is a groundbreaking, transformational wireless technology that is now in use in oil and gas wells. The technology, which incorporates innovative proprietary sensor technology, eliminates the need for down-hole power or batteries.

Current methods of communicating with down-hole sensors are limited, as they require relatively fragile wires or are very low bandwidth. The INFICOMM technology allows for high bandwidth from multiple sensors collected from different locations. It can be deployed for a low cost and is rugged enough to survive even the most aggressive down-hole environments.

This technology will allow for increases in oil and gas recovery efficiency and production rates, increasing energy security. In addition to increasing the production of these resources, the technology will also reduce the amount of energy required in production, while also reducing equivalent CO2 levels from this production energy.

For example, heavy oil reservoirs require steam to be injected into the reservoir to allow the heavy oil to become viscous enough to be pumped out of the reservoir. How much steam is needed and what the temperature of that steam needs to be has always been a part of the art of production. Often, these heavy oil reservoirs have hundreds to thousands of producing wells in them. By understanding the temperature and pressure at each well, the optimal amount of steam pressure and temperature can be injected into the field. With the introduction of this low-cost technology, the entire field will be modeled and managed as one integrated field rather than individual wells.

Los Alamos partnered with Chevron Energy Technology Corporation to develop this military technology for the oil and gas industry. Chevron has licensed the background intellectual property and sublicensed this technology to the startup company INFICOMM, Inc., to commercialize broadly in the oil and gas industry in both exploration and drilling, which has a market estimate of over $1 billion per year.

"Estimates from the industry suggest that as much as 50% of the reserves in a reservoir are never extracted; this is known as its "economic limit."

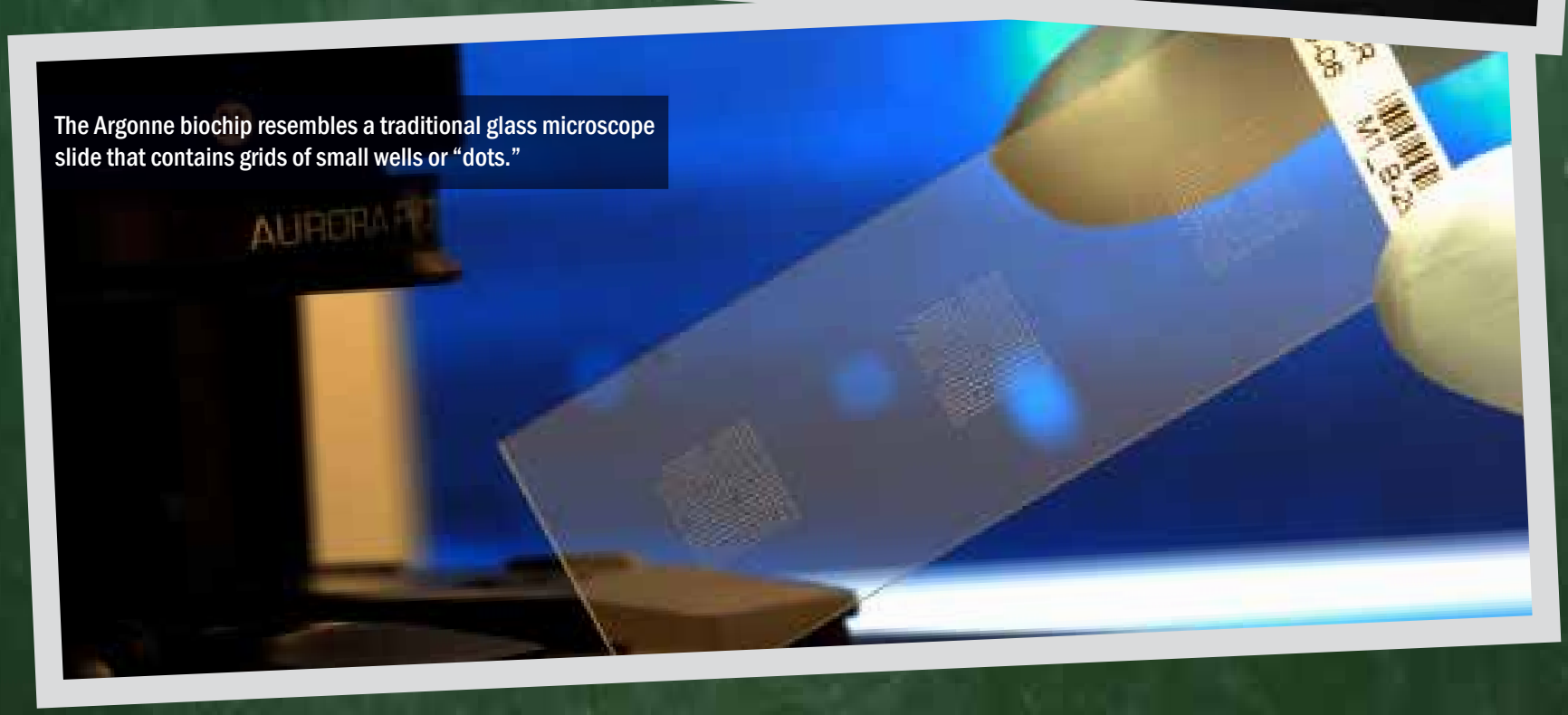
Los Alamos National Laboratory
Los Alamos, New Mexico

About LANL

Los Alamos National Laboratory (LANL) is a premier national security research institution, delivering scientific and engineering solutions for the nation's most crucial and complex problems. Its primary responsibility is ensuring the safety, security, and reliability of the nation's nuclear deterrent. The Los Alamos of today emphasizes worker safety, effective operational safeguards and security, and environmental stewardship, while outstanding science remains the foundation of the Laboratory. In addition to supporting LANL's core national security mission, its work advances bioscience, chemistry, computer science, earth and environmental sciences, materials science, and physics disciplines.

www.lanl.gov

Biologist Dan Schabacker loads a biochip onto a reader for analysis. Developed initially to become a standard diagnostic tool for human and veterinary medicine, Argonne's biochip technology can also be employed to determine the "signatures" of biological agents that can be used for bioterrorism.



The Argonne biochip resembles a traditional glass microscope slide that contains grids of small wells or "dots."

Argonne Biochip Advances Medical Diagnostics, Forensics, Pet Care, and More

In their fight against virulent diseases such as cancer, doctors have recently gained an impressive new weapon to add to their arsenal. Researchers at the U.S. Department of Energy's Argonne National Laboratory have developed a chip that can save lives by diagnosing certain diseases even before patients become symptomatic.

The technology is a biochip system aimed at rapid detection of emerging diseases by protein and DNA analysis. The new technology consists of a one-centimeter by one-centimeter array that comprises anywhere between several dozen and several hundred "dots," or small drops. Each of these drops contains a unique protein, antibody, or nucleic acid that will attach to a particular DNA sequence or antigen indicating aberration from a healthy person.

This technology includes a method for gel-drop-based sequencing by hybridization on the chip and a low-cost biochip reader. A portion of this technology is the product of joint research between Argonne and the Englehardt Institute of Molecular Biology in Moscow. Other partners have included the Defense Advanced Research Projects Agency, Defense Threat Reduction Agency, Akonni Biosystems, Eprogen, Inc., Safeguard Biosystems, Motorola, Perkin-Elmer (Packard Instruments), and Aurora Photonics.

Potential applications include use in handheld point-of-care devices located in physician offices, hospitals, clinics, and field use.

The technology is capable of identifying causative pathogens and associated antibiotic resistance within 120 minutes of sample collection. It is also capable of identifying common cancer biomarkers and a wide variety of infections, such as those caused by multidrug-resistant tuberculosis and the often deadly methicillin-resistant *Staphylococcus aureus*.

"It is also capable of identifying common cancer biomarkers and a wide variety of infections..."

Benefits of this technology include faster genetic testing (minutes), multiplexing, small footprint (1 square centimeter), minimal sample volume (less than 5 microliters), increased sensitivity and specificity, and lower cost.

The medical diagnosis technology has been developed to the point where it is now available for commercial licensing. To date, it has been licensed to three startup companies. One company (Akonni Biosystems) has sales of DNA extraction kits, and the technology is in Food and Drug Administration (FDA) trials for use as a point-of-care human diagnostic instrument. Another company (Eprogen, Inc.) is using it to search for biomarkers indicating cancer. Another (Safeguard Biosystems) is using it for veterinary diagnostic applications. FDA trials are underway.

Efforts will continue to improve the product's marketability to the point where it is routinely used in physician offices, emergency rooms, and veterinary centers.

Recent research has expanded the application of this technology to microbial forensics, including bioterrorism. The biochip technology provides information on how a biological agent was grown, purified, and prepared for dissemination. This information can then be used to develop a profile of the perpetrator's expertise and resources, thereby narrowing the pool of potential suspects. A patent application has been submitted for this technology in partnership with Loyola University Medical Center.

Argonne National Laboratory
Argonne, Illinois

About Argonne

Argonne National Laboratory, one of the U.S. Department of Energy's oldest and largest national laboratories for science and engineering research, employs roughly 3,200 employees, including about 1,000 scientists and engineers, three-quarters of whom hold doctoral degrees. Argonne's annual operating budget of around $630 million supports upwards of 200 research projects. Since 1990, Argonne has worked with more than 600 companies and numerous federal agencies and other organizations. Argonne's mission is to apply a unique mix of world-class science, engineering and user facilities to deliver innovative research and technologies. We create new knowledge that addresses the most important scientific and societal needs of our nation.

www.anl.gov

A recent Amonix 7700 installation at the Solar Technology Acceleration Center (SolarTAC) in Aurora, Colorado, features nine pedestals that generate about 0.5 megawatts. SolarTAC, the largest test facility for solar technologies in the United States, provides a venue for researching, demonstrating, testing, and validating a broad range of solar technologies at the early commercial or near-commercial stage of development.

Dennis Schroeder

NREL, Amonix Light the Way to Utility-Scale Solar Electricity

Where utility-scale solar electricity is concerned, good things come in large, powerful packages. In this case, the package is the Amonix 7700, a concentrating photovoltaic (CPV) generating system with a 27% (AC) sunlight-to-electricity conversion efficiency.

"It's the most efficient solar power system on the planet, generating more energy per acre than any other solar system," said Vahan Garboushian, founder, chief technology officer, and chairman of the board of Amonix. "This achievement is the result of advances in CPV solar technology generally and specifically the work that Amonix and the National Renewable Energy Laboratory (NREL) have done together to accelerate multijunction cell development and improve packaging, the module, and system-integration technology."

The 7700 is a 53-kilowatt CPV power generator based on the MegaModule®, a turnkey unit pairing a durable Fresnel lens with ultra-high-efficiency multijunction cells.

The Amonix 7700 concentrates the energy of the sun by 500 times to generate bulk power—"more power per tower"—than any of its competitors. Its utility-scale size reflects its desired impact on the energy grid: reducing costs and land use.

The Amonix 7700 is a game-changer in propelling solar electricity to grid parity with fossil fuels.

The working relationship between NREL and Amonix played on the strengths of each partner, including Amonix's 15 years of developing CPV systems and NREL's more than three decades of R&D in PV technologies. NREL's 1991 invention of the multijunction PV cell was applied in the redevelopment of the Amonix flagship CPV system.

After substituting a high-efficiency multijunction PV cell with about 41.6% record efficiency for the previously used silicon cell with about 27.6% efficiency, engineers developed the Amonix seventh-generation 7700.

It demonstrates a 50% increase in solar power output over previous generations. This was accomplished in partnership with NREL through the High-Performance PV Project funded by the U.S. Department of Energy (DOE) Solar Energy Technologies Program. Other DOE-funded support came from the Small Business Innovation Research and Technology Pathway Partnership programs. DOE's Sandia National Laboratories and Brookhaven National Laboratory also facilitated the scale-up of this project.

The Amonix 7700's modular design is the key to the system's low cost and high efficiency. Each 7700 has seven MegaModules®, each of which uses 1,080 PV cells.

The 7700's advantages, as recognized by a 2010 R&D 100 Award, include factory assembly of the MegaModules®, which reduces installation time from months to days. Operating and maintaining the 7700 is streamlined based on the design modularity.

Amonix uses a turnkey manufacturing system that incorporates cost savings at each step of the manufacturing-to-installation pipeline. The company's state-of-the-art robotics and a capital-efficient (one-half to one-third the cost of competing technologies) process enables distributed manufacturing. Integration of the lens, mounting structure, and solar cell into a single unit eliminates more than 75% of the parts and costs associated with other concentrator designs.

"They are a wonderful marriage of high technology and engineering at a scale that is truly impressive."
Ryne Raffaelle, Director, NREL National Center for Photovoltaics

Ryne Raffaelle, director of the National Center for Photovoltaics at NREL, recently visited the Solar Technology Acceleration Center in Aurora, Colorado, site of the latest installation of the Amonix 7700. "Seeing these CPV systems up close blew me away—they are huge," he said. "They are a wonderful marriage of high technology and engineering at a scale that is truly impressive. I think this is only the beginning of what can be accomplished in terms of the overall system efficiency when one combines world-record PV technology with a CPV system designed by the absolute leader in their field."

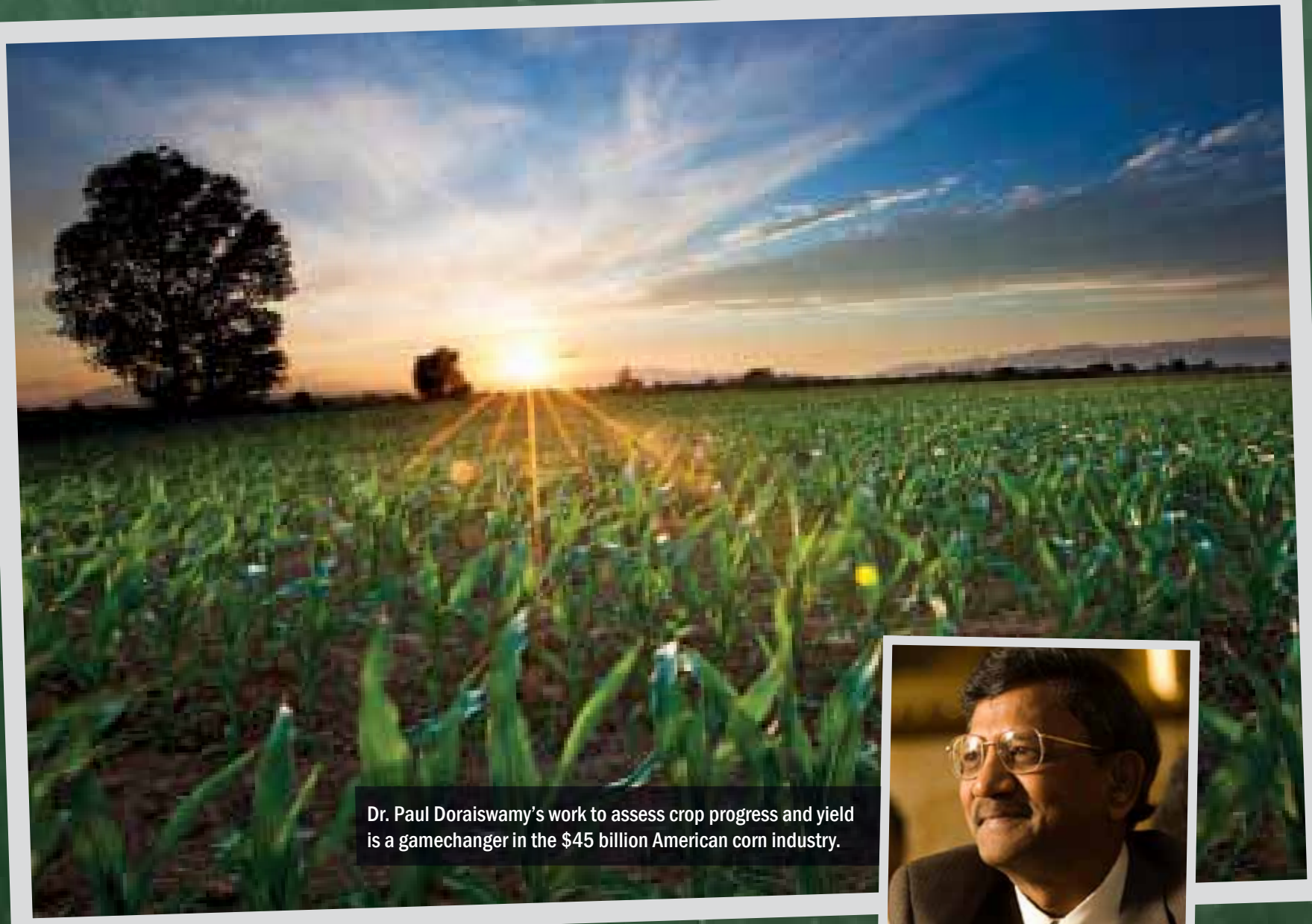
National Renewable Energy Laboratory
Golden, Colorado

About NREL

The National Renewable Energy Laboratory (NREL) is the U.S. Department of Energy's (DOE) primary laboratory for renewable energy and energy efficiency research and development. Established in 1974, NREL began operating in 1977 as the Solar Energy Research Institute. NREL's mission and strategy are focused on advancing the DOE's and our nation's energy goals. The Laboratory's scientists and researchers support critical market objectives to accelerate research from scientific innovations to market-viable alternative energy solutions. At the core of this strategic direction are NREL's research and technology development areas. These areas span from understanding renewable resources for energy, to the conversion of these resources to renewable electricity and fuels, and ultimately to the use of renewable electricity and fuels in homes, commercial buildings, and vehicles.

www.nrel.gov

TECHNOLOGY FOR TODAY



Dr. Paul Doraiswamy's work to assess crop progress and yield is a gamechanger in the $45 billion American corn industry.

Bettering the Way We Assess Crop Yields Proves Critical for Billion-Dollar Agriculture Industry

Dr. Paul Doraiswamy of the Agricultural Research Service was the lead scientist for several competitive USDA National Agricultural Statistics Service (NASS)-funded projects for the development of a robust technology to assess real-time crop progress, its condition during the season, tracking accumulative effects of water deficit conditions and to predict yields prior to crop maturity.

The target area for the use of such innovation is the U.S. corn belt, where 90% of the corn and soybean crops are cultivated under rain-fed conditions.

The regional assessment is accomplished by scaling up local assessment crop responses to county and state yield estimates.

Accurate and timely monitoring of agricultural crop conditions and estimating potential crop yields are essential for the operational programs of the USDA.

Assessment of decreased production caused by a natural disaster, such as drought, floods, or pest infestation, can be critical for areas where the economy is dependent on the crop harvest.

Early assessment of yield reductions could avert a disastrous situation and help in strategic planning to meet demands.

Currently, NASS acquires crop yield indications via ground-based sample surveys (objective plant and fruit counts and farmer reports), which are collectively used in its decision support system to assess weekly crop progress, monthly crop yield estimates for each state and the U.S., and annual county yield estimates.

The technology developed by Dr. Doraiswamy builds yield estimates from field to regional scales by accounting for every field that is observable at the satellite resolution (250 meters), and it is designed to supplement and potentially replace much of the labor-intensive NASS ground-based surveys.

The total planted area for corn in the U.S. is 86.6 million acres and 77.5 million acres for soybean. The monetary value of crop yield production is about $45.5 billion for corn and $33.03 billion for soybean.

Hence, a technology that can provide real-time assessment of changes in corn and soybean yields at regional scales is critical for predicting commodity prices and potential economic impacts on farmers/producers and consumers.

The significant impact of this technology not only allows for spatial assessment of real-time changes in crop yields, but also provides estimates several months prior to NASS's final state estimates made in January and final county estimate made in March of the following year after harvest.

"The monetary value of crop yield production is about $45.5 billion for corn and $33.03 billion for soybean".

This technology has been operational for the past two years at the NASS facility in Fairfax, Va.

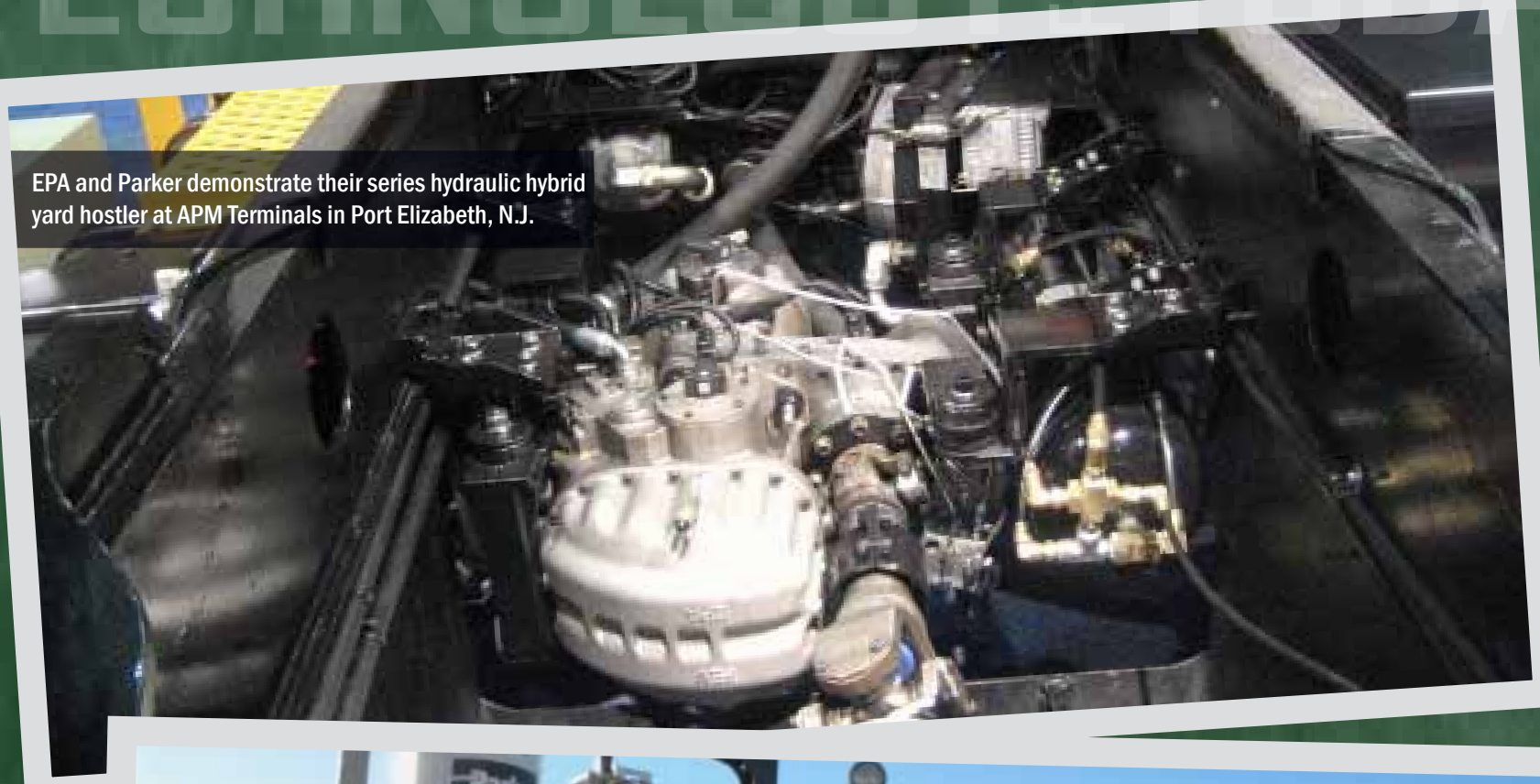
The development of this tool was achieved with financial support from ARS, NASA and the NASS, which funded a research support staff given the multidisciplinary nature of this technology.

National Agricultural Statistics Service
Washington, D.C.

About NASS

The USDA's National Agricultural Statistics Service (NASS) conducts hundreds of surveys every year and prepares reports covering virtually every aspect of U.S. agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of U.S. producers are only a few examples. NASS is committed to providing timely, accurate, and useful statistics in service to U.S. agriculture.

www.nass.usda.gov



EPA and Parker demonstrate their series hydraulic hybrid yard hostler at APM Terminals in Port Elizabeth, N.J.

Hydraulic pump-motor components in the EPA/ Parker series hydraulic hybrid yard tractor

EPA's National Clean Diesel Campaign Motivates Hybrid Vehicle Technology for Moving Cargo Containers

In April 2009, the Environmental Protection Agency (EPA) and its industry partners offered a preview of a leading-edge, pollution-saving truck for transferring cargo containers at the Society of Automotive Engineers World Congress in Detroit, Michigan.

The special cargo mover, called a series hydraulic hybrid yard hostler, moved from the exhibition into field testing at port terminals in the United States.

The EPA and its partners have applied EPA's patented series hydraulic hybrid vehicle (HHV) technology to the heavy-duty truck as part of the EPA National Clean Diesel Campaign (NCDC) Clean Ports USA program.

Hostlers are large, off-road vehicles used to transfer cargo containers at marine ports, rail yards, warehouses and distribution centers. The trucks spend about half of their time idling and contribute to air pollution generated in ports throughout the world.

The EPA's unique series HHV power train efficiently recovers, stores and reuses braking power while significantly reducing idling and optimizing engine operation to use less fuel and reduce air pollution.

HHV technology has been demonstrated and field-tested in a number of vehicles, including package delivery vehicles and reuse trucks. The EPA believes that this vehicle design can improve the efficiency of the yard hostler operation by 50-60 percent.

Several EPA programs, including the National Clean Diesel Campaign and its Clean Ports USA, Clean Automotive Technology, Office of International Affairs, and EPA Region 2 (New York and New Jersey) collaborated on this project. Industry technical partners include APM Terminals, Parker-Hannifin, Kalmar Industries, FEV Inc., R. H. Sheppard Co Inc., and Webasto. Additional support was provided by the Port Authority of New York and New Jersey and the New Jersey Department of Environmental Protection.

The EPA established the National Clean Diesel Campaign to promote diesel emission reduction strategies. Reducing emissions from diesel engines is one of the most important air quality challenges facing the country today.

The NCDC includes innovative programs to address the millions of diesel engines already in use, as well as regulatory programs to address new diesel engines.

The EPA's Clean Automotive Technology Program conducts innovative research primarily to:

- Achieve ultra-low pollution emissions
- Reduce greenhouse gases
- Increase fuel efficiency.

By developing cost-effective technologies, the Clean Automotive Technology Program also encourages manufacturers to produce cleaner and more fuel-efficient vehicles. Fleet owners benefit by being able to recoup the initial hybrid system costs through lower operating costs within a few years.

"EPA's unique series HHV power train efficiently recovers, stores and reuses braking power while significantly reducing idling and optimizing engine operation to use less fuel and reduce air pollution".

Environmental Protection Agency
Washington, D.C.

About the EPA

In July 1970, the White House and Congress worked together to establish the EPA in response to the growing public demand for cleaner water, air and land. Prior to the establishment of the EPA, the federal government was not structured to make a coordinated attack on the pollutants that harm human health and degrade the environment. The EPA was assigned the daunting task of repairing the damage already done to the natural environment and establishing new criteria to guide Americans in making a cleaner environment a reality. EPA leads the nation's environmental science, research, education and assessment efforts. The mission of the Environmental Protection Agency is to protect human health and the environment. Since 1970, EPA has been working for a cleaner, healthier environment for the American people.

www.epa.gov

Comparison of standard chromia refractory with NETL's phos-modified chromia refractory showing improved wear resistance.

Improved Refractory Liner for Coal Gasification

Researchers from the Department of Energy's National Energy Technology Laboratory (NETL) in Albany, Oregon, have developed a novel refractory material that could overcome one of the major challenges preventing the widespread adoption of the next generation of advanced power plants based on coal gasification. The newly developed refractory material has a longer service life, leading to greater online availability of the gasifier for coal processing.

Coal gasification is an important part of the nation's efforts to obtain the most energy from its abundant coal supplies. It involves reacting coal with high-temperature, high-pressure steam in a shortage of oxygen, and converting it to a carbon monoxide and hydrogen gas mixture called synthesis gas, or syngas.

By increasing refractory life, NETL researchers have helped to make coal gasification a more efficient and eco-friendly process versus coal combustion, making it a viable technology for the future.

Syngas can be used to make gasoline, diesel, and aviation fuels in the coal-to-liquids process, or can be combusted to drive turbines producing electricity. Hydrogen can also be separated from syngas to power advanced fuel cells. Carbon dioxide can be captured for reuse in other processes such as enhanced oil recovery, or it can be sequestered underground to prevent it from contributing to global climate change. The versatility and carbon capture ability of coal gasification highlights its need as an economically viable process.

Gasification is not always viewed as the technology of choice by industry, in part because of the high costs associated with rapidly deteriorating refractory linings. Refractories are heat-resistant materials that protect the metal gasification chamber from its service environment. Investigation by NETL researchers revealed that the major causes of refractory wear are:

- Penetration of corrosive molten material (slag) that originates from coal mineral impurities into the refractory brick
- Corrosion of the refractory by that molten slag. Once slag is inside the brick, it generates cracks parallel to the brick's face. Eventually these cracks link and cause flaking (spalling) of the brick's surface as pieces up to one-inch deep, leading to premature lining failure.

Refractory linings typically cost $1 million or more to replace, depending on the gasifier size and the amount of lost production during the plant shutdown. For that reason, refractory service life has slowed the adoption of gasification technology.

NETL researchers targeted altering the internal structure of the refractories through chemical changes to prevent slag penetration, with the goal of eliminating spalling as a wear mechanism. The addition of a few percent of phosphate compounds to the chromia brick formulation was found to be successful.

Once the technology was patented, NETL entered into a CRADA with Harbison-Walker Refractories Company to scale the process for field trials. The resulting refractory was found to increase refractory service life by up to 50 percent. Harbison-Walker licensed the technology from NETL, conducted additional field trials, and commercialized the product as AUREX™ 95P. It has received reviews of "exceptional" and "excellent" at test sites, and is the refractory of choice in high wear areas of a gasifier. One gasifier site has lined almost the entire gasifier with the product.

National Energy Technology Laboratory
Albany, Oregon

About NETL

The National Energy Technology Laboratory (NETL) supports DOE's mission to advance the national, economic, and energy security of the United States. NETL implements a broad spectrum of energy and environmental research and development (R&D) programs that will return benefits for generations to come. NETL has expertise in coal, natural gas, and oil technologies; contract and project management; analysis of energy systems; and international energy issues. In addition to research conducted onsite, NETL's project portfolio includes R&D conducted through partnerships, Cooperative Research and Development Agreements, financial assistance, and contractual arrangements with universities and the private sector.

www.netl.doe.gov

Breeding potatoes involves choosing parents that complement each other in their strengths and weaknesses. In crossing two clones, geneticist Richard Novy pollinates a potato flower with pollen from another parent.

Peggy Greb

Geneticist Rich Novy harvests tubers of a potato breeding clone at Tetonia, Idaho.

Scott Bauer

Agricultural Research Service Scientists Develop Noteworthy Potato Varieties in the Pacific Northwest

The development of a new potato variety takes 12 plus years and the expertise of many scientific disciplines.

Agricultural Research Service (ARS) scientists Richard Novy, Jonathan Whitworth, Roy Navarre, James Crosslin, and Chuck Brown have achieved just that.

Some of the noteworthy varieties that have come out of the program include:

- Premier Russet, a mid- to late-season variety notable for its high yield of oblong-long, medium russeted tubers
- Classic Russet, an early-maturing, russeted clone, well-suited for use by the fresh-pack industry
- Alturas, used primarily for processing, but also rated highly for its culinary quality
- Defender, a high yielding, lightly russeted, processing potato
- Highland Russet, a mid- to late-season variety notable for its high yield of uniform, oblong-long, lightly russetted tubers
- IdaRose, a medium to late maturing selection with bright red skin and round tuber for the fresh market
- Purple Pelisse, a mid-season specialty potato with purple skin and dark purple flesh, with excellent taste, and high levels of antioxidants
- Yukon Gem, a high yielding, mid-season selection with light-yellow flesh.

There are two serious obstacles faced by ARS potato breeders. The first is associated with crossing and the second is the time it takes to improve breeding material to agronomically useful levels. Crossing is the way that genes encoding important agronomic traits are moved into useful potato lines.

Wild relatives of potato are a very important source of agronomically important genes and crossing with wild relatives is extremely difficult.

Crossing with them requires a long series of intermediate crosses, until a line is generated that can be eventually crossed with a breeding potato. In addition, the fact that the genome in potato is extremely large and highly diverse means that each time a cross is performed, it is like completely reshuffling a deck of cards.

These factors contribute to the second major obstacle. Whether the breeding line was derived from a cross with a wild relative or a variety not adapted to Pacific Northwest growing conditions, it takes a long time with intense work to improve breeding material to generate a useful clone.

Despite the obstacles, federal reserachers have developed and transferred a technology that will enhance dinner tables and restaurant menus nationwide, maybe worldwide!

"...the fact that the genome in potato is extremely large and highly diverse means that each time a cross is performed, it is like completely reshuffling a deck of cards."

Agricultural Research Service
Pacific West Area
Albany, California

About ARS Pacific West

The Agricultural Research Service (ARS) is the U.S. Department of Agriculture's chief scientific research agency. ARS's job is to find solutions to agricultural problems that affect Americans every day, from field to table. ARS has 1,200 research projects within 21 national programs employing over 6,000 employees, including 2,100 scientists. ARS conducts research to:

- Ensure high-quality, safe food, and other agricultural products
- assess the nutritional needs of Americans
- Sustain a competitive agricultural economy
- Enhance the natural resource base and the environment, and
- Provide economic opportunities for rural citizens, communities, and society as a whole.

ARS's Pacific West Area is one of eight ARS Areas located in the major farm and rangeland ecosystems throughout the United States and overseas. It conducts research in the areas of:

- Climate change
- Food safety
- Children's nutrition / health
- Global food security
- Bioenergy

www.ars.usda.gov/pwa

Dr. Robin L. Brigmon, Fellow Engineer, Savannah River National Laboratory.

a microscopic picture of the BioTiger consortium of microbes

microscopic picture of BioTiger attaching to oil sands materials

Mutant Toxic Lagoon Microbes Eat Oil

They were discovered, living virtually unnoticed, in the depths of a toxic sludge lagoon at a 100-year-old refinery in Poland.

After a trip across the ocean to the U.S. Department of Energy's Savannah River National Laboratory (SRNL)—and eight years of careful research—scientists are slowly unlocking the unique secrets of two mutant strains of the microbe known as Sphingomonas.

Their claim to fame: They eat oil — and have already proved to be useful in cleaning contaminated soil.

This past summer, with the Gulf Coast spill on everyone's minds, scientists are accelerating their studies to see whether the microbes might someday help remove oil from oceans.

"...perhaps they could be used to clean up beach sand, estuaries..."
Dr. Robin L. Brigmon, SRNL Engineer

"We're just getting started in terms of looking at saltwater, but we're pretty excited about it," said Dr. Robin L. Brigmon, an engineer at SRNL. "There are a lot of possibilities."

The microbes—named BPH and BPF—developed their oil-eating properties over the course of a century at the Cechowice refinery in southern Poland.

They are part of a newly patented consortium of microbes, known collectively as BioTiger ™, which is being marketed by the lab to companies interested in further research and product development.

The Polish refinery microbes have been evaluated over a period of years under varying conditions, and their performance has been consistent.

Of the many microbes that were tested, BPH and BPF were able to consistently remove or reduce polycyclic aromatic hydrocarbons in soil. These are typical pollutants linked to oil products.

Additional work on the project is being conducted at South Carolina State University, where research focuses on enhancing the expression of the genes to increase the rate at which the strains break down oil-based contaminants. Those strains are slated to be tested in polluted soil at sites around the state.

Exploring other uses, such as applying the microbes to contaminated seawater, could yield some exciting discoveries, Brigmon said.

"It wouldn't be an answer to a whole problem, but it might be a good tool we could use," he said. "We've already gotten some water from the coast and some marine media with the same salinity of seawater. The next steps would be to test it in some Gulf oil—and we do plan to get some actual samples to work with."

Even if the microbes are not found to be useful in seawater, it is likely they could still have practical uses in situations such as the Gulf spill and beyond.

"If not seawater, then perhaps they could be used to clean up beach sand, estuaries, those kinds of things, and the potential applications for use in the Canadian oil sands is equally exciting," Brigmon said.

Considerable effort has been conducted on applying BioTiger to the Canadian oil sands. The action of the organisms on the oily portions of the sand increases the amount of recoverable bitumen.

Tests have shown the microbial activity could be instrumental in the rapid reclamation of existing tailing ponds and potential recovery of significant amounts of bitumen currently discarded to the ponds as "waste" products.

The breakdown, recovery, and processing of these waste products could provide the capability to recover an estimated equivalent of 30 million barrels of oil housed in the tailing ponds, which could play a significant role in America's energy security.

Savannah River National Laboratory
Aiken, South Carolina

About SRNL

The Savannah River National Laboratory (SRNL) is the applied research and development laboratory at the Department of Energy's Savannah River Site (SRS). Originally established to support SRS, with its mission to produce the basic materials used in the fabrication of nuclear weapons, today SRNL puts science to work to serve a variety of customers across DOE, NNSA, other federal agencies, and a small number of commercial customers, in the areas of national and homeland security, energy security, and environmental and process technology. Since the end of the Cold War, SRNL has played an instrumental role in finding solutions to environmental remediation and waste stabilization problems at SRS and other government sites. SRNL has a wide spectrum of expertise in areas such as hydrogen energy, nonproliferation and counterintelligence, environmental science, waste processing, homeland security, analytical chemistry, instruments and sensors, robotics, and materials technologies.

http://srnl.doe.gov

TECHNOLOGY FOR TODAY

Dr. Cymbeline Culiat performs research on the NELL1 gene. Dr. Culiat is leading the NellOne Therapeutics™ research effort to translate the NELL1 pathway discoveries into a therapy that restores both mass and function to damaged human tissues, such as heart and skeletal muscle.

Oak Ridge Research to Aid in Treatment of Cardiovascular Disorders and Enhance Skeletal Muscle Regeneration

Research conducted at Oak Ridge National Laboratory (ORNL) by Dr. Cymbeline T. Culiat based on a mutant mouse model indicates that the cell-signaling pathway based on the NELL1 (neural tissues containing epidermal growth factor-like domains) gene is critical to tissue growth and maturation in key mammalian organs.

NELL1 is a gene that codes for a cell-signaling protein that is critical for the formation and maturation of cardiovascular systems.

NELL1 triggers cell differentiation and growth via production of important factors (primarily extracellular matrix, cell adhesion and cell communication proteins) that are needed for the development of cardiomyocytes (heart muscle cells).

About 70% of the genes in the NELL1 pathway are critical in proper formation and function of the heart and blood vessels. Alterations in these genes (including NELL1) cause a variety of cardiovascular defects in humans and/or mice.

In the United States alone, 800,000 people per year suffer from a heart attack and 4.8 million are diagnosed with congestive heart failure.

Treatments for cardiovascular disorders based on the NELL1 protein or NELL1-secreting cells could repair and regenerate damaged cardiac muscle and blood vessels.

Direct delivery of the protein or cells to the site of treatment can occur using biological matrices, direct injection, catheter, and other delivery methods common to clinical treatments.

Furthermore, treatments for wound healing and myopathy based on the NELL1 protein or NELL1-secreting cells could repair and regenerate damaged skeletal muscle and blood vessels.

This opportunity has the potential of significantly improving human health by providing diagnostics and treatments for diseases that affect millions of people. Cardiovascular therapies with NELL1 can be utilized primarily for patients with damaged heart tissue resulting from heart attacks, congestive heart failure, and other cardiovascular disorders. The estimated potential market value is upwards of $3 billion.

Using genetic, genomic and molecular analyses of an ORNL mutant mouse model (NELL16R) generated from an earlier DOE-funded mutagenesis program, Dr. Culiat determined that the Nell1 protein stimulates the growth and maturation of cells/tissues in the musculoskeletal system such as bone, cartilage (Desai et al, 2006), cardiovascular and skeletal muscle systems (unpublished, 2007).

UT-Battelle, LLC (the contractor of ORNL) provided maturation funding support for Dr. Culiat to work on a commercial vision for this technology.

These key maturation projects completed the proof-of-concept studies needed to engage the commercial interest of a venture-funded startup, NellOne Therapeutics™, to pursue development of therapeutics that may one day provide critical medical treatments.

NellOne is an ORNL spinof that quickly began exploring the impact of Dr. Culiat's research and sponsored work under a Work for Others at ORNL.

Today, Dr. Culiat is leading the NellOne Therapeutics™ research effort to translate the NELL1 pathway discoveries into a therapy that restores both mass and function to damaged human tissues, such as heart and skeletal muscle.

"In the United States alone, 800,000 people per year suffer from a heart attack and 4.8 million are diagnosed with congestive heart failure."

Oak Ridge National Laboratory
Oak Ridge, Tennessee

About ORNL

Oak Ridge National Laboratory (ORNL) is the Department of Energy's largest science and energy laboratory. Managed since April 2000 by a partnership of the University of Tennessee and Battelle, ORNL was established in 1943 as a part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. During the 1950s and 1960s, ORNL was an international center for the study of nuclear energy and related research in the physical and life sciences. ORNL is an international leader in a range of scientific areas that support the Department of Energy's mission. The laboratory's six major mission roles include neutron science, energy, high-performance computing, systems biology, materials science at the nanoscale, and national security.

www.ornl.gov

Researchers Chris Doona and Florence Feeherry of the Natick Soldier Research, Development and Engineering Center (NSRDEC) have developed a means for conveniently generating aqueous chlorine dioxide (ClO_2) without the usual need for caustic chemicals or large capital equipment. ClO_2 inactivates food pathogens and resistant bacterial spores, while minimizing hazards to the user and the environment.

David Kamm

Diluted aqueous chlorine dioxide can be applied directly to tomatoes, lettuce and other fresh fruits and vegetables to eliminate microbial hazards such as *E. coli* and *Listeria*, and to inactivate browning enzymes in sliced apples.

David Kamm

Army Sanitizes Food With "Green" Technology

The U.S. Army has primary responsibility for ensuring food safety in the U.S. military.

To protect the health and well-being of the nation's warfighters, the Army is charged with leading the development of more enabling technologies to sanitize foods and food contact surfaces, particularly in battlefield kitchens.

Researchers led by Dr. Christopher Doona from the U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) have been working on solutions to this challenge and have developed "D-FENS" (Disinfectant-sprayer for Foods and ENvironmentally-friendly Sanitation) as an innovative chlorine dioxide (ClO2) "green" technology that promotes the safety of human health and the environment. While D-FENS is directed toward food surface sanitization, it has additional applications in common living environments.

The seminal idea of this technology relates more specifically to unique chemical and physical methods for generating aqueous ClO2 solutions in a lightweight, closed container, which can then dispense the solution directly as a fine mist onto contaminated food contact surfaces for purposes of reducing or eliminating inhabitant microorganisms.

The "recipe" for developing D-FENS as an easy-to-use handheld sprayer for sanitizing Army field kitchens required an understanding of the basic principles of chemistry to controllably generate a potent disinfectant using complex oxyhalogen reactions, an understanding of the basic principles of microbiology to exploit the mechanisms of microbial inactivation by chemical agents, and an element of innovation to generate a ready-made disinfectant solution in a collapsible, flexible, plastic pouch material that cleans, sanitizes, and disinfects while reducing adverse impact on the environment.

The solution can also be diluted to appropriate concentrations and applied directly to fresh fruits and vegetables to eliminate microbial hazards such as *E. coli* and *Listeria*, and to inactivate browning enzymes in sliced apples.

The novel two-step process of preparing the ClO2 solution in D-FENS is intended to take 2-3 minutes and remain stable for a minimum 8-hour shift, after which it will begin to turn back into water. But any remaining ClO2 solution can be safely poured down the drain and will function as a drain purge.

Chlorine dioxide is not only a superior sanitizer, at higher concentrations it is an excellent sterilizing agent.

It kills not only bacteria but also other pathogens, mold, and fungus. Although it has been used for decades in various industries, including as a sanitizer and sterilant, it has been necessary to generate ClO2 onsite as needed by means of expensive industrial chlorine dioxide generators.

By using unique precursors, the D-FENS chemistry makes it possible to controllably generate ClO2 in a lightweight, collapsible, single-use plastic sprayer as a "green" technology designed to meet military needs for decontaminating surfaces while reducing corrosion and adverse impact on the environment compared to other chemical sanitizers and sterilants that do not always perform well in the field.

"By using unique precursors, the D-FENS chemistry makes it possible to controllably generate ClO2 in a lightweight, collapsible, single-use plastic sprayer as a "green" technology designed to meet military needs for decontaminating surfaces while reducing corrosion and adverse impact on the environment..."

Natick Soldier RD&E Center
Natick, Massachusetts

About NSRDEC

The Natick Soldier RD&E Center (NSRDEC) is located at the U.S. Army Natick Soldier Systems Center in Natick, Massachusetts, under the Army's Research, Development and Engineering Command (RDECOM). We have the dedicated mission to maximize the Warrior's survivability, sustainability, mobility, combat effectiveness and quality of life by treating the Soldier as a System. Situated near the birthplace of the Nation's Army, NSRDEC is also the birthplace of the Soldier as a System concept.

http://nsrdec.natick.army.mil

CSA gives carriers a tool to identify and address unsafe behaviors and provides an opportunity for commercial carriers to fix safety problems before they become bigger road safety issues. (Volpe Center photo)

Department of Transportation Takes the Technology Fast Lane to Save Lives

The Federal Motor Carrier Safety Administration (FMCSA) has launched a national rollout of Compliance, Safety, Accountability (CSA), an innovative new method of reducing bus and truck crashes, injuries and fatalities on our roads.

FMCSA, its state partners, and staff at the U.S. Department of Transportation Research and Innovative Technology Administration's Volpe National Transportation Center designed CSA to more effectively identify the safety problems of motor carriers and their drivers. CSA offers innovative new tools that enable motor carriers to enhance the measurement of their safety performance and correct safety problems.

Volpe Center has assisted FMCSA in developing and implementing the CSA program over the past several years.

The program team re-engineered the enforcement and compliance process to provide a better view into how well large commercial motor carriers and their drivers are complying with safety rules, and to intervene earlier with those who are not.

CSA captures all on-road safety performance data (all safety-based roadside violations and crash data) and classifies this information according to seven specific categories of carrier/driver behavior, called Behavior Analysis and Safety Improvement Categories (BASICs): Unsafe Driving, Fatigued Driving (Hours-of-Service), Driver Fitness, Controlled Substances/Alcohol, Crash Indicator, Vehicle Maintenance, and Cargo-Related.

Beginning in February 2008, FMCSA conducted a 30-month CSA field test involving 92,000 randomly chosen commercial motor vehicle carriers in nine states: Colorado, Georgia, Missouri, New Jersey, Delaware, Kansas, Maryland, Minnesota, and Montana. Throughout the test, FMCSA solicited feedback and listened carefully to enforcement staff, test participants, and industry safety experts.

The team then incorporated its input into the new CSA program prior to the phased national rollout that began in December 2010.

"CSA's data analysis expands on the previous SafeStat system, covering more behavioral areas specifically linked to crash risk."

CSA now offers a comprehensive measurement system, with monthly evaluations of all safety-based violations found during roadside inspections.

Violations are weighted by their relationship to crash risk for both carriers and drivers. CSA then takes steps according to its new intervention process, based on the risk posed by carriers. The process is designed to reach more carriers and drivers, and to identify and correct problems sooner, before a crash occurs. Interventions promote safety through several proactive tools, including early warning letters and onsite comprehensive investigations.

CSA covers the full spectrum of safety issues: from how data are collected, evaluated, and shared to how enforcement officials can intervene most effectively and efficiently to improve safety on our roads.

CSA's data analysis expands on the previous SafeStat system, covering more behavioral areas specifically linked to crash risk. This approach allows FMCSA and its state partners to use less resource-intensive means while maintaining a strong enforcement presence.

As CSA rolls out, a concerted effort will continue to inform carriers, drivers, and safety partners of the changes, and to encourage all stakeholders to become more involved in their own safety management practices by understanding how CSA impacts them.

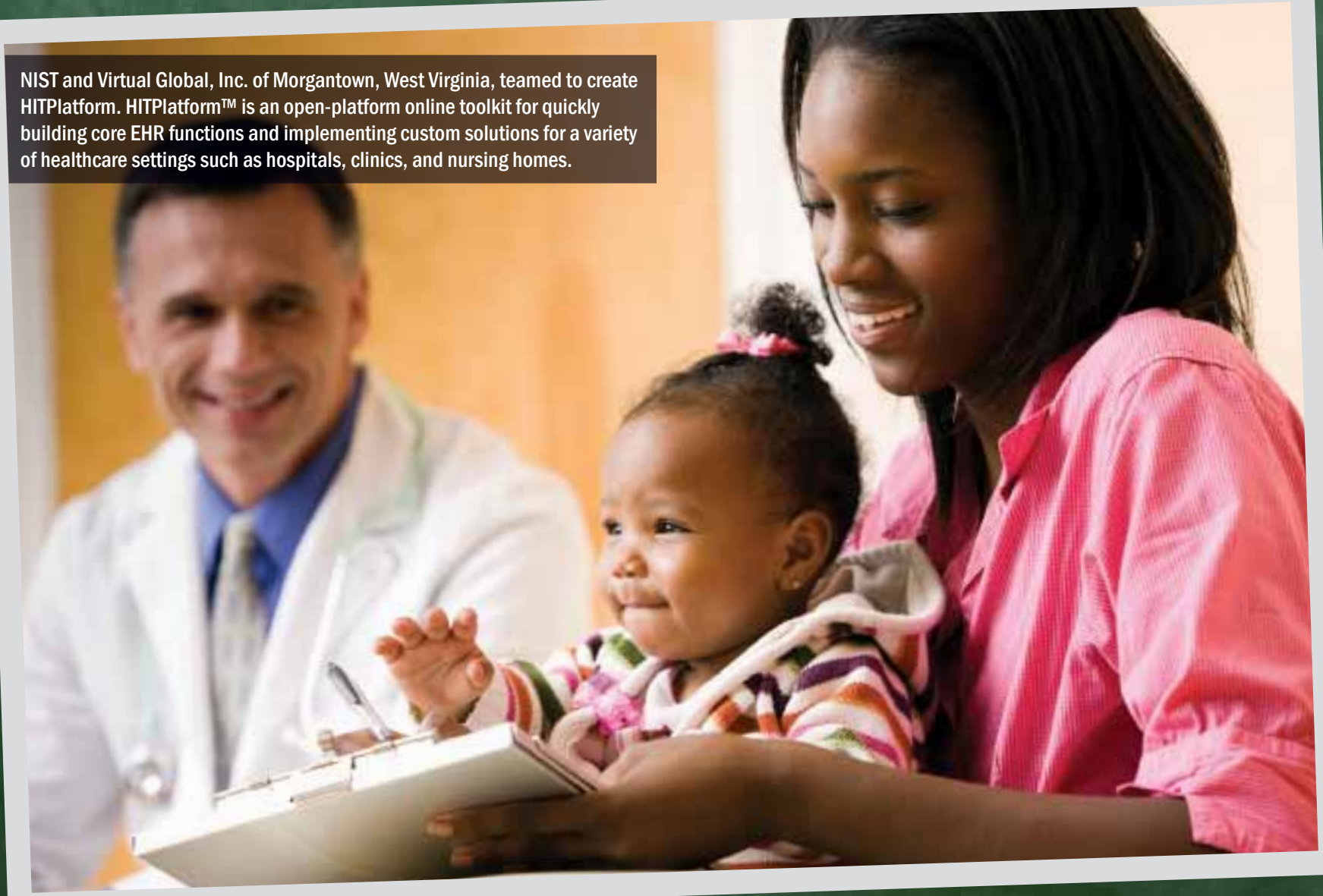
John A. Volpe National Transportation System Center
Cambridge. Massachusetts

About Volpe

The John A. Volpe National Transportation System Center in Cambridge, Massachusetts, is an internationally recognized center of transportation and logistics expertise. Through research and development, engineering, and analysis, the Volpe Center helps decision-makers define problems and pursue solutions to lead transportation in the 21st century. In essence, the Volpe Center is a catalyst for innovation—a source of critical insight necessary to realize transportation's promising future. Volpe's work includes a broad mix of projects that cut across traditional transportation modes and technical disciplines. The Center is well known internationally for its transportation expertise, and the highly skilled staff of experts is respected for their comprehensive knowledge and understanding of the transportation system.

www.volpe.dot.gov

TECHNOLOGY FOR TODAY



NIST and Virtual Global, Inc. of Morgantown, West Virginia, teamed to create HITPlatform. HITPlatform™ is an open-platform online toolkit for quickly building core EHR functions and implementing custom solutions for a variety of healthcare settings such as hospitals, clinics, and nursing homes.

NIST Leads Effort to Advance Medical Records Management

While there is no dispute over the potential benefits of electronic health records (EHR), including improved quality of care, saving lives, and speeding up delivery of medical care, the sharing of information opens the door to confidentiality and privacy concerns.

Patients want control over who is looking at their health information. Assurance of patient privacy is a key element in widespread acceptance of EHR.

With the backing of the technology transfer program at the National Institute of Standards and Technology (NIST), Virtual Global, Inc., of Morgantown, West Virginia, a provider of software and platform solutions, developed a promising solution to significantly improve privacy within records management software applications.

Virtual Global received funding from the NIST Small Business Innovation Research (SBIR) Program Phases 1 (a feasibility study) and 2 (research and development), and obtained an exclusive license for a NIST patent for role-based workflow (RBW).

The NIST patent provides an algorithm that can be built into a larger piece of software and is designed to control access to sensitive information, such as medical records. Inventor John Barkley believes that this software provides dramatically improved security and privacy to patients by solving the problem of overly broad access to patient information. Virtual Global integrated the NIST invention into HITPlatform™ to demonstrate that it works, and the tools are now available for others to use.

Many current EHR systems allow anyone who has access to patient records to look up any record, even if the user is not involved in the patient's case.

"Role-based Workflow is a monumental advancement in patient privacy. It protects against potential abuse while maintaining efficiency." Cary Landis, Virtual Global CEO

To fully protect patient privacy, only relevant portions of specific records need to be available to designated staff members. Virtual Global's HITplatform™ utilizes the NIST RBW algorithm to manage and control privileged access to electronic records on a need-to-know basis.

It gives healthcare workers temporary access to customized views of relevant records necessary to complete their current task.

HITplatform™ is an open-platform online toolkit for quickly building core EHR functions and implementing custom solutions for a variety of healthcare settings such as hospitals, clinics, and nursing homes. EHR vendors or federal agencies may also use RBW separately for their special needs.

HITPlatform™ markedly enhances the confidentiality of patient records and is a viable alternative to other high-cost EHR systems.

According to Virtual Global CEO Cary Landis, "Role-based Workflow is a monumental advancement in patient privacy. It protects against potential abuse while maintaining efficiency. It's also about continuing to steadily apply forward-thinking, and Role-based Workflow fits that bill with its ability to help prevent the types of informational security lapses that have caused embarrassing data leakages."

National Institute of Standards and Technology
Gaithersburg, Maryland

About NIST

NIST, an agency of the U.S. Department of Commerce, was founded in 1901 as the nation's first federal physical science research laboratory. Over the years, the scientists and technical staff at NIST have made solid contributions to image processing, DNA diagnostic "chips," smoke detectors, and automated error-correcting software for machine tools. A few of the other areas in which NIST has had major impact include atomic clocks, X-ray standards for mammography, scanning tunneling microscopy, pollution-control technology, and high-speed dental drills.

www.nist.gov

Before rapid molecular methods, flu had to be detected by virus isolation, which often uses eggs and can take up to a week.

4 hours vs. 2 Weeks: Preventing Pandemic

The pH1N1 virus was first recognized in humans in April 2009 as a novel influenza with genes primarily of North American swine origin, but with two genes most closely associated with European swine influenza viruses.

The number of cases rapidly increased in the human population and eventually became the first human pandemic virus of the 21st century.

As soon as the genetic data and first isolates became available in late April, Agricultural Research Service (ARS) researchers started developing a molecular test that could identify the pH1N1 virus and differentiate it from the classical H1N1 swine influenza viruses already circulating in U.S. swine and turkey populations.

Additionally, bioinformatic analysis of the official USDA real-time RT-PCR test for type A influenza or the "M gene test" (this test detects all influenza A viruses) identified important sequence mismatches that required updating the test to assure acceptable sensitivity and specificity of this important diagnostic screening tool. Completing the development and the initial validation of the pH1N1 test was given a top priority, and the team worked long hours to ensure that the test would be available as quickly as possible.

The test protocol was first transferred to the Diagnostic Virology Laboratory at the National Veterinary Services Laboratories (NVSL), USDA-APHIS, on May 3, 2009.

The ARS researchers worked with the NVSL researchers to collect additional field validation data and further optimize the test so that it could be implemented by the state and regional veterinary diagnostic laboratories of the National Animal Health Laboratory Network (NAHLN).

In early June 2009, the tests were adopted by the NVSL as official diagnostic assays and were subsequently implemented by the NAHLN.

These are currently the official tests for pH1N1 in veterinary specimens, and have been used to identify infection in swine, turkeys, ferrets, cheetahs, and other species by the NVSL and NAHLN laboratories (currently the test has been implemented at 37 NAHLN labs).

Equally important, these tests have allowed veterinary diagnostic labs to rule out the presence of pH1N1 in specimens. The tests were also transferred, without restriction, through the OFFLU network (collaboration on influenza between the OrE and United Nations Food and Agriculture Organization) to any interested veterinary laboratory and bilaterally to Canada and Mexico to support their surveillance and diagnostic efforts.

These real-time RT-PCR tests have numerous benefits over the previously available technology.

Without these tests, laboratories would have to rely on virus isolation to diagnose influenza, which can take from 1 to 2 weeks, and then an additional 2 to 3 days to identify the specific influenza strain as pH1N1 (or in some cases to rule out pH1N1) by genetic sequencing. These real-time RT-PCR tests can identify influenza virus and determine whether it is pH1N1 within 3-4 hours.

"Without these tests, laboratories would have to rely on virus isolation to diagnose influenza, which can take from 1 to 2 weeks, and then an additional 2 to 3 days to identify the specific influenza strain as pH1N1."

Agricultural Research Service
Washington, D.C.

About ARS

The Agricultural Research Service (ARS) is the U.S. Department of Agriculture's chief scientific research agency. ARS's job is to find solutions to agricultural problems that affect Americans every day, from field to table. ARS has 1,200 research projects within 21 national programs employing over 6,000 employees, including 2,100 scientists. ARS conducts research to:

- Ensure high-quality, safe food, and other agricultural products
- Assess the nutritional needs of Americans
- Sustain a competitive agricultural economy
- Enhance the natural resource base and the environment, and
- Provide economic opportunities for rural citizens, communities, and society as a whole.

www.ars.usda.gov

In an early test of BAMC's capabilities, a sharpened wafer of the material is used to make a cut in hardened stainless steel.

Nanoscale Coating Reduces Friction, Boosts Industrial Energy Efficiency

Friction is the bane of any machine.

When moving parts are subject to friction, it takes more energy to move them, the machine doesn't operate as efficiently, and the parts have a tendency to wear out over time.

But if parts could be manufactured with tough, "slippery" surfaces, there would be less friction, requiring less input energy, and parts would last longer.

Researchers at the U.S. Department of Energy's (DOE) Ames Laboratory, in collaboration with DOE's Oak Ridge National Laboratory (ORNL), Eaton Corporation and Greenleaf Corporation, have developed just such a coating, nicknamed BAMC, that exhibits exceptional hardness and an even lower coefficient of friction than Teflon®.

"When a hydraulic pump moves fluid, the friction between the turbine vanes and the housing translates into additional torque needed to operate the pump, particularly at startup," said Bruce Cook, the Ames Laboratory scientist who discovered BAMC along with Ames Lab colleague and Iowa State University professor of materials science and engineering Alan Russell. "It takes extra energy to get the pump started, and you can't run it at its optimum (higher speed) efficiency because it would wear out more quickly."

Coating the blades to reduce friction and increase wear resistance could have a significant effect in boosting the efficiency of all kinds of industrial and commercial pumps.

"It takes extra energy to get the pump started, and you can't run it at its optimum (higher speed) efficiency because it would wear out more quickly."

Bruce Cook, Ames Laboratory Scientist

According to Cook, a modest increase in pump efficiency could reduce U.S. industrial energy usage by 31 trillion BTUs annually by 2030, or a savings of $179 million a year.

BAMC is different from most superhard materials, such as diamond, that have a simple, regular and symmetrical crystalline structure. Instead, BAMC's structure is complex, unsymmetrical, and its lattice contains gaps.

As for its slipperiness, the researchers speculate that boron oxidation takes place on the surface, and these tiny amounts of boron oxide attract water molecules from the air to make the surface slippery.

"It's almost as if it's a self-lubricating surface," Russell said. "It's inherently slippery, so you don't need to add oil or other lubricants."

Using a technique called pulsed laser deposition, the Ames Laboratory team deposited an ultra-thin layer of BAMC on hydraulic pump components as well as tungsten carbide cutting tools.

Initial tests at ORNL, one of the nation's leading friction and wear research facilities, showed a decrease in friction relative to an uncoated surface of at least an order of magnitude with the AlMgB14-based coating. In preliminary tests, the coating also appears to outperform other coatings such as diamond-like carbon and TiB2.

BAMC is licensed to an Iowa-based startup company located in Des Moines, and several leading equipment and tool manufacturers plan to use BAMC in their products.

Ames Laboratory
Ames, Iowa

About Ames Lab

Ames Laboratory conducts fundamental as well as intermediate-range applied research in support of current and future energy technologies and seeks solutions to energy-related and other critical national problems through the exploration of chemical, engineering, materials, mathematical and physical sciences. The laboratory is operated by Iowa State University (ISU) and is located on the university's campus. Of a total permanent staff of 400, approximately 250 are scientists and engineers. The laboratory's relationship with ISU allows many senior scientists to hold joint appointments as faculty members in ISU academic departments and enables about 150 undergraduate and graduate students to serve on Ames's scientific staff.

www.ameslab.gov

Argonne researcher Sam Jody displays items from shredder residue, recovered polyethylene and polypropylene, and a knee bolster manufactured from recovered plastics.

Argonne researchers evaluate operating conditions and process economics at the laboratory's 2-ton-per-hour pilot plant.

Argonne's Approach to Recycling Shredder Residue Leads to Greener World, Profitable Polymers

More than 12 million vehicles reach the end of their useful life each year in the U.S. Most of each vehicle is recycled (primarily the metals), but about 25% of the materials end up being sent to landfills as shredder residue, which also includes other industrial waste sources such as scraps from electronics and home appliances.

Shredder residue contains polymers and residual metals that, if recovered, can be recycled profitably.

Novel technologies developed by the U.S. Department of Energy's Argonne National Laboratory can enable industry to economically recover these materials from end-of-life vehicles (ELVs) and other sources to make valuable products, including auto parts (e.g., spare tire covers, steering column covers, and battery trays).

Vehicle recycling in North America is a $10-billion, market-driven industry that provides more than 100,000 jobs, benefiting the economy, reducing energy use for vehicle manufacture, and protecting the environment from contamination by metals.

As vehicles become smaller and lighter to improve fuel economy, auto manufacturers will incorporate relatively higher percentages of lightweight, nonmetallic materials such as plastics, foam, and carbon fiber composites. With the share of metal in cars and trucks dwindling, the recycling industry needs technologies for nonmetallic scrap recovery to help maintain its profits.

The U.S. government and industry have partnered to devise economical methods for recovering valuable contents from shredder residue.

One new technology, developed at Argonne National Laboratory, can separate many types of polymers and residual metals from the residue at a yield never before attained in the recycling industry.

The Argonne-developed process consists of two basic steps. In the first step, mechanical separation concentrates the plastics and residual metals into a manageable fraction, and conventional sink- or-float techniques separate some of the plastics in the concentrate based on differences in density.

Individual plastics are then separated using other techniques such as froth flotation, a process for separating water-shedding (hydrophobic) materials from water-attracting (hydrophilic) materials.

The typical waste stream generated by shredders contains about 25% to 40% recoverable polymers, including polypropylene, polyethylene, rubber foam acrylonitrile butadiene styrene (ABS), and high-impact polystyrene (HIPS).

Plastics such as ABS and HIPS are readily separable from other plastics, but not from each other because they share the same density. Fortunately, Argonne's froth flotation technology can separate HIPS from ABS.

Altered water chemistry enables an air bubble to attach to hydrophobic HIPS, lowering its apparent density relative to ABS. As a result, HIPS floats away from ABS, which sinks in the solution.

Argonne developed a 2-ton-per-hour pilot plant to determine optimal operating conditions and process economics.

The laboratory then evaluated potential business opportunities for specific recovery applications. As a result, Argonne worked with a commercial shredder to build a 20-ton-per-hour pilot plant that performs both mechanical and sink-float separations.

Argonne also worked with the United States Council for Automotive Research's (USCAR) Vehicle Recycling Partnership and the American Chemistry Council's Plastics Division under a Cooperative Research and Development Agreement structured by the Department of Energy to advance ELV recycling.

Argonne's energy-saving approach to recycling shredder residue will reduce waste, offer an environmentally friendly alternative to more expensive virgin plastics, and make the process of recycling cars more sustainable and profitable.

"The typical waste stream generated by shredders contains about 25% to 40% recoverable polymers."

Argonne National Laboratory
Argonne, Illinois

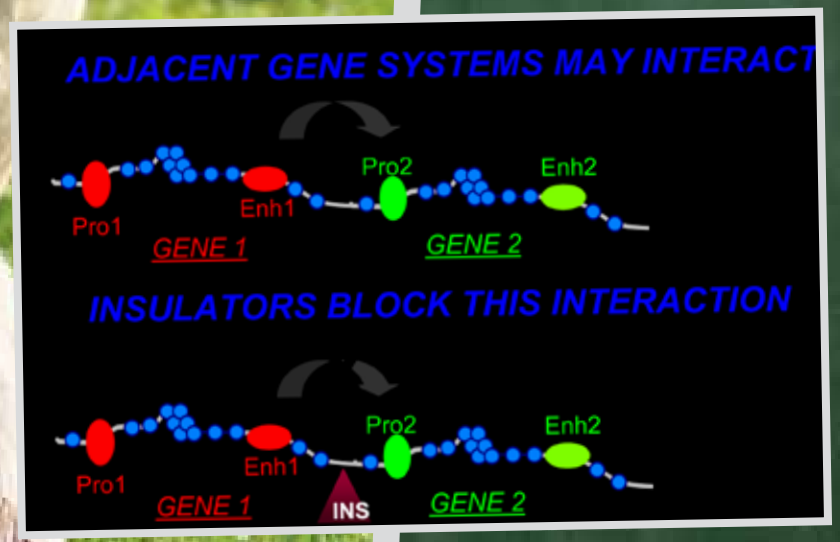
About Argonne

Argonne National Laboratory, one of the U.S. Department of Energy's oldest and largest national laboratories for science and engineering research, employs roughly 3,200 employees, including about 1,000 scientists and engineers, three-quarters of whom hold doctoral degrees. Argonne's annual operating budget of around $630 million supports upwards of 200 research projects. Since 1990, Argonne has worked with more than 600 companies and numerous federal agencies and other organizations. Argonne's mission is to apply a unique mix of world-class science, engineering and user facilities to deliver innovative research and technologies. We create new knowledge that addresses the most important scientific and societal needs of our nation.

www.anl.gov

As a reult of NIDDK's insulator element, several different species may be used to produce protein in milk ranging from mice to rabbits, goats, and cows. This work will undoubtedly pave the way for treatment of diseases that have no other protocols.

Tom Grayson



DNA Insulator Enables Gene Expression, Generates Licenses and Royalties

Genes have control regions, called insulator elements, that dictate when, where, what, and how the gene will be expressed.

To leverage this espression, Drs. Jay Chung and Gary Felsenfeld of the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) focused on the chemistry of interactions between DNA and regulatory proteins, particularly on the relationship between chromatin structure and gene expression.

In 1996 they isolated, identified and characterized a DNA sequence residing in chromatin from the chicken globin gene family, providing the first pure, functional, insulator element in mammalian cells.

Drs. Chung and Felsenfeld further demonstrated that the insulator molecule actively shields the expression of a gene from the regulatory effects of host chromatin while not disturbing the expression of the intended gene.

Their technology was patented in 1997 and has been used broadly by both academic and industry research scientists.

The seminal publication by Chung, Whitely and Felsenfeld, "*A 5' element of the chicken beta-globin domain serves as an insulator in human erythroid cells and protects against position effect in Drosophila*," has been cited by authors in scientific journals as well as patents more than 575 times. The insulator element has significantly advanced the way in which genetic research is conducted.

Fifteen years later, the DNA insulator element has been openly and widely shared with academic institutions for basic research under more than 265 material transfer agreements.

The applications for this technology are wide-ranging, perhaps limited only by the identity of the gene that may correlate to the condition of interest.

Academic scientists have used the insulator element for research in developmental biology to produce transgenic animals, as well as preclinical research into a variety of genetic diseases.

The NIH Office of Technology Transfer (OTT) has licensed this patented invention to for-profit companies in over 30 royalty-bearing licenses.

One such license is enabling a company to produce and extract human therapeutic proteins from the milk of transgenic animals by coupling the milk protein promoter to the gene of a desired protein.

The protein, which would otherwise be difficult to express or cost-prohibitive to manufacture utilizing traditional recombinant DNA technologies, is progressing to market.

NIDDK and the OTT have also arranged licenses to enable a company to market the insulator element as a research tool. Depending on the protein of interest, several different species may be used to produce protein in milk ranging from mice to rabbits, goats, and cows.

Goats have become perhaps the most popular as the tradeoffs in animal size, growth rate, and milk production are well-balanced.

Their milk provides the desired protein at 2-10 grams/liter. This work will undoubtedly pave the way for treatment of diseases that have no other protocols.

The royalty income resulting from the licenses has exceeded $900,000. Following NIH practice, these funds have been reinvested in the NIDDK intramural research program to further the NIH mission.

"The royalty income resulting from the licenses has exceeded $900,000."

Dr. Felsenfeld continues to be interested in the function of insulator elements and the identification of factors that stabilize long-range interactions in the nucleus.

National Institute of Diabetes and Digestive and Kidney Diseases
Bethesda, Maryland

About NIDDK

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) conducts and supports research on many of the most serious diseases affecting public health. The Institute supports much of the clinical research on the diseases of internal medicine and related subspecialty fields, as well as many basic science disciplines. The Institute's Division of Intramural Research encompasses the broad spectrum of metabolic diseases such as diabetes, obesity, inborn errors of metabolism, endocrine disorders, mineral metabolism, digestive and liver diseases, nutrition, urology and renal disease, and hematology. Basic research studies include biochemistry, biophysics, nutrition, pathology, histochemistry, bioorganic chemistry, physical chemistry, chemical and molecular biology, and pharmacology.

www2.niddk.nih.gov

TECHNOLOGY FOR TODAY

From bicycles and baseball bats to military aircraft and window frames, a Navy-developed technology could be a game-changer for aluminum- and zinc-containing products that are used daily throughout the United States and the world.

Tom Grayson

Navy Tech Revolutionizes Metals Industry

A Navy-developed technology could be a game changer for the metal-coatings industry.

The technology is a solution of trivalent chromium sulfate and other additives that reacts with metal surfaces to form a protective undercoat for paint or other coating materials.

The liquid chemical solution is applied to aluminum, zinc, and other substrates to minimize corrosion and provide an improved bonding surface for paints. The substrates are treated with an acidic aqueous solution containing trivalent chromium salt, an alkali metal hexafluorozirconate, and a thickening agent.

Developed by personnel at the Naval Air Warfare Center Aircraft Division in Patuxent River, Maryland, the technology will reduce or replace the ubiquitous use of hexavalent chromium, a known environmental hazard and carcinogen banned in some nations.

In addition to being corrosion-inhibitive and adhesion-enhancing, trivalent chromium processes (TCP) are chemically resistant, weather-resistant, flexible at low temperatures, easy to apply, and price-competitive. The technology meets the more demanding EPA and OSHA requirements recently implemented in response to concerns over use of the highly toxic hexavalent chromium.

TCP is the first protective chromium-based metal finishing coating to satisfy military specifications that is both highly effective and environmentally benign.

From bicycles to military aircraft, from metal fasteners to window frames, aluminum- and zinc-containing products are used daily throughout the United States and the world. These metals require a protective coating, called a conversion coating, to prevent corrosion and enhance adhesion to their slick surfaces by paint or other coatings.

For more than 50 years, this conversion coating traditionally contained hexavalent chromium, now known to be highly toxic, carcinogenic, and thus hazardous to both humans and the environment.

The U.S. military recently mandated that replacement technologies be used on its aircraft and vessels. The new TCP processes, utilizing non-toxic trivalent chromium instead of hazardous hexavalent chromium, were developed at the Navy laboratory in response to Department of Defense needs.

Not only does TCP fully address government expectations, it will radically change industry-wide standards for treating aluminum and other metals. Examples of military usage include improved protection for surfaces of Navy aircraft, which are exposed to corrosive seawater environments, yet require a lightweight coating. Aircraft operating from non-nuclear-powered carriers also are exposed to sulfur dioxide stack emissions and thus require additional anti-corrosion capability. The degrading effects of corrosion increasingly threaten aging commercial airliners as limited airline resources restrict replacing aircraft. Corrosion prevention and weather resistance provided by self-priming topcoats made possible by TCP technology thus will become more important to our present-day airline industry.

The greatest benefit of TCP technology, however, is industrial and military compliance with environmental regulations and the resultant enhancement of public health. Both tangible financial benefits and nontangible environmental benefits have already been realized as a result of the five current licenses.

The Navy's royalties through 2007 were more than $500,000, in addition to more than $100,000 in initial payments.

"...the TCP licensees combined sales of TCP-based products to users such as General Dynamics, BAE Systems, Northrop Grumman, Lockheed, and Boeing totaled more than $9 million."

Commercial products based on the new TCP technology already are available to a wide variety of consumers. Other products stemming from the five licenses granted in 2004 are now entering the marketplace.

By the end of 2007, the TCP licensees combined sales of TCP-based products to users such as General Dynamics, BAE Systems, Northrop Grumman, Lockheed, and Boeing totaled more than $9 million.

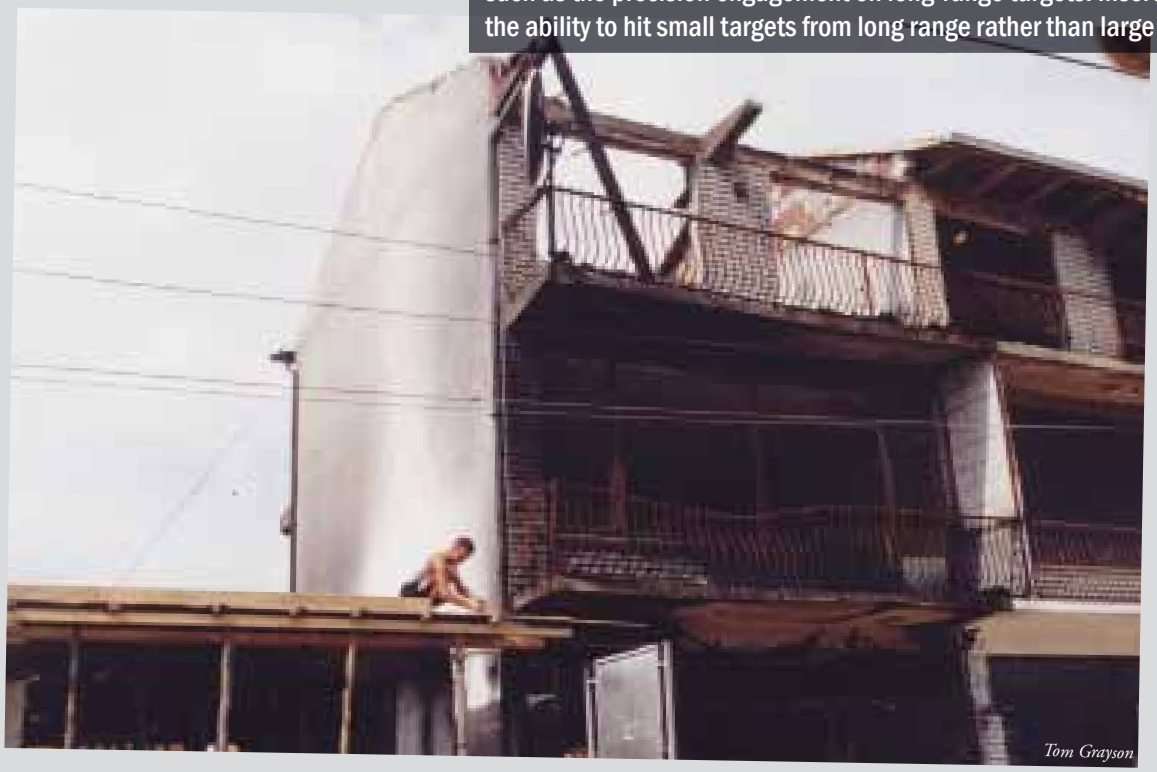
Naval Air Warfare Center
Aircraft Division - Patuxent River
Patuxent River, Maryland

About NAWC-Patuxent River

The Naval Air Warfare Center Aircraft Division (NAWCAD) was established in October 1993 as a result of a reorganization of five predecessor Navy research, development, test, and evaluation (RDT&E) centers. NAWCAD hosts unique R&D aircraft systems laboratories and test facilities, serving the needs of the U.S. Navy, as well as other services, federal agencies, foreign customers, and commercial entities. The complex at Patuxent River, Md. (NAWCAD PAX) includes research and engineering disciplines of systems engineering, air vehicles, propulsion, avionics, crew systems, and test and evaluation. Life-cycle communications expertise for multiple platforms resides at the St. Inigoes, Md. annex. The Key West, Fla. detachment provides testing of developmental anti-submarine warfare hardware in the open ocean environment.

www.navair.navy.mil/nawcad

The LOCSET technology has applications ranging from industrial applications such as welding to military applications such as the precision engagement on long-range targets. Insertion of the LOCSET technology on UAVs would enhance the ability to hit small targets from long range rather than large structures, minimizing collateral damage.



Tom Grayson

Amplifying Power at Light Speed

Scaling single element fiber laser or optical amplifier systems to high power can often be limited due to damaged thresholds of optical materials, size, heating and cooling issues.

One approach to achieving high optical powers is to accept the power limitation of a single optical amplifier, and look for ways to efficiently combine the outputs of multiple optical amplifier sources.

This approach, known as Locking of Optical Coherence by Single-detector Electronic-frequency Tagging (LOCSET) is a method pioneered by the Air Force Research Laboratory that optimally combines multiple optical beams into a single coherent high power beam.

In LOCSET, each beam of the optical array is phase-modulated at a unique radio frequency (RF). A portion of each beam is picked off via a beam sampler and interfered onto a single photodetector.

The interference beat note measured by the photodetector is then processed by the feedback electronics, where the relative phase error of each array element with respect to all other array elements is electronically isolated from the beat note and fed to the phase adjusters of the optical array.

Each phase adjuster in the array applies the appropriate phase correction to coherently combine the optical beams on the photodetector. The LOCSET architecture and hardware have been shared with other government agencies and their contractors for laboratory demonstrations.

It is becoming the preferred method for phase-locking multiple optical amplifiers. This method is being sought out by multiple large defense system integrators for system insertion.

The primary application of this technology is to combine multiple lower power coherent light sources into a single higher power light source. This is intended primarily for directed energy applications that require long-range standoff and precision engagement of difficult targets for the military, but is also of use for industrial applications such as precision cutting, welding and materials processing.

The ability to combine multiple low-power optical amplifiers into one high-power beam is much more economical and technologically stable than trying to build one large optical amplifier.

Additionally, the LOCSET electronic feedback design can be used for other closed loop locking applications where high-speed convergence of many channels is required.

LOCSET is a well-established research grade technology. It has been tested and successfully demonstrated with several cutting-edge beam combination techniques over the past couple of years by organizations such as Northrop Grumman, Lockheed Martin, Raytheon, and DARPA.

LOCSET is currently implemented using discrete off-the-shelf radio frequency components used in standard commercial cable television modulation architectures.

Commercial development of LOCSET will include monolithic integration of RF functions onto custom integrated circuits and tailored printed circuit boards with graphical user interface functionality.

Fiber laser-based technology is slated for insertion on multiple military platforms, including fighter jets and unmanned aerial vehicles (UAVs), and is considered by many as the nirvana of lasers for long-range strike applications.

LOCSET's architecture creates an enabling technology for precision engagement of critical military targets that minimizes collateral damage.

"It answers the question—why bomb the building when you only need to disable the cell phone antennas mounted on the top?"

It answers the question—why bomb the building when you only need to disable the cell phone antennas mounted on the top?

The LOCSET architecture is being sought by multiple large defense system integrators for system insertion.

Air Force Research Laboratory
Directed Energy Directorate
Kirtland AFB, New Mexico

About AFRL

The Air Force Research Laboratory's Directed Energy Directorate, Kirtland AFB, N.M. is the U.S. Air Force's center of expertise in the range of technologies required for high-energy lasers, high-power microwaves, high-power millimeter waves and advanced optics. Associated technologies include optical imaging and communication technologies and modeling, simulation and effects studies. As the technical expert, the Directorate also provides independent assessment and analysis of directed energy concepts for multiple Air Force customers. The Directorate has a space optical site and high performance computing center on the island of Maui, Hawaii.

www.kirtland.af.mil/afrl_de

computers

space

biochemistry

nanotech

rob

medicine

oceanography

textiles

communicatio

environment

aviation

technology

physics

otics

the future of r&d

The federal laboratories understand that the future of innovation in America begins with instilling a passion for science and technology in today's young minds. From elementary school to the university level, federal laboratories and research centers work with students through a variety of outreach programs. These programs involve hands-on scientific adventures in areas such as nanotechnology, aviation, medicine, and environmentally friendly energy development. The next few pages highlight just a small sampling of this work in action. These activities demonstrate how the efforts of the federal laboratories have been set in action to ensure that the United States does not lose its competitive edge in the world of technology.

math

agriculture

biology

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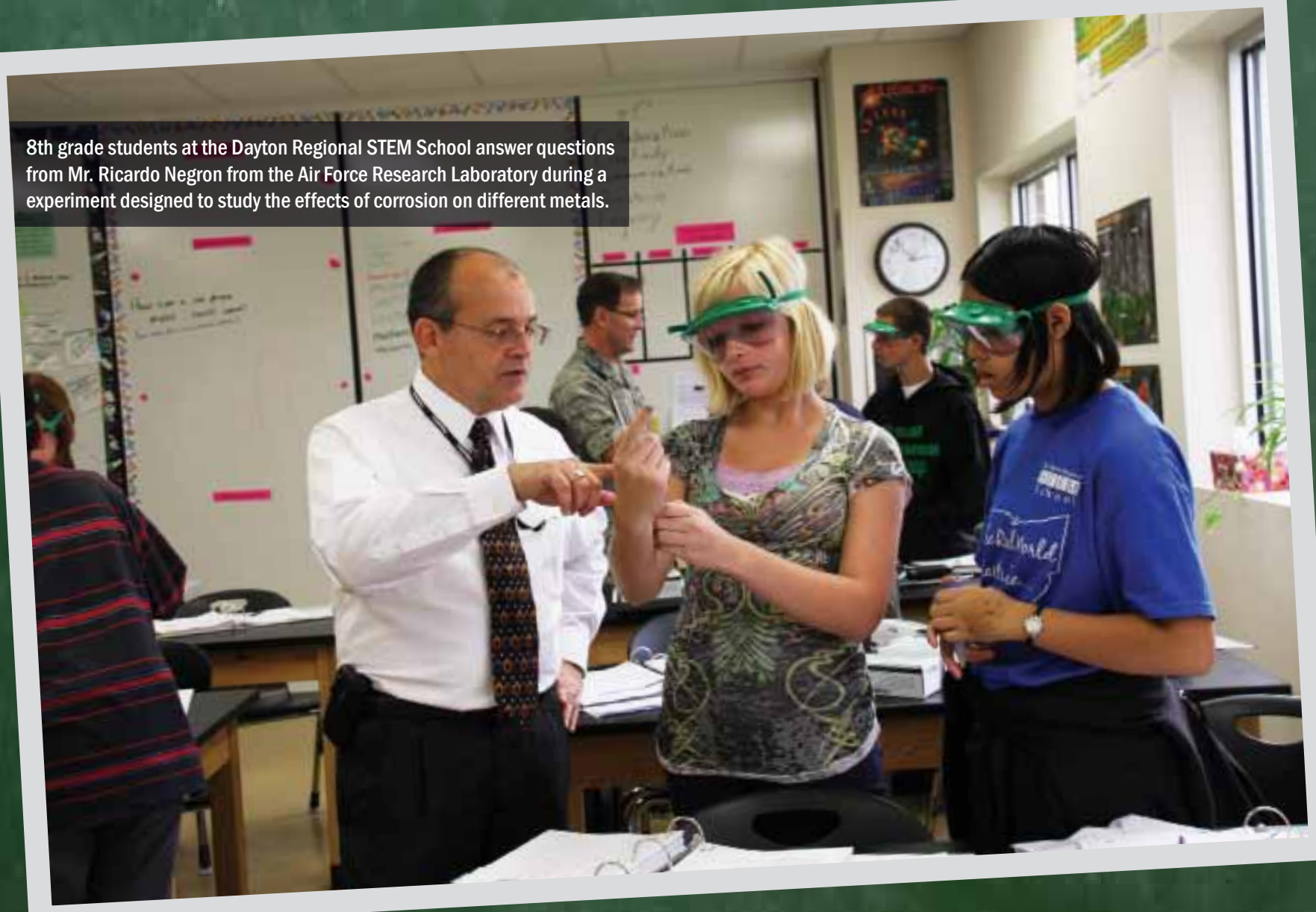
engineering

TECHNOLOGY FOR TODAY



8th grade students at the Dayton Regional STEM School answer questions from Mr. Ricardo Negron from the Air Force Research Laboratory during a experiment designed to study the effects of corrosion on different metals.

Air Force Research Lab Fosters America's Future in 65 Ohio Districts

The Air Force Research Laboratory Domestic Partnering Branch (AFRL/XPPD) has helped create a key science, technology, engineering, and mathematics (STEM) program for students and teachers in 65 districts in the Dayton, Ohio area.

The Dayton Regional STEM Center is preparing thousands of students for careers that will foster innovation for the future of America.

The Center pulls together scientists, engineers and educators, known as STEM fellows, who meet in small teams twice a month to develop STEM curricula around particular topics. Volunteers from several AFRL directorates participate on these teams and, in some cases, bring their real-world experience to the classroom in helping teach lessons. The Center also develops teaching aids, gaming pieces and STEM videos with the Public Broadcasting System.

Supported by the National Defense Education Program (NDEP), AFRL/XPPD is responsible for STEM outreach in Ohio. The Center, created in conjunction with industry partners and supported by over 100 industry and university STEM fellows, is AFRL/XPPD's largest outreach effort.

The program helps children prepare for STEM careers not only by getting them excited about science, but also by providing a realistic component to the teaching. AFRL's input ensures that the lesson plans fit actual needs and match up with how STEM work is performed.

A crucial piece of this is integrating STEM preparation into students' everyday learning. As a regular part of the curriculum, the lessons become a consistent and valued element of the standard school day. In this way, the Center encourages STEM learning to become as natural to students as other basic subjects.

"The thing that I think has the biggest impact to our nation's future is our work in education outreach efforts," said Joe Sciabica, AFRL's Executive Director. "Giving kids… the 'a-ha moment' where it suddenly clicks is what makes all our efforts worthwhile."

"Giving kids… the 'a-ha moment' where it suddenly clicks is what makes all our efforts worthwhile."

Joe Sciabica, AFRL Executive Director

The Center has delivered 70 lesson plans to over 65 school districts at no cost to educators. These lessons have helped educate 25,000 students in grades K-12.

In addition, the Center also trains teachers for STEM instruction and leadership. More than 500 teachers and 60 school leaders have been trained.

"From being a STEM fellow, I feel I learned how to incorporate engineering design into my classroom," said Heidi Steinbrink, a science teacher at Oakwood High School in Dayton. "To take those ideas and be able to work with the experts in the field to bring classroom lessons to life has been a remarkable experience."

AFRL/XPPD measures the Center's progress through quantitative and qualitative methods. Teachers submit their comments after using the STEM lessons.

In addition to collecting statistics on the number of teachers and students the program reaches, pre- and post-assessments are used to determine the lessons' effectiveness. The Center's successful modules are shared with other NDEP coordinators so the program's reach can be expanded.

Last year the Center recognized 43 engineers and scientists who volunteered at the STEM Center at a banquet, which celebrated their efforts along with the launch of the Center's website (*www.daytonregionalstemcenter.org*).

"We have just seen an explosion in how many of our people want to volunteer and help keep children engaged," said AFRL/XPPD Chief Ricardo Negron.

Air Force Research Laboratory
Wright-Patterson Air Force Base, Ohio

About AFRL

The Air Force Research Laboratory's (AFRL) mission is to discover, develop, and integrate affordable warfighting technologies for air and space forces. AFRL accomplishes this through nine technology directorates, the Air Force Office of Scientific Research, and Headquarters staff. AFRL Headquarters and five directorates are co-located at Wright-Patterson Air Force Base. AFRL is a full-spectrum laboratory, responsible for planning and executing the Air Force's entire science and technology budget, basic and applied research, and advanced technology development.

www.afrl.af.mil

Science On a Sphere® at the Stennis Space Center Visitors Center in Stennis, MS.

Byunghwan Lim

Science On a Sphere® at the McWane Science Center in Birmingham, Alabama

Will von Dauster

NOAA's Science On a Sphere® Provides Educational Technology for All Ages

Science On a Sphere® (SOS) is a room-sized global display system that uses computers and video projectors to display planetary data onto a gleaming, six-foot-diameter carbon-fiber sphere, analogous to a giant animated globe.

Suspended from invisible wires in a darkened "theater," the sphere looks like a rotating Earth as seen from outer space. The software to run SOS is written and maintained by the National Oceanic and Atmospheric Administration (NOAA).

The system comes preprogrammed with over 300 datasets that show the Earth's land, oceans, and atmosphere, to name just a few. SOS was initially developed as a way to explore environmental data using new visualization techniques.

It quickly became obvious that when combined with narration and supporting educational material, SOS becomes a unique and powerful teaching tool. With this in mind, researchers at NOAA developed SOS as an educational tool to help illustrate Earth System science to people of all ages. SOS is currently installed in over 60 laboratories, universities, research centers, science centers, science museums and aquariums.

Enthusiasm for SOS continues to grow as onlookers are drawn into engaging animations of swirling hurricanes, devastating tsunamis and earthquakes, as well as other weather phenomena. This wow factor fosters collaboration with the sites that have installed SOS and promotes an ideal partnership between these sites and NOAA. NOAA provides data and scientific expertise, while the partners provide a public forum for dissemination of ideas and audience-appropriate presentations.

Over the past several years, distributorships for further promotion of SOS have been established.

Currently, six distributorships have been developed: three in the U.S. and three internationally. This increases the expansion of the technology, furthers the economic value of the organizations involved in the distributorship, and provides the potential for increased employment.

Dr. Alexander MacDonald developed an early prototype of SOS in 1995, followed by an earnest effort to develop a complete system beginning in 2000. A patent was awarded to NOAA for SOS in August 2005. SOS is constantly evolving as technology progresses.

The original SOS, for example, used eight computers and two spares, the second version used four computers and one spare, and the current system uses just one computer and one spare. The control device for SOS has also evolved over time from using a keyboard, to a radio-frequency television remote control, to currently a Bluetooth Wii remote control.

In October 2002, an early version of SOS was temporarily installed in a local Colorado middle school. The overwhelmingly positive reactions of the students and teachers indicated a successful future for SOS. Recognizing the value of SOS, the NOAA Office of Education created an Environmental Literacy grant competition in 2005 to fund the installation of SOS for science centers and museums.

Although this is an ongoing effort, many sites now choose to purchase SOS directly from NOAA. Many sites have developed expertise with the exhibit, and are now generating their own datasets, lesson plans, and supplemental technologies to add more versatility to the system. Through the collaborative SOS Users Network, all of these new developments are shared with the other SOS sites.

"SOS is currently installed in over 60 laboratories, universities, research centers, science centers, science museums and aquariums."

Because this is an evolving project, additional progress will always accompany SOS into the future. Three goals for the Science On a Sphere® project remain constant: to increase the ease of use, reduce the cost, and improve the educational capabilities.

National Oceanic and Atmospheric Administration
Washington, D.C.

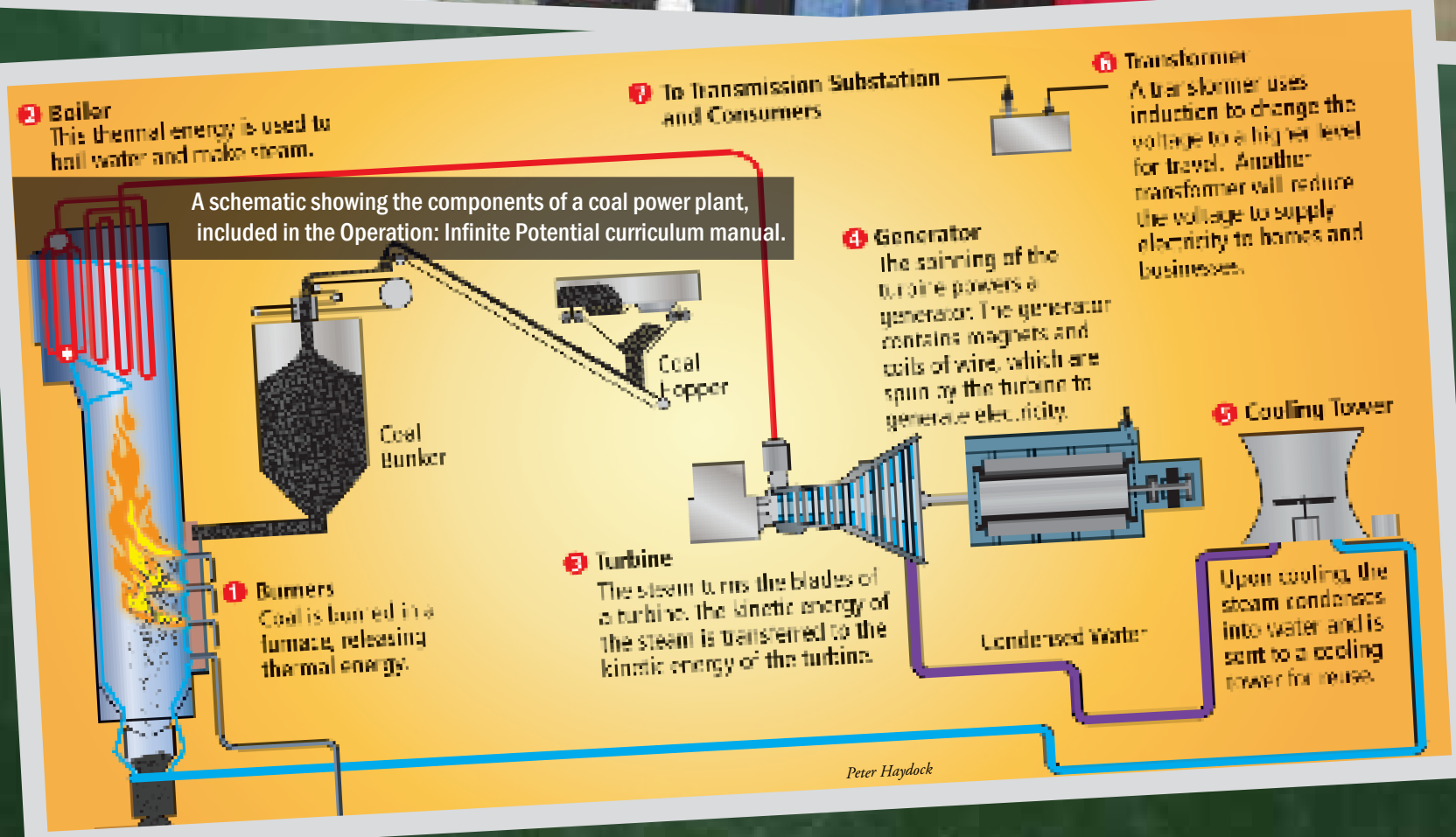
About NOAA

NOAA is an agency that enriches life through science. Our reach goes from the surface of the sun to the depths of the ocean floor as we work to keep citizens informed of the changing environment around them. From daily weather forecasts, severe storm warnings and climate monitoring to fisheries management, coastal restoration and supporting marine commerce, NOAA's products and services support economic vitality and affect more than one-third of America's gross domestic product. NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers and other decision makers with reliable information when they need it. NOAA's mission touches the lives of every American, and we are proud of our role in protecting life and property and conserving and protecting natural resources.

www.noaa.gov

Peter Haydock

At the National Energy Technology Laboratory in Morgantown, West Virginia, Dr. Larry Shadle (left) shows Argonauts (l to r) Jackie Martin, Tim West, Hiyam Añorve Garza, and teacher Melissa Hall how new technology can reduce carbon emissions from the burning of coal.



A schematic showing the components of a coal power plant, included in the Operation: Infinite Potential curriculum manual.

Peter Haydock

Operation: Infinite Potential

"Alert! Argonauts, the world is in crisis, and we need your help!"

Does that sound like a superhero radio broadcast from the 1950s? Good guess, but it's not.

This message was issued by Larry Shadle of the Department of Energy's (DOE) National Energy Technology Laboratory (NETL) to his four "Argonauts"—three middle school students and their teacher—to launch Mission 3 of Operation: Infinite Potential, a research exercise designed to give the participants real-world experience with the energy challenges facing our planet.

The Operation is part of the JASON Program created by the National Geographic Society in 1989. JASON's purpose is to "Create the Spark to Engage Students in Science" by immersing fifth through eighth grade students, along with their teachers, in real-world research situations, guided by a Host Researcher.

This matches well with NETL's educational mission of developing the next generation of researchers by helping to inspire our youth, providing opportunities to learn through experience, and providing tools and materials to our education system for K-12 science and math programs.

Mission 3, entitled "Power to the People: The Current State of the Grid," is one of five missions of the Operation, each dealing with a different aspect of the world's energy challenges.

In his instructions, Shadle, who leads the Model Validation Research Group at NETL, noted that coal resources may only last 150 more years, with demand increasing 67 percent by 2030. Furthermore, carbon dioxide, a greenhouse gas that contributes to global climate change, may also increase by the same percentage.

Meanwhile, promising alternative forms of energy being developed are still uncertain. "How can we use all the resources at our disposal," Shadle asked, "to meet our current energy needs in an environmentally responsible manner?"

His Argonauts set out to answer this question by studying a series of Mission Briefings that included the history of energy, the nature of various engines, the relationship of electricity and magnetism, the workings of power plants, and the power grid.

Hands-on laboratory exercises helped them to explore each topic in depth. Perhaps of greatest value was working with an actual energy researcher like Shadle, who could answer their questions and engage them in his project, which uses circulating fluidized bed technology to efficiently capture CO2 from fossil fuel power plants.

In order to reach the most students possible, the Host Researcher and the Argonauts are videotaped during some of their activities. When the project ends, they work with National Geographic to develop curricula based on their experiences; these curricula are available to any school through the JASON Mission Center.

The materials include mission manuals, videos, digital labs, and games designed to let students around the world experience the thrill of scientific exploration.

The excellence of the Operation: Infinite Potential curriculum was recognized with two 2010 Distinguished Achievement Awards from the Association of Educational Publishers. For the first award, the judges cited the curriculum's "efficacy, usability, and overall educational value." The second award, in the category of Educational Toys and Games, recognized the entertaining yet educational functionality of the project's online interactive games.

In the end, it wasn't just the Argonauts who benefitted from the experience. Reflecting the students' enthusiasm, Shadle said, "When I work with the Argonauts, I get energized!"

> *"How can we use all the resources at our disposal," Shadle asked, "to meet our current energy needs in an environmentally responsible manner?"*
> *Larry Shadle, National Energy Technology Laboratory*

National Energy Technology Laboratory
Morgantown, West Virginia

About NETL

The National Energy Technology Laboratory (NETL) supports DOE's mission to advance the national, economic, and energy security of the United States. NETL implements a broad spectrum of energy and environmental research and development (R&D) programs that will return benefits for generations to come. NETL has expertise in coal, natural gas, and oil technologies; contract and project management; analysis of energy systems; and international energy issues. In addition to research conducted onsite, NETL's project portfolio includes R&D conducted through partnerships, Cooperative Research and Development Agreements, financial assistance, and contractual arrangements with universities and the private sector.

www.netl.doe.gov

Teacher Lisa Davidson (Austin-East High School, Knoxville) tries out a 3-D digital microscope in a Y-12 laboratory.

Teacher Lee Spurling (Robertsville Middle School, Oak Ridge) rides a stationary bike to power light sources as Jeff Parrott, Y-12 employee, coaches.

Y-12 Caring About K-12

What happens when 40 curious teachers spend a day rubbing elbows with some of the best and brightest scientists, engineers, and inventors at the Y-12 National Security Complex? A lot of positive energy is exchanged, and tomorrow's workforce benefits.

Knoxville-Oak Ridge Innovation Valley, a regional economic development initiative, is busy building bridges between the business community and area teachers through summer tours at science and technology centers such as Y-12 and other area businesses. "With the ever-increasing market for advanced technologies, today's engineering and technical students certainly have exciting careers ahead of them.

"We hope to pique the interest of visiting teachers so they'll share with their students some of the cool, innovative work happening at places like Y-12. Students need to see that careers in math and science are creative and exciting," said inventor Lee Bzorgi, a seasoned mechanical engineer and master tinkerer who has earned numerous patents and awards by marrying his interests and government needs.

As the teachers stepped into Y-12's wide-open National Security Technology Center (NSTC) laboratory, they saw and got to try out several of Bzorgi's latest inventions—technologies developed at Y-12, some of which have been transferred to private industry.

The one-day tour began with an overview of Y-12 and its history rooted in the 1940s Manhattan Project. The plant's sole mission 60 plus years ago was to make enough enriched uranium for an atomic bomb that helped end World War II.

Today, Y-12 provides manufacturing, technical, and scientific expertise to produce components, subassemblies, and quality evaluations to sustain a U.S. nuclear deterrent; reduce the threat from weapons of mass destruction; supply nuclear material to the Naval Reactors Program; and provide solutions to other emerging national security challenges. And that's a plate full of challenges for today's students to grasp and tackle.

"I like to visit facilities of major employers in the area to understand the types of workers they're seeking"

Jim Friedrich, Teacher, Hardin Valley Academy

Their teachers are the go-betweens who sow seeds and provide guidance, hopefully setting students on a path toward academic and career success.

A mechanical engineer and part-time university teacher, Dr. Reid Kress ensures that NSTC's resources are readily available online for students and other teachers. "Our slides are available on the web for students to see what some of Y-12's scientists and engineers do. There's also a link to the kinds of people Human Resources is looking for," said Kress. "Students need to know that it takes good communication, teamwork, and leadership, in addition to math and science skills, to be a good engineer or scientist. Writing and computer skills are also essential."

In another lab close by, the teachers pedaled a stationary bicycle to power a light bulb, tried their hands at programming a robot, and took in a demo on amorphous metal wire, a technology too complex to be demonstrated in a school laboratory.

Kathy Barber, Existing Industry Manager of the Oak Ridge Economic Partnership, stressed the importance of inviting educators into the workplace to establish a solid two-way relationship. "Our 'Educators in the Workplace Lunch and Learn Program' is one way teachers can see firsthand what it's like in the business world, and they find ways to make what they teach relevant to the workplace," she said. This successful program doubled in size since last year.

Hardin Valley Academy teacher Jim Friedrich added, "I like to visit facilities of major employers in the area to understand the types of workers they're seeking and the skill sets that are most important. Having grown up in Oak Ridge, it was a treat to get 'inside the gates' to see the facilities I've heard so much about." Friedrich will tell his students that the Knoxville-Oak Ridge area is rich with opportunities for entrepreneurship.

Y-12 National Security Complex
Oak Ridge, Tennessee

About Y-12

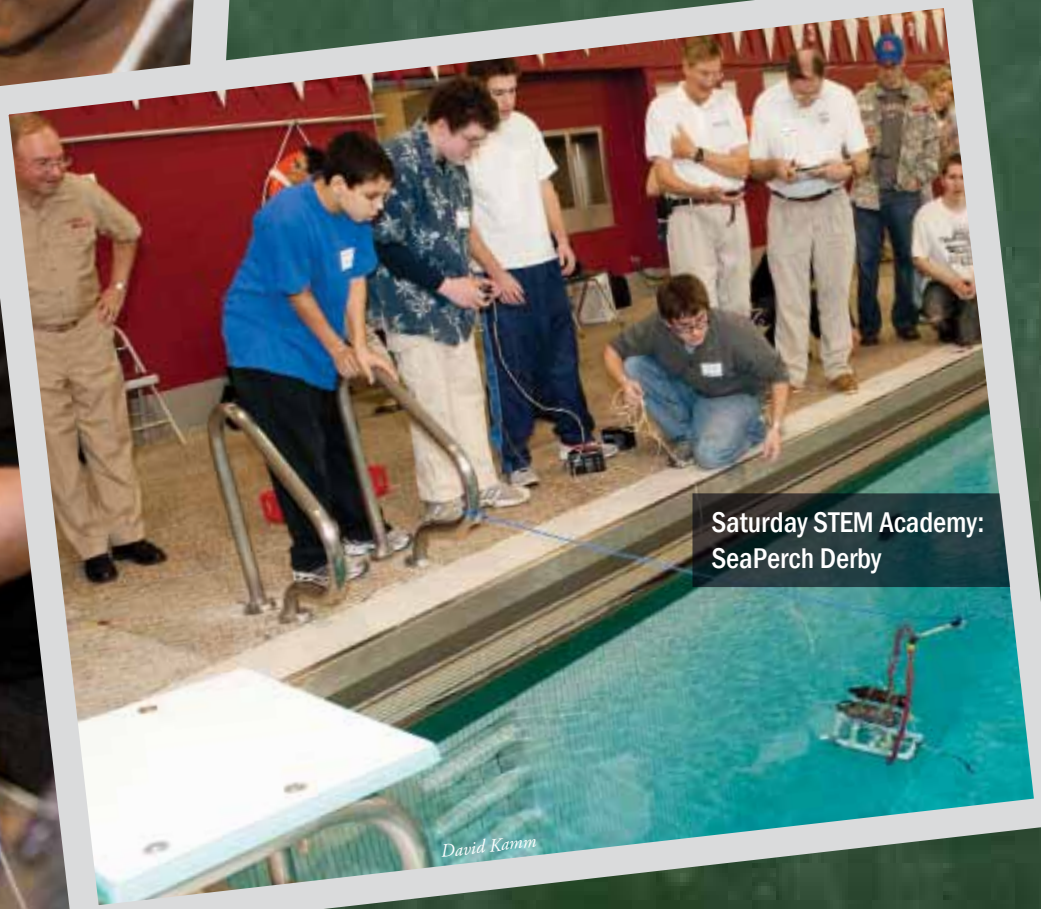
With more than 60 years of experience to draw from, Y-12 is uniquely qualified to address the existing and emerging security challenges facing our nation and the world today. Operated by BWXT Y-12 for the National Nuclear Security Administration (NNSA) within the Department of Energy, Y-12 is a one-of-a-kind manufacturing facility that plays an integral role in DOE's Nuclear Weapons Complex. In this role, Y-12 provides critical elements of NNSA's missions that ensure the safety, reliability and performance of the U.S. nuclear weapons deterrent. Y-12 also uses its unique capabilities to support the Research Reactors Programs for U.S. and international customers, other federal agencies, such as the Department of Defense and Department of Homeland Security, state and local governments, and private-sector companies.

www.y12.doe.gov

TECHNOLOGY FOR TODAY

Saturday STEM Academy: Parachute Challenge

David Kamm



Saturday STEM Academy: SeaPerch Derby

David Kamm

STEM Education: A Natick and National Priority

It is a national priority! science, technology, engineering and math (STEM) education in the United States has the attention of policy makers.

Discussed in the President's education agenda, national security strategy, a congressional hearing, and other important national and local forums, STEM education is getting the attention it deserves.

Inspiring the next-generation workforce capable of maintaining the U.S. position as a leader in innovation and to address the complexities and challenges we face as a nation is no small task. The Department of Defense (DOD), industry and academia, no strangers to collaboration, are joining forces to ensure widespread attention to this topic and lending their most valuable resources: talented STEM professionals to assist with tackling the challenge.

The primary benefit of the U.S. Army Natick Soldier Research, Development and Engineering Center's (NSRDEC) STEM outreach is to inspire and motivate a future technology workforce ready to carry on the important mission of the Army and the DOD.

This is particularly important to the Massachusetts economy, which relies heavily on STEM professionals. Massachusetts' knowledge-based economy has the largest percentage of STEM workers per capita of any other state, with many employers linked to DOD partners.

Massachusetts students appear well-prepared for STEM careers, as evidenced by their top scores in math and science; however, they are choosing STEM college majors well below the national average. NSRDEC's efforts are focused on improving career awareness by exposing educators and students to the real-world application and importance of STEM.

NSRDEC believes that it can reach more students by partnering with teachers to provide resources and knowledge that add excitement to traditional classroom programs.

"NSRDEC's efforts are focused on improving career awareness by exposing educators and students to the real-world application and importance of STEM."

Teacher training initiatives promote better understanding of the application of materials science and the inquiry design process through the proven Materials World Modules training program reaching over 100 teachers this year.

NSRDEC STEM professionals and teachers participate side- by-side in modules that include smart sensors, ceramics, biodegradable materials, biosensors and sports materials.

NSRDEC's soldier mission area is rich with interesting and engaging engineering design and science challenges that lend themselves to classroom activities such as the parachute challenge, load carriage design and nutrition on the go. Each summer NSRDEC has teachers participating in a Massachusetts teacher training initiative that teaches classroom leadership combined with real-world science and engineering experience.

Robotics competitions and summer camps add new experiences for students.

NSRDEC is fortunate to be a part of the Department of Defense laboratory community through the National Defense Education Program (NDEP), where collectively it is constantly looking for new STEM outreach opportunities and partners.

By leveraging NSRDEC's collective resources, it will be able to offer more focused and proven programs as it gains a reputation as a key part of the education process.

NSRDEC's unique laboratories and professionals will continue to be primary resources for our communities, with a focus on increasing the number of students choosing STEM careers, building the future workforce, and ultimately providing the best equipment and technology for warfighters.

Natick Soldier Research, Development & Engineering Center
Natick, Massachusetts

About Natick

The Natick Soldier Research, Development & Engineering Center (NSRDEC) is located at the U.S. Army Soldier Systems Center in Natick, Mass., under the Army's Research, Development and Engineering Command (RDECOM). Natick's mission is to maximize the soldier's survivability, sustainability, mobility, combat effectiveness and quality of life by treating the soldier as a system. Situated near the nation's birthplace of the Army, NSC is the birthplace of the soldier as a system concept. From its early manifestation in the Soldier Integrated Protective Ensemble (SIPE) Advanced Technology Demonstration (ATD), through transition to the PM managed Land Warrior (LW) program, to the current Future Force Warrior (FFW) ATD supporting the Army's transformation to the future force.

www.natick.army.mil/soldier/index.htm

Teachers try out paper towel roll spectrometers to see the spectrum of fluorescent light, and how it compares to that of an incandescent bulb, light from the sun, and other gases.

Teachers prepare gels for separating DNA with gel electrophoresis, just as they observed that morning in a NIST lab.

NIST Program Connects Middle School Teachers and Students with Engineers and Scientists

The National Institute of Standards and Technology (NIST) Summer Institute for Middle School Science Teachers provides a bridge between the cutting-edge research at NIST and the educational community, with the goal of improving science education by supporting middle school science teachers.

To develop future generations of scientists and engineers, NIST works with middle school science teachers to translate research into the classroom, providing classroom activities that parallel research underway in NIST labs. Each summer, the teachers visit NIST for two weeks of hands-on activities, lectures, tours, and visits with scientists and engineers. NIST scientists teach in-depth lessons, and provide resources and instructional tools so teachers can in turn offer those lessons in the classroom. Teachers return for occasional Science Afternoons at NIST.

The NIST Summer Institute was founded in 2007 by then NIST Chief Scientist Hratch Semerjian, who wanted to encourage more students to pursue careers in science, technology, engineering, and mathematics (STEM), and who realized that middle school is a critical time in maintaining student interest in science.

The NIST Summer Institute initially focused on local teachers, and now attracts participants from across the United States. For those teachers outside of the D.C. metro area who cannot attend Science Afternoons at NIST, the Summer Institute encourages them to connect with scientists at their local universities and laboratories, and provides online materials and resources.

"Most middle school science teachers don't know any scientists," said Dr. Mary Satterfield, who runs the NIST Summer Institute and was a teacher herself before entering graduate school and coming to work at NIST as a chemist. "The NIST scientists share their expertise and enthusiasm, which in turn makes teachers more excited about science. The scientists serve as role models for STEM careers since they sometimes visit the classrooms, and teachers may talk about the scientists during lessons."

Forensics was the topic at the latest Summer Institute. Teachers visited a lab that studies human identification using DNA.

The NIST scientist performed a common lab technique to separate DNA molecules in minutes for the teachers. A lecture followed the lab experiment and then the teachers carried out their own experiments. They extracted DNA from a strawberry and then separated the DNA by the same technique they had just observed in the lab, but modified for classroom use. Another day teachers learned about diffraction and created out of paper towel spectrometers tubes that allowed them to study a material by splitting its light to determine the material's composition.

The program increases teachers' understanding of the science they teach, provides resources for new lessons, rekindles their enthusiasm for science, and offers a network of NIST scientists and engineers available for consultation after the program ends.

"Those two weeks not only provided me with well-planned lessons and technical materials, but they also allowed me to forge relationships with experts whose scientific advice is only a call away," one teacher wrote of her Summer Institute experience. "Imagine how excited my students were to make ice cream from liquid nitrogen."

> *"Imagine how excited my students were to make ice cream from liquid nitrogen. This experience would not be possible but for the assistance of dedicated NIST professionals vicariously excited about students learning."* Participating Teacher

National Institute of Standards and Technology
Gaithersburg, Maryland

About NIST

NIST, an agency of the U.S. Department of Commerce, was founded in 1901 as the nation's first federal physical science research laboratory. Over the years, the scientists and technical staff at NIST have made solid contributions to image processing, DNA diagnostic "chips," smoke detectors, and automated error-correcting software for machine tools. Just a few of the other areas in which NIST has had major impact include atomic clocks, X-ray standards for mammography, scanning tunneling microscopy, pollution-control technology, and high-speed dental drills.

www.nist.gov

FEDERAL LABORATORY CONSORTIUM

FLC

FOR TECHNOLOGY TRANSFER

advancing federal research and technology

About the FLC

www.federallabs.org

The Federal Laboratory Consortium for Technology Transfer (FLC), a nationwide network of over 250 federal laboratories, is the only government-wide forum for technology transfer (T2). Organized in 1974 and formally chartered by the Federal Technology Transfer Act of 1986, the FLC provides the framework for developing T2 strategies and opportunities by promoting and facilitating technical cooperation among federal laboratories, industry, academia, and state and local governments.

As the recognized leader in maximizing collaborative research for the transfer of technologies, the FLC enhances the socioeconomic well-being of the nation in the global marketplace. Industry, government, and academic personnel looking to strengthen their T2 capabilities to capitalize on the nation's investment, better their position in the marketplace, or research technology can look to the FLC to foster the rapid movement of federal laboratory research results into the mainstream of the U.S. economy.

The FLC advances T2 by expanding communication among industry, government, and academia. The FLC's website, Technology Locator, T2 Desk Reference, *FLC NewsLink*, trade show exhibits, awards program, education and training publications, and network of experts are only a few of the tools it provides for successful T2.

The FLC is a consortium driven by the dedicated people of the federal laboratory system. These people are the scientists, agency representatives, and T2 professionals who transfer federally funded technology and expertise to the marketplace. Serving as a gateway for industry, government, and academia to access research and development, the FLC also serves as a resource for T2 education and training, news, programming, awards, and initiatives.

Goals and Objectives

- Enhance communication by expanding communication among member agencies and their laboratories; increase dialogue with state and local governments, businesses, academia, and other external participants; and publicize best practices, solutions, and success stories.
- Leverage research and development investments by exploring innovative approaches to technical assistance and other technology transfer activities; reduce time, cost, and risk of R&D projects; and increase use of federal technology by all participants.
- Improve and innovate the technology transfer process by characterizing and analyzing agency technology transfer policy, procedures, and activities; address barriers identified by external participants and others; provide fundamental and advanced education and training to enhance the technology transfer process; and provide federal agencies an analysis of key performance measurement elements and assessment options.

Strategies

- Create innovative partnerships
- Influence technology policy
- Optimize diverse resources
- Strengthen the FLC structure
- Lead the vision
- Project a positive and consistent image

FLC Tools for Technology Transfer Professionals

Technology Locator

The Technology Locator is a free service that provides 1:1 personalized assistance locating federal laboratories ready to transfer their technologies to the marketplace and bringing these laboratories together for collaborative R&D. Call the Locator toll-free at 1-888-388-5227.

Education & Training

The FLC provides education and training on all aspects of technology transfer. This service includes fundamentals, intermediate, and advanced training courses offering continuing education units (CEUs); a wide range of publications and resources; a training resources database; and an online T2 curriculum.

FLC Awards Program

The FLC honors technology transfer excellence through its awards program. Each year, the FLC recognizes those who advance federal technology and expertise to the marketplace.

FLC Online Laboratory Profiles

To learn more about, and connect with, its more than 300 member laboratories, the FLC has created a web-based, searchable database utility for displaying laboratory profiles. The tool allows the user to search based on various criteria, including by agency, technology area, and geographical region. Information displayed includes laboratory contact, history, technology focus, mission, website, and facilities.
More info: www.federallabs.org/labs

www.federallabs.org

The FLC website makes it easy to find people, capabilities, and applications within the FLC's network of federal labs and centers. The site publicizes T2 news and technology trends and provides a gateway to FLC products and services.

Technology for Today
An annual publication showcasing the recent successes of the federal laboratory system.

FLC NewsLink
A free monthly newsletter reporting on technology transfer news and issues.

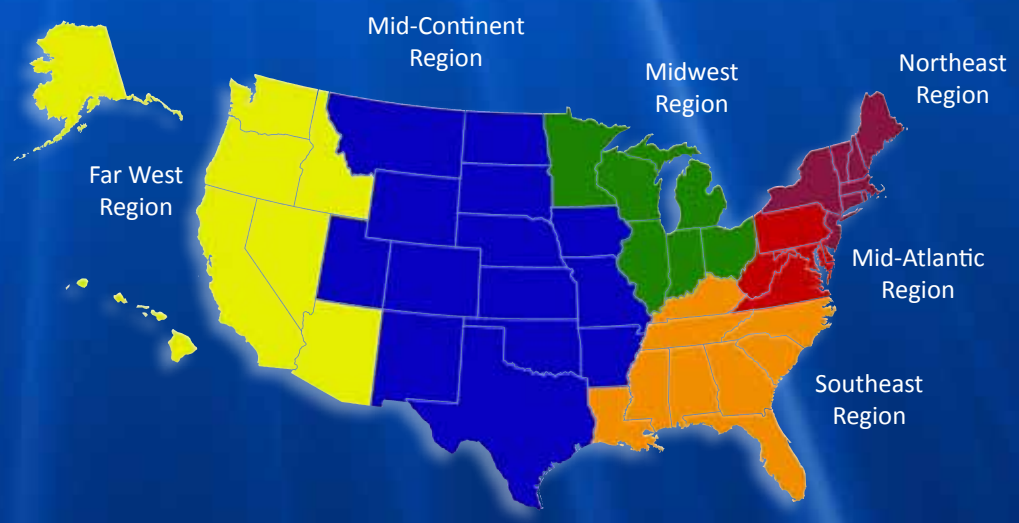
Federal Labs and State & Local Governments
A publication detailing the successes and process for conducting federal T2 to aid state and local government needs.

Washington, DC Representative
Your resource to stay informed about changes in T2 legislation and policy. More info: Gary Jones, 202-296-7201, or at gkjones@federallabs.org.

T2 Desk Reference
The desktop essential for T2 pros and laboratory representatives!

advancing f

FLC Regions



Far West
www.flcfarwest.org
Regional Coordinator: Ida Shum
Lawrence Livermore National Laboratory
925-423-9724
shum3@llnl.gov

Midwest
www.flcmidwest.org
Regional Coordinator: Kristen Schario
AFRL, Propulsion Directorate
937-255-3428
kristen.schario@wpafb.af.mil

Mid-Atlantic
www.flcmidatlantic.org
Regional Coordinator: Mojdeh Bahar
National Institutes of Health
301-435-2950
baharm@mail.nih.gov

Northeast
www.flcnortheast.org
Regional Coordinator: Lewis Meixler
Princeton Plasma Physics Laboratory
609-243-3009
lmeixler@pppl.gov

Mid-Continent
www.flcmidcontinent.org
Regional Coordinator: J. Susan Sprake
Los Alamos National Laboratory
505-665-3613
sprake@lanl.gov

Southeast
www.flcsoutheast.org
Regional Coordinator: Andrew Watkins
Centers for Disease Control and Prevention
770-488-8610
awatkins@cdc.gov

Laboratory State Profiles
The spirit of American innovation is alive and well at over 300 federal laboratories nationwide. Each year, through the efforts of over 100,000 federal researchers and scientists, the United States makes a significant investment in research and development (R&D). The FLC's Laboratory State Profiles webpage provides information on federal research being conducted in each state. To see whats happening in your state, go to www.federallabs.org/sandlg/state_profiles.

Fed Labs RSS News
From new inventions to available technologies for license, the nation's federal laboratories are doing great things that you need to know about. Keeping up-to-date on 300-plus laboratories isn't easy. To help, the FLC has created a Fed Labs RSS page. The site displays RSS fed news as it is posted by the federal laboratories. The searchable feeds include "Available Technologies," "CRADAs", "Lab News", and more. You can even sign-up to have the news you choose sent straight to your email.

Department of Agriculture

Agricultural Research Service
www.ars.usda.gov

Animal and Plant Health Inspection Service
www.aphis.usda.gov

Forest Service
www.fs.fed.us

APHIS - National Wildlife Research Center
www.aphis.usda.gov/ws/nwrc

ARS - Beltsville Area
www.ba.ars.usda.gov

ARS - Children's Nutrition Research Center
www.ars.usda.gov/main/site_main.htm?modecode=62-50-00-00

ARS - Cropping Systems Research Laboratory
www.lbk.ars.usda.gov

ARS - Grassland, Soil & Water Research Laboratory
www.ars.usda.gov/spa/gswrl

ARS - Grand Forks Human Nutrition Research Center
www.gfhnrc.ars.usda.gov

ARS - Grazinglands Research Laboratory
http://ars.usda.gov/main/site_main.htm?modecode=62180000

ARS - Lincoln Location
www.ianr.unl.edu/arslincoln/swcru/home.htm

ARS - Mid South Area
http://msa.ars.usda.gov

ARS - Midwest Area
www.mwa.ars.usda.gov

ARS - National Animal Disease Center
http://ars.usda.gov/main/site_main.htm?modecode=36-25-30-00

ARS - National Center for Agricultural Utilization Research
www.ncaur.usda.gov

ARS - National Seed Storage Laboratory
www.ars.usda.gov/main/site_main.htm?modecode=54-02-05-00

ARS - North Atlantic Area
www.naa.ars.usda.gov

ARS - Northern Great Plains Research Laboratory
www.mandan.ars.usda.gov

ARS - Northern Plains Agricultural Research Laboratory
www.ars.usda.gov/npa/nparl

ARS - Northern Plains Area
www.ars.usda.gov/main/site_main.htm?modecode=54-00-00-00

ARS - Pacific West Area
www.ars.usda.gov/main/site_main.htm?modecode=53-00-00-00

ARS - Plant Genetic Research Unit
www.ars.usda.gov/mwa/columbia/pg

ARS - Plant Science & Water Conservation Research Laboratory
www.pswcrl.ars.usda.gov

ARS - Roman L. Hruska U.S. Meat Animal Research Ctr.
www.ars.usda.gov/Main/docs.htm?docid=2340

ARS - South Atlantic Area
www.ars.usda.gov/Main/site_main.htm?modecode=66-00-00-00

ARS - South Central Agricultural Research Laboratory
www.lane-ag.org

ARS - Southern Plains Area
www.ars.usda.gov/main/site_main.htm?modecode=62-00-00-00

ARS - Southern Regional Research Center
www.ars.usda.gov/msa/srrc

ARS - Southwestern Cotton Ginning Research Laboratory
www.ars.usda.gov/Main/docs.htm?docid=17426

FS - Forest Products Laboratory
www.fpl.fs. fed.us

FS - Missoula Technology & Development Center
www.fs.fed.us/eng/techdev/mtdc.htm

FS - Northeastern Area
www.na.fs.fed.us

FS - Northern Research Station
www.nrs.fs.fed.us

FS - Pacific Northwest Research Station
www.fs.fed.us/pnw

FS - Rocky Mountain Research Station
www.fs.fed.us/rm

FS - San Dimas Technology & Development Center
www.fs.fed.us/eng/techdev/sdtdc.htm

FS - Southern Research Station
www.srs.fs.fed.us

Department of Commerce

National Institute of Standards and Technology
www.nist.gov

National Oceanic and Atmospheric Administration
www.noaa.gov

National Telecommunications and Information Administration
www.ntia.doc.gov

NIST - Boulder Laboratories
www.boulder.nist.gov

NIST - Center for Advanced Cement-Based Materials
http://acbm.northwestern.edu

NOAA - Earth System Research Laboratory
www.esrl.noaa.gov

NOAA - Geophysical Fluid Dynamics Laboratory
www.gfdl.noaa.gov

NOAA - National Geophysical Data Center
www.ngdc.noaa.gov

NOAA - National Marine Fisheries Service - Galveston Lab
http://galveston.ssp.nmfs.gov

NOAA - National Marine Fisheries Service - Northeast Fisheries Science Center
www.nefsc.noaa.gov

NOAA - National Severe Storms Laboratory
www.nssl.noaa.gov

NOAA - Space Weather Prediction Center
www.swpc.noaa.gov

NTIA - Institute for Telecommunication Sciences
www.its.bldrdoc.gov

Department of Defense

Air Force - 30th Space Wing
www.vandenberg.af.mil

Air Force - 311th Human Systems Wing
www.brooks.af.mil

Air Force - Aeronautical Systems Center
www.wpafb.af.mil

Air Force - Air Armament Center
www.eglin.af.mil

Air Force - Air Combat Command
www.acc.af.mil

Air Force - Air Mobility Battlelab
www.mcguire.af.mil/library/factsheets/factsheet.asp?id=4066

Air Force - Arnold Engineering Development Center
www.arnold.af.mil

Air Force - Ogden Air Logistics Center
www.hill.af.mil

Air Force - Oklahoma City Air Logistics Center
www.tinker.af.mil/units/

Air Force - Space and Missile Systems Center
www.losangeles.af.mil

Air Force - Warner Robins Air Logistics Center
www.robins.af.mil

Air Force Academy
www.usafa.af.mil

Air Force Center for Environmental Excellence
www.afcee.af.mil

Air Force Civil Engineer Support Agency
www.afcesa.af.mil

Air Force Electronic Systems Center
http://hanscom.af.mil

Air Force Flight Test Center
www.edwards.af.mil

Air Force Information Operations Center
www.8af.acc.af.mil/units/airforceinformationoperationscenter/index.asp

Air Force Institute of Technology
www.afit.edu

Air Force Intelligence, Surveillance and Reconnaissance Agency
www.afisr.af.mil

Air Force Logistics Management Agency
www.aflma.hq.af.mil

Air Force Office of Scientific Research
www.wpafb.af.mil/AFRL/afosr

Air Force Packaging Technology & Engineering Facility
www.wpafb.af.mil/units/afptef/index.asp

Air Force Research Laboratory
www.afrl.af.mil

Air Force Research Laboratory - Air Vehicles Directorate
www.wpafb.af.mil/afrl/rb

Air Force Research Laboratory - Directed Energy Directorate
www.kirtland.af.mil/afrl_de/

Air Force Research Laboratory - Human Effectiveness Directorate
www.wpafb.af.mil/afrl/he

Air Force Research Laboratory–Information Directorate
www.rl.afrl.af.mil

Air Force Research Laboratory - Materials and Manufacturing Directorate
www.wpafb.af.mil/afrl/rx

Air Force Research Laboratory - Munitions Directorate
www.eglin.af.mil/afrl_mn

Air Force Research Laboratory - Propulsion Directorate
www.wpafb.af.mil/afrl/rz

Air Force Research Laboratory - Sensors Directorate
www.wpafb.af.mil/afrl/sn

Air Force Research Laboratory - Space Vehicles Dir.
www.kirtland.af.mil/afrl_vs/

Air Force Research Laboratory - Space Vehicles Directorate – Hanscom AFB
www.kirtland.af.mil/afrl_vs/

Air Force Weather Agency
www.afweather.af.mil

Army - Aberdeen Test Center
www.atc.army.mil

Army - Aeromedical Research Laboratory
www.usaarl.army.mil

Army - AMC - Aviation & Missile Command
http://ams15.redstone.army.mil:7443/pls/apws/apwsdba.apws_home

Army - AMRDEC - Aeroflightdynamics Directorate
www.redstone.army.mil/amrdec/RD&E/AFDD.html

Army - AMRDEC - Aviation Applied Technology Directorate
www.redstone.army.mil/amrdec/RD&E/AATD.html

Army - ARL - Aberdeen Proving Ground Site
www.arl.army.mil

Army - ARL - Adelphi Site
www.arl.army.mil

Army - ARL - Army Research Office
www.arl.army.mil/aro

Army - ARL - Vehicle Technology Directorate - Propulsion Program
www.arl.army.mil/vtd/vtcindex.html

Army - ARL - Vehicle Technology Directorate - Structures Program
www.arl.army.mil/vtd/vtcindex.html

Army - ARL - Weapons & Materials Directorate
www.arl.army.mil/wmrd

Army - Armament Research, Development, and Engineering Command
www.pica.army.mil/PicatinnyPublic/organizations/ardec/index.asp

Army - Benet Laboratories
www.benet.wva.army.mil

Army - Center for AMEDD Strategic Studies
https://cass.amedd.army.mil

Army - Center for Environmental Health Research
http://usacehr.amedd.army.mil

Army - Clinical Investigation Regulatory Office
www.cs.amedd.army.mil/ciro

Army - Developmental Test Command
www.dtc.army.mil

Army - Dugway Proving Ground
www.dugway.army.mil

Army - Edgewood Chemical Biological Center
www.ecbc.army.mil

Army - Electronic Proving Ground
www.epg.army.mil

Army - Institute of Surgical Research
www.usaisr.amedd.army.mil

Army - Natick Soldier Research, Development & Engineering Ctr.
www.natick.army.mil/soldier/index.htm

Army - Redstone Technical Test Center
www.rttc.army.mil

Army - RDECOM - CERDEC - Night Vision and Electronic Sensors Directorate
www.nvl.army.mil

Army - Space & Missile Defense Command
www.smdc.army.mil

Army - Tank Automotive Research, Development & Engineering Center
http://tardec.army.mil

Army - Technology Integration Center
www.hqisec.army.mil/isec/directorates/tic/tic.asp

Army - TRADOC Analysis Center
www.trac.army.mil

Army - USACE - Engineer Research and Development Ctr.
www.erdc.usace.army.mil

Army - USACE - ERDC - Construction Engineering Research Laboratory
www.cecer.army.mil

Army - USACE - ERDC - Cold Regions Research and Engineering Laboratory
www.crrel.usace.army.mil

Army - USACE - ERDC - Information Technology Laboratory
http://itl.erdc.usace.army.mil

Army - USACE - ERDC - Coastal and Hydraulics Laboratory
http://chl.erdc.usace.army.mil

Army - USACE - ERDC - Environmental Laboratory
http://el.erdc.usace.army.mil

Army - USACE - ERDC - Geotechnical and Structures Laboratory
http://gsl.erdc.usace.army.mil

Army - USACE - Hydrologic Engineering Center
www.hec.usace.army.mil

Army - USACE - Institute for Water Resources
www.iwr.usace.army.mil

Army - USAMRMC - Telemedicine and Advanced Technology Research Center
www.tatrc.org

Army - Walter Reed Army Institute of Research
http://wrair-www.army.mil

Army - White Sands Missile Range
www.wsmr.army.mil/wsmr.asp

Army - Yuma Proving Ground
www.yuma.army.mil

Army Battle Command Battle Lab, Experimentation Division – Gordon
www.gordon.army.mil/bcblg

Army Communications-Electronics Command
www.monmouth.army.mil/CELCMC

Army Geospatial Center
www.agc.army.mil

Army Medical Materiel Development Activity
www.usammda.army.mil

Army Medical Research and Materiel Command
https://mrmc.detrick.army.mil

Army Research Institute for the Behavioral and Social Sciences
www.hqda.army.mil/ari

Army Medical Research Institute of Chemical Defense
https://ccc.apgea.army.mil

Army Medical Research Institute of Infectious Diseases
www.usamriid.army.mil

Army Research Institute of Environmental Medicine
www.usariem.army.mil

Army Tank-Automotive and Armaments Command
www.tacom.army.mil

Army Test & Evaluation Command
www.atec.army.mil

Defense Advanced Research Projects Agency
www.darpa.mil

Defense Information Systems Agency
www.disa.mil

DISA - Joint Interoperability Test Command
http://jitc.fhu.disa.mil

Defense Language Institute Foreign Language Center
www.dliflc.edu

Defense Microelectronics Activity
www.dmea.osd.mil

Defense Technical Information Center
www.dtic.mil

Marine Corps Installations West
www.mciwest.usmc.mil

Marine Corps Systems Command
www.marcorsyscom.usmc.mil

Missile Defense Agency
www.mda.mil

National Geospatial-Intelligence Agency
www.nga.mil

Naval Aerospace Medical Research Laboratory
www.namrl.navy.mil

Naval Air Systems Command
www.navair.navy.mil

Naval Air Warfare Center Aircraft Division - Lakehurst
www.navair.navy.mil/lakehurst/nlweb/index-non-flash.asp

Naval Air Warfare Center Aircraft Division - Patuxent River
www.navair.navy.mil/nawcad

Naval Air Warfare Center Training Systems Division
http://nawctsd.navair.navy.mil

Naval Air Warfare Center Weapons Division - China Lake and Pt. Mugu
www.navair.navy.mil/nawcwd

Naval Explosive Ordnance Disposal Technology Division
http://eodtechdiv.nswc.navy.mil

Naval Facilities Engineering Command
https://portal.navfac.navy.mil

Naval Facilities Engineering Service Center
https://portal.navfac.navy.mil/NFESC

Naval Health Research Center
www.med.navy.mil/sites/nhrc/Pages/default.aspx

Naval Medical Center - Portsmouth
www-nmcp.med.navy.mil

Naval Medical Center - San Diego
www.med.navy.mil/sites/nmcsd/Pages/default.aspx

Naval Medical Research Center
www.nmrc.navy.mil

Naval Postgraduate School
www.nps.edu

Naval Research Laboratory
www.nrl.navy.mil

Naval Safety Center
www.safetycenter.navy.mil

Naval Sea Systems Command
www.navsea.navy.mil

Naval Submarine Medical Research Laboratory
www.nhrc.navy.mil/nsmrl

Naval Surface Warfare Center - Carderock Division
www.dt.navy.mil

Naval Surface Warfare Center - Crane Division
www.crane.navy.mil

Naval Surface Warfare Center - Dahlgren Division
www.nswc.navy.mil

Naval Surface Warfare Center - Indian Head Division
www.ih.navy.mil

Naval Surface Warfare Center - Panama City Division
http://nswcpc.navsea.navy.mil

Naval Surface Warfare Center - Port Hueneme Division
www.phdnswc.navy.mil

Naval Undersea Warfare Center - Division Keyport
www-keyport.kpt.nuwc.navy.mil

Naval Undersea Warfare Center - Division Newport
www.nuwc.navy.mil/npt

Naval War College
www.nwc.navy.mil

Navy - National Naval Medical Center
www.bethesda.med.navy.mil

Navy - Naval Meteorology and Oceanographic Command
www.navmetoccom.navy.mil

Navy - Office of Naval Research
www.onr.navy.mil

Navy - Portsmouth Naval Shipyard
www.ports.navy.mil

Navy - Space and Naval Warfare Systems Center Atlantic - Charleston
http://enterprise.spawar.navy.mil/body.cfm?type=c&category=32&subcat=72

Navy - Space and Naval Warfare Systems Ctr. Atlantic – New Orleans
http://enterprise.spawar.navy.mil/body.cfm?type=c&category=31&subcat=115

Navy - Space and Naval Warfare Systems Center Atlantic – Norfolk
http://enterprise.spawar.navy.mil/body.cfm?type=c&category=30&subcat=64

Navy - Space and Naval Warfare Systems Center Pacific
http://enterprise.spawar.navy.mil/body.cfm?type=c&category=29&subcat=105

Navy - U.S. Naval Academy
www.usna.edu

Navy - U.S. Naval Observatory
www.usno.navy.mil

Navy Clothing and Textile Research Facility
www.navy-nex.com/command/nctrf/nctrf-index.html

Uniformed Services University of the Health Sciences
www.usuhs.mil

U.S. Joint Forces Command
www.jfcom.mil

U.S. Transportation Command
www.transcom.mil

Department of Energy

Ames Laboratory
www.ameslab.gov

Argonne National Laboratory
www.anl.gov

Brookhaven National Laboratory
www.bnl.gov

Chicago Operations Office
www.ch.doe.gov

Fermi National Accelerator Laboratory
www.fnal.gov

Hanford Site
www.hanford.gov

Idaho National Laboratory
www.inl.gov

Kansas City Plant
www.kcp.com

Laboratory of Structural Biology and Molecular Medicine
www.doe-mbi.ucla.edu

Lawrence Berkeley National Laboratory
www.lbl.gov

Lawrence Livermore National Laboratory
www.llnl.gov

Los Alamos National Laboratory
www.lanl.gov

National Energy Technology Laboratory
www.netl.doe.gov

National High Magnetic Field Laboratory
www.nhmfl.gov

National Renewable Energy Laboratory
www.nrel.gov

Nevada Site Office
www.nv.doe.gov

New Brunswick Laboratory
www.nbl.doe.gov

Oak Ridge National Laboratory
www.ornl.gov

Oak Ridge Operations Office
www.oakridge.doe.gov

Office of Scientific & Technical Information
www.osti.gov

Pacific Northwest National Laboratory
www.pnl.gov

Pantex Plant
www.doeal.gov/pxso

Princeton Plasma Physics Laboratory
www.pppl.gov

Rocky Mountain Oilfield Testing Center
www.rmotc.doe.gov

Sandia National Laboratories
www.sandia.gov

Sandia National Laboratories – California
www.ca.sandia.gov

Savannah River National Laboratory
http://srnl.doe.gov

Stanford Linear Accelerator Center
www.slac.stanford.edu

Thomas Jefferson National Accelerator Facility
www.jlab.org

Y-12 National Security Complex
www.y12.doe.gov

Department of Health and Human Services

Centers for Disease Control and Prevention
www.cdc.gov

Food and Drug Administration
www.fda.gov

National Institutes of Health
www.nih.gov

CDC - National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention
www.cdc.gov/nchhstp

CDC - Nat. Ctr. for Immunization and Respiratory Diseases
www.cdc.gov/ncird

CDC - National Center for Preparedness, Detection, and Control of Infectious Diseases
www.cdc.gov/ncpdcid

CDC - National Center for Zoonotic, Vector-Borne, and Enteric Diseases (ZVED)
www.cdc.gov/nczved

CDC - National Institute for Occupational Safety and Health
www.cdc.gov/niosh

CDC - NIOSH - National Personal Protective Technology Laboratory
www.cdc.gov/niosh/npptl

CDC - NIOSH - Pittsburgh Research Laboratory
www.cdc.gov/niosh/im-prl.html

CDC - NIOSH - Spokane Research Laboratory
www.cdc.gov/niosh/im-srl.html

CDC - NIOSH - Health Effects Laboratory Division
www.cdc.gov/niosh/im-held.html

FDA - Center for Biologics Evaluation and Research
www.fda.gov/cber

FDA - Center for Devices and Radiological Health
www.fda.gov/cdrh

FDA - Center for Drug Evaluation and Research
www.fda.gov/cder

FDA - Center for Veterinary Medicine
www.fda.gov/cvm

FDA - Center for Food Safety and Applied Nutrition
www.cfsan.fda.gov/list.html

FDA - National Center for Toxicological Research
www.fda.gov/nctr

NIH - Center for Information Technology
www.cit.nih.gov

NIH - Clinical Center
www.cc.nih.gov

NIH - Fogarty International Center
www.fic.nih.gov

NIH - National Cancer Institute
www.cancer.gov

NIH - National Center for Complementary and Alternative Medicine
http://nccam.nih.gov

NIH - National Center for Research Resources
www.ncrr.nih.gov

NIH - National Eye Institute
www.nei.nih.gov

NIH - National Heart, Lung, and Blood Institute
www.nhlbi.nih.gov

NIH - National Human Genome Research Institute
www.genome.gov

NIH - National Institute of Allergy and Infectious Diseases
www.niaid.nih.gov

NIH - National Institute of Arthritis and Musculoskeletal and Skin Diseases
www.niams.nih.gov

NIH - National Institute of Biomedical Imaging and Bioengineering
www.nibib.nih.gov

NIH - National Institute of Child Health and Human Development
www.nichd.nih.gov

NIH - Nat. Institute of Dental and Craniofacial Research
www.nidcr.nih.gov

NIH - Nat. Institute of Diabetes, Digestive and Kidney Diseases
www.niddk.nih.gov

NIH - National Institute of Environmental Health Sciences
www.niehs.nih.gov

NIH - National Institute of General Medical Sciences
www.nigms.nih.gov

NIH - National Institute of Mental Health
www.nimh.nih.gov

NIH - National Institute of Neurological Disorders and Stroke
www.ninds.nih.gov

NIH - National Institute of Nursing Research
www.ninr.nih.gov

NIH - National Institute on Aging
www.nia.nih.gov

NIH - Nat. Institute on Alcohol Abuse and Alcoholism
www.niaaa.nih.gov

NIH - National Institute on Deafness and Other Communication Disorders
www.nidcd.nih.gov

NIH - National Institute on Drug Abuse
www.nida.nih.gov

NIH - National Library of Medicine
www.nlm.nih.gov

NIH - Office of Research Services
www.ors.od.nih.gov

NIH - Rocky Mountain Laboratories
http://www3.niaid.nih.gov/about/organization/dir/rml

Department of Homeland Security

Coast Guard R&D Center
www.uscg.mil/hq/cg9/rdc/default.asp

Environmental Measurements Laboratory
www.eml.st.dhs.gov

National Biodefense Analysis and Countermeasures Center
www.dhs.gov/xres/labs/gc_1166211221830.shtm

Plum Island Animal Disease Center
www.dhs.gov/xres/labs/editorial_0901.shtm

Transportation Security Laboratory
www.dhs.gov/xres/labs/editorial_0903.shtm

Department of the Interior

Bureau of Reclamation
www.usbr.gov

U.S. Geological Survey
www.usgs.gov

BR - Water Quality Improvement Center
www.usbr.gov/lc/yuma/facilities/wqic/yao_facilities_wqic.html

USGS - Alabama Water Science Center
http://al.water.usgs.gov

USGS - Alaska Science Center
http://alaska.usgs.gov

USGS - Arizona Water Science Center
http://az.water.usgs.gov

USGS - Arkansas Water Science Center
http://ar.water.usgs.gov

USGS - Astrogeology Research Program
http://astrogeology.usgs.gov

USGS - Biological Resources Discipline - Central Regional Office
http://biology.usgs.gov/cro/

USGS - Biological Resources Discipline - Western Regional Office
http://biology.usgs.gov/wro

USGS - California Water Science Center
http://ca.water.usgs.gov

USGS - Caribbean Water Science Center
http://pr.water.usgs.gov

USGS - Colorado Water Science Center
http://co.water.usgs.gov

USGS - Columbia Environmental Research Center
www.cerc.usgs.gov

USGS - Florida Integrated Science Center
http://fisc.er.usgs.gov

USGS - FISC - Center for Coastal and Watershed Studies
http://coastal.er.usgs.gov

USGS - FISC - Water Resources of Florida - Tallahassee
http://fl.water.usgs.gov

USGS - Forest and Rangeland Ecosystem Science Center
http://fresc.usgs.gov

USGS - Georgia Water Science Center
http://ga.water.usgs.gov

USGS - Great Lakes Science Center
www.glsc.usgs.gov

USGS - Idaho Water Science Center
http://id.water.usgs.gov

USGS - Illinois Water Science Center
http://il.water.usgs.gov

USGS - Indiana Water Science Center
http://in.water.usgs.gov

USGS - Iowa Water Science Center
http://ia.water.usgs.gov

USGS - Kansas Water Science Center
http://ks.water.usgs.gov

USGS - Kentucky Water Science Center
http://ky.water.usgs.gov

USGS - Louisiana Water Science Center
http://la.water.usgs.gov

USGS - Maine Water Science Center
http://me.water.usgs.gov

USGS - Maryland-Delaware-District of Columbia Water Science Center
http://md.water.usgs.gov

USGS - Massachusetts/Rhode Island Water Science Center
http://ma.water.usgs.gov

USGS - Michigan Water Science Center
http://mi.water.usgs.gov

USGS - Minnesota Water Science Center
http://mn.water.usgs.gov

USGS - Mid-Continent Ecological Science Center
www.mesc.usgs.gov

USGS - Mississippi Water Science Center
http://ms.water.usgs.gov

USGS - Missouri Water Science Center
http://mo.water.usgs.gov

USGS - Montana Water Science Center
http://mt.water.usgs.gov

USGS - National Wetlands Research Center
www.nwrc.usgs.gov

USGS - National Wildlife Health Center
www.nwhc.usgs.gov

USGS - Nebraska Water Science Center
http://ne.water.usgs.gov

USGS - Nevada Water Science Center
http://nevada.usgs.gov/water

USGS - New Hampshire/Vermont Water Science Center
http://nh.water.usgs.gov

USGS - New Jersey Water Science Center
http://nj.usgs.gov

USGS - New Mexico Water Science Center
http://nm.water.usgs.gov

USGS - New York Water Science Center
http://ny.water.usgs.gov

USGS - North Carolina Water Science Center
http://nc.water.usgs.gov

USGS - North Dakota Water Science Center
http://nd.water.usgs.gov

USGS - Northern Prairie Wildlife Research Center
www.npwrc.usgs.gov

USGS - NWHC - Honolulu Field Station
www.nwhc.usgs.gov/hfs/Homepage.htm

USGS - Ohio Water Science Center
http://oh.water.usgs.gov

USGS - Oklahoma Water Science Center
http://ok.water.usgs.gov

USGS - Oregon Water Science Center
http://or.water.usgs.gov

USGS - Pennsylvania Water Science Center
http://pa.water.usgs.gov

USGS - South Carolina Water Science Center
http://sc.water.usgs.gov

USGS - Tennessee Water Science Center
http://tn.water.usgs.gov

USGS - Texas Water Science Center
http://tx.usgs.gov

USGS - Utah Water Science Center
http://ut.water.usgs.gov

USGS - Virginia Water Science Center
http://va.water.usgs.gov

USGS - Upper Midwest Environmental Science Center
www.umesc.usgs.gov

USGS - Wisconsin Water Science Center
http://wi.water.usgs.gov

USGS - Cascades Volcano Observatory
http://vulcan.wr.usgs.gov

USGS - Washington Water Science Center
http://wa.water.usgs.gov

USGS - Western Fisheries Research Center
http://wfrc.usgs.gov

USGS - West Virginia Water Science Center
http://wv.usgs.gov

USGS - Wyoming Water Science Center
http://wy.water.usgs.gov

Department of Justice

Federal Bureau of Investigation
www.fbi.gov

Department of Labor
Mine Safety and Health Administration
www.msha.gov

Department of Transportation
Civil Aerospace Medical Institute
www.faa.gov/about/office_org/headquarters_offices/avs/offices/aam/cami/

Transportation Technology Center
www.fra.dot.gov

Turner-Fairbanks Highway Research Center
www.tfhrc.gov

Volpe National Transportation Systems Center
www.volpe.dot.gov

William J. Hughes Technical Center
www.faa.gov/about/office_org/headquarters_offices/ato/tc/

Department of Veterans Affairs
Atlanta VA Rehabilitation Research and Development Center
www.varrd.emory.edu

Rehabilitation Research & Development Service
www.rehab.research.va.gov

Environmental Protection Agency
National Center for Computational Toxicology
www.epa.gov/comptox/

National Center for Environmental Research
http://es.epa.gov/ncer

National Exposure Research Laboratory
www.epa.gov/nerl

National Health and Environmental Effects Research Lab
www.epa.gov/nheerl

National Homeland Security Research Center
www.epa.gov/nhsrc

National Risk Management Research Laboratory
www.epa.gov/ord/nrmrl

Office of Science and Policy
www.epa.gov/osp

NASA
Ames Research Center
www.arc.nasa.gov

Dryden Flight Research Center
www.nasa.gov/centers/dryden/home/index.html

Glenn Research Center
www.nasa.gov/centers/glenn/home/index.html

Goddard Space Flight Center
www.nasa.gov/centers/goddard/home/index.html

Jet Propulsion Laboratory
www.jpl.nasa.gov

Johnson Space Center
www.nasa.gov/centers/johnson/home/index.html

Kennedy Space Center
www.nasa.gov/centers/kennedy/home/index.html

Langley Research Center
www.larc.nasa.gov

Marshall Space Flight Center
www.nasa.gov/centers/marshall/home/index.html

Stennis Space Center
www.nasa.gov/centers/stennis/home/index.html

National Science Foundation
Advanced Technology for Large Structural Systems Center
www.atlss.lehigh.edu

Brigham Young University
www.byu.edu

Institute for Systems Research
www.isr.umd.edu

National Center for Atmospheric Research
www.ncar.ucar.edu

National Science Foundation
www.nsf.gov

National Security Agency

National Information Assurance Research Laboratory
www.nsa.gov/research/ia_research/index.shtml

National Security Agency
www.nsa.gov

Tennessee Valley Authority

Tennessee Valley Authority
www.tva.gov

TECHNOLOGY FOR TODAY

Enhancing America Through Federally Developed Research and Technology

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- **40ka** (40,000 Years Ago) — The Boat
- **3500 BCE** — The Wheel
- **3000 BCE** — The Toothbrush
- **2800 BCE** — The Button
- **2700 BCE** — The Alphabet
- **1900 BCE** — Veterinary Medecince
- **592 BCE** — The Anchor
- **406 BCE** — The Wheelbarrow
- **247 BCE** — The Compass
- **21 BCE** — The Umbrella
- **960 AD** — Paper Money
- **1150 AD** — Sunglasses