NEED TO KNOW

a national security newsletter

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Retooling Armor

INEEL Researchers Bring High-Tech Solutions to an Ancient Problem

Armor is almost as ancient as war itself. Five thousand years ago, Egyptian soldiers marched into battle wearing body armor in the form of a quilted belt stretching from their armpits to their knees. Not far away and during that same time period, tight-fitting caps of beaten copper protected the heads of Sumerian fighters. By the 15th century, a medieval knight rode a heavy charger while fully encased in articulated plate weighing as much as 65 pounds, yet so well-fitted that he could mount his horse without stirrups.

The knight was almost invulnerable against pointed weapons – swords, lances, and knives. But when the weapon changed to lead bullets, the armor needed to protect against that increased threat became too heavy to be practical and was soon abandoned.

An anonymous author summarized the history of armor development in four lines.

Weapon – Armor
Bigger weapon – Heavier armor
Bigger weapon – Refined armor
Bigger weapon – Heavier refined armor

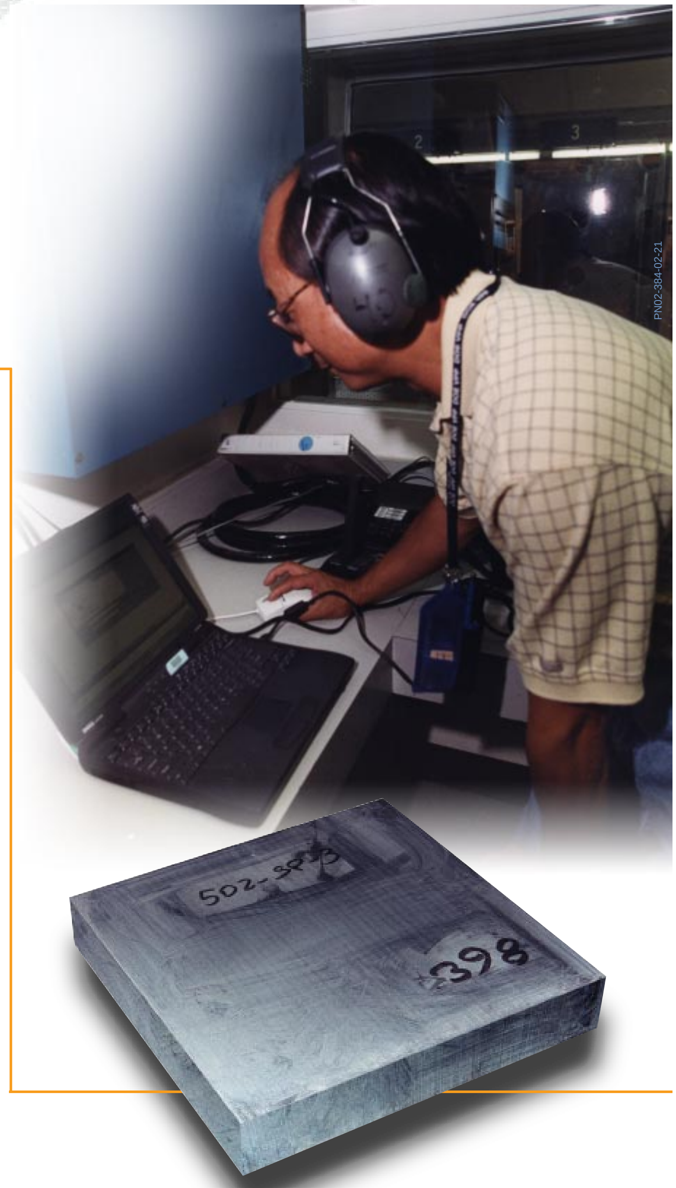
In the centuries since, the threats have increased and the armor material has changed but the relationship of weight versus protection remains a critical factor.

Military Armor

The U.S. Army categorizes armor – light, medium and heavy – based on pounds per square foot. Each type of armor is designed to stop a certain caliber of threat. A new category of ultra-lightweight was instituted about 10 years ago to address body armor requirements.

INEEL mechanical engineer Henry Chu has delved some into the high-density, polyethylene "Kevlar-type"

See **ARMOR**, page 2



Modern armorers like the INEEL's Henry Chu use computers and sophisticated composites to do their work. The materials used in a medieval knight's helmet and the INEEL armor test sample shown above are very different, but the basic principle remains the same: maximum protection with the least possible weight.

ARMOR *(continued from page 1)*

ultra-lightweight armors. For INEEL's National Security Division and its U.S. military customers, however, Chu primarily develops and tests lightweight armor. This armor, weighing 20 to 25 pounds per square foot or less, is designed for vehicles and aircraft – everything from limousines carrying presidents to troop carriers for special forces.

Chu – teaming with other INEEL researchers – first tasted success with an alumina powder ceramic armor. The key is the high-purity and fine, uniform size of the starting powder. Using a concept initiated at Michigan Technological University, the team produced a denser and stronger fine uniform grain-sized alumina plate at relatively low temperatures and short duration. The resultant material was denser and stronger than commercially available material.

Lightweight ceramic armor such as this became the military standard but armor never stops evolving. The Army is now driving research and industry into developing and improving other advanced ceramics such as silicon carbide and boron carbide. These materials are either less dense than alumina, or possess better ballistic performance, or both. Trouble is, quality and quantity of starting material are hard to come by, therefore constraining use. These materials require greater temperatures during processing – 1,900 to 2,000C compared to 1,200C for alumina – and still do not lend themselves to sintering. Chu and colleague Tom Lillo are working on solutions through INEEL's Laboratory Directed Research and Development program.

"The importance of the LDRD program is clear in armor research," says Chu. "It allows us to plant the seed of initial development, demonstrate proof-of-concept, and subsequently obtain external funds to bring the products to market."

Chu and Lillo's concepts also snared a commercial partner who provides the raw material and who – together with the INEEL team – is responding to a Broad Agency Announcement to provide 15 samples to the Army for testing.

According to Chu, only about three commercial companies manufacture advanced ceramic armor for the military and they are unable to keep up with even limited production. The Army wants other sources, and Chu's industrial partner would like to be one of them.

The material continues to undergo tests at INEEL's live-fire range. Results are good, but Chu will continue research and testing until he is satisfied that the material is as good as it can get. In the meantime, he works on the opposite spectrum from material development. Chu provides technical advice to the government and the contractor manufacturing armored riverboats.

Under Fire

The public is familiar with this type of boat, having seen them in news clips of wars in foreign lands and in movies such as *Apocalypse Now*. INEEL researchers wrote the armor requirements for the boat and the INEEL team, including Chu, reviewed and tested several proposed solutions.

Chu included one requirement in the specifications that was different from anything written before. The requirement resulted from a test Chu had witnessed sometime earlier. Initial tests on a new armor validate the material itself. Can it withstand the threat; stop the bullet? Once that is proven, additional experiments test the product design, or how the armor is put together. Chu witnessed the test of the first prototype riverboat under scripted combat conditions. The boat was launched and attacked from the land. Sharpshooters aimed at vulnerable points. To make the test more realistic, full-scale silhouettes of soldiers were placed in normal operating positions in the 9- by 31-foot boat. The shooting began.

The armor withstood the barrage of bullets effectively and passed. But when Chu examined the boat closely, he saw stray shots had riddled the silhouettes. It wasn't poor marksmanship; it was ricochet. Chu recognized that deflection wasn't enough, the armor had to absorb the bullet. Chu incorporated this requirement into the specifications for the riverboat.

For the next two months, Chu worked closely with the manufacturing contractor to improve the armor solutions. The resultant

A marksman zeros in a rifle to test a new ceramic armor composite; a hydraulic dolly used to raise the armor sample into position for ricochet tests; an actual armor sample and the resultant flattened slugs from a successful armor test.

(from left) Shelly Fried, Tom Gioconda, Bob Summers, Kurt McGee, and John Pickler review test results with Henry Chu.

product stopped and controlled the projectile, becoming a "bullet trap." That boat is now in production in Louisiana and Chu regularly takes calls from the manufacturer. He will provide ongoing consultation until the fleet is finished.

As good as Chu and Lillo's research is, another component makes INEEL armor development particularly strong—the live-fire test range.

"The live-fire test range is absolutely critical to our research," says Chu. "You can only conceptualize so much. Ballistic impact is such a violent phenomenon that it defies imagination. Armor designers always get humbled in the end. We still lack full understanding on how armor really works. A lot of theories and basic principles have been devised and published on armor systems and materials, but in the end, one still has to perform live-fire tests with any potential solution to ensure there are no surprises."

The range supports not only research and development, but also the day-to-day training and certification of INEEL's elite security forces. Its combination of multiple ranges, shooting house and environmental controls makes it fairly unique, and not just in the Department of Energy complex. Security forces from around the state and other locations have come to train there. Furthermore, the Laboratory can offer independent testing and certification to any organization developing armor products. The National Security Division considers it a vital component as it establishes the INEEL Critical Infrastructure Test Range.

Whether Henry Chu is developing his own armor solutions, consulting for the military, or testing an armor product, he keeps the engineering focus of the IN "E"EL in mind.

"We see a lot of proposed solutions. Some are not realistic, and some would just waste taxpayer money. We want to stay practical, application-driven. We want to emphasize the engineering integration part. After all, this is not abstract research; this armor can save soldiers' lives. This armor is good for the country."

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State of the Division

Laurin Dodd,
Associate Laboratory Director, National Security

Lightweight armor developments described in this issue are leading to some exciting opportunities for new applications.

This work is a direct result of two special INEEL assets: the Specific Manufacturing Capability and the Live-Fire Test Range. SMC is comprised of a modern manufacturing facility and some pretty special staff that manufacture armor for the Army's Abrahms tanks.

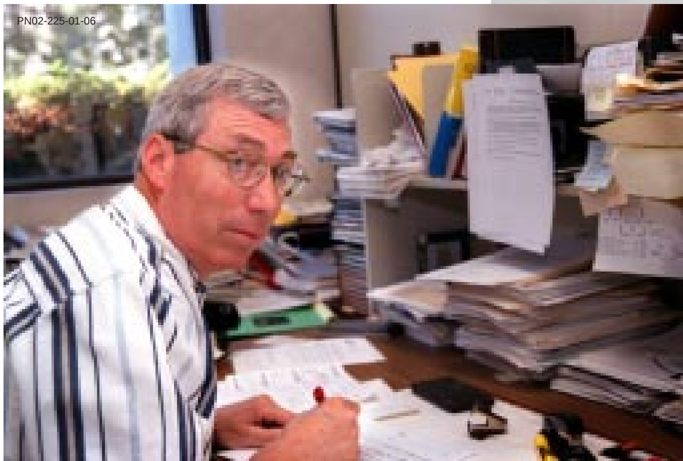
Dr. Henry Chu splits his time between supporting the SMC mission and developing new armor materials. The Live-Fire Test Range allows Henry and his co-workers to test new armor materials that have applications ranging from protecting Future Combat Systems to protecting 'first responders.'

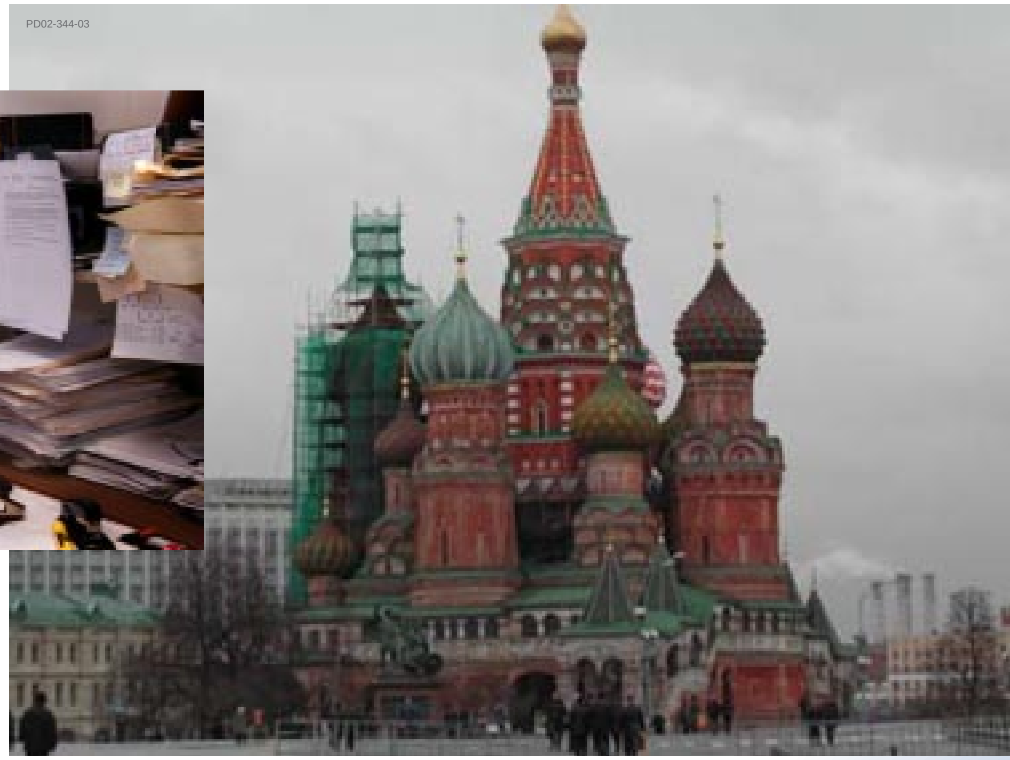
The ability to both develop and test lightweight armor in real-world conditions is one small example of our capability to test and demonstrate research products. We can apply the full strength of an integrated laboratory that is engaged in operations and manufacturing as well as research and development.

Our customers – new and old – increasingly recognize that INEEL is a special place with a potential for becoming a national asset as a test range in support of emerging critical infrastructure / homeland security missions. The INEEL is on a self-contained 890-square-mile site that has an array of infrastructures that are a microcosm of those infrastructures that are critical to the operation of our nation. Most of these infrastructures – including power production and distribution systems, telecommunications systems, and transportation systems – were designed and built and are operated by INEEL staff. They are ideally suited for use as a test range for characterizing vulnerabilities of critical infrastructure systems and for developing more robust new systems and components.

This emerging mission is in keeping with the 50-year history of the INEEL as a test bed for development of nuclear and environmental technologies, and it builds upon many current programs. I do not think that there is another site within the Department of Energy that has the full range of infrastructures under one contractor. Throw in our engineering discipline and it is hard to not conclude that there is something special here.

Watch for future developments as our CIP Test Bed mission emerges!





INEEL microbiologist Rob Rogers is the principal investigator for several IPP projects, coordinating both technical and administrative aspects. The photo at right was taken during a recent visit to Moscow.

INEEL programs create "positive science" in U.S. and Russia

Initiatives for Proliferation Prevention is a U.S. Department of Energy program that employs former Soviet Union scientists who had previously worked on weapons-type research and development. The IPP program furthers U.S. national security and nonproliferation objectives by making participating scientists unavailable to third world countries wishing to develop weapons of mass destruction capabilities. These scientists are now funded to develop technologies addressing national and international problems that can lead to commercial ventures.

As a result, the Department of Energy and U.S. commercial partners obtain quality research from renowned Russian Federation institutions and researchers at very reasonable cost. The institutions receive more than just an influx of cash. They get the chance to establish viable commercial enterprises from the ashes of Cold War activities. And they receive good help doing it. In the second phase of the multi-year IPP programs, the Russian institutions partner with successful U.S. businesses interested in commercial applications of the developing technologies.

"Positive Science"

National Security's Trudy Overlin refers to it as "positive science" – transitioning Russian scientists from biological weapons testing to microbial concrete decontamination. Overlin manages the overall IPP program for the National Security Division. The INEEL IPP program encompasses about a dozen individual projects in various stages of maturity.

Overlin works with INEEL principal investigators to submit project concepts to DOE for consideration and funding. Once approved, she ensures the complicated contracts required to do business in the former Soviet Union are in place. She follows the tortuous path of payment through the labyrinth of bureaucracies on both sides of the Atlantic until the appropriate sums drop tidily into the Russian scientist's checking accounts. She helps solves problems when they arise.

There is a lot of administrative oversight with any international program. However, Overlin will be the first to tell you that the IPP program is not about necessary but sometimes cumbersome processes. The IPP program is about the science, the exciting collaborations between former adversaries attempting to solve international problems while bringing new opportunities to capital-starved communities.

INEEL microbiologist Rob Rogers, principal investigator for several IPP projects, says his role is both technical and administrative. Rogers develops the technical scope of the project and the contract's statement of work.

INEEL Initiatives for Prolifera

- **Phosphate Development** ....
- **Biodecontamination for Cement** ....
- **Fission Studies** ....
- **Fuel Cell Development** ....
- **Titanium Welding** ....
- **Hydraulic Force Engine** ....
- **Chemical Weapons Detection System** ....
- **Anthrax Detection** ....
- **Concealed Weapons Detection Sensor Deve**
- **Medical Imaging** ....
- **PINS Detection System** ....

He works closely to incorporate the commercial drivers from the industrial partner and the research capabilities of Russian institutions. Rogers then reviews the research coming from the institutions and assesses the work performed. Once or twice a year, he travels to Russia to meet with the researchers and discuss progress. The several projects he oversees demonstrate the wide scope of the IPP program.

Vera Dmitrieva, executive director of the Russian Biotrade Center, converses with fellow scientists during a tour of INEEL microbiology laboratories.

Microbial Hunters

In one, a Russian Ecological Biotrade Center – the first of its kind in Russia – was created among four Russian institutes and a U.S. industrial partner, Diversa Corporation. Through the center, U.S. and Russian scientists work to discover novel organisms and bacteria from selected pristine and contaminated environments in Russia. Diversa searches the world over for unique enzymes that can be commercialized, and the center helps mine previously unexplored environments.

The two-year old program employs 57 scientists on 16 separate projects and is going quite well, according to Rogers. Lab directors from each of the four institutes meet quarterly – which is in itself unique in the Russian scientific world – to talk about issues and where the center is going. The center is actively marketing other commercial partners with the goal of being totally self-sustaining soon. This project is successful for several reasons one of which is that Rogers required Diversa representatives meet with the Russian researchers before making any commitments.

"Diversa saw that untapped potential, not only in the Russian biodiversity but also with the quality and integrity of the researchers," said Rogers. "On the flip side, this was the first time for some of these Russians to work in a commercial world, (and) see what businesses are looking for."

Bug Killers

It took Rogers three years to find a willing industrial partner for another one of his projects. Many U.S. companies are wary about working in Russia, regardless of the potential commercial profitability of a technology. Government instability, cultural misconceptions and perceived red tape can make businesses hesitant to get involved. Rogers overcame those obstacles and enlisted a U.S. company interested in a patented Russian technology for mosquito control.

For the most part, mosquitoes are merely an annoyance in the States, subject to local jokes regarding insect size and biting ability. But for much of the world, the prevalence of mosquitoes creates a vector for disease. An effective and inexpensive control could impact global disease abatement.

Using combined cultures of two Bacillus spores, the Russian bioinsecticide offers an environmentally friendly, yet long-term alternative to toxic chemical insecticides. Project researchers will work to develop efficient and cost-effective methods to mass-produce the spores.

Rogers informally refers to this project as "Super Thrust II." He is working hard to leverage the IPP project with a State Department program that would upgrade a former biological weapons facility to commercially produce the "biocide." The upgrade would permanently eradicate its previous use. Transforming a former threat into benevolent production. Positive science.

Rob Rogers
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This poster touts the Russian Ecological Biotrade Center, which was created among four Russian institutes and a U.S. industrial partner, Diversa Corporation.

...tion Prevention projects

...	Rob Rogers
...	Rob Rogers
...	Jerald Cole
...	Chester Motloch
...	Art Watkins
...	Manohar Sohal
...	Rob Rogers
...	Rob Rogers
...lopment	Dale Kotter
...	David Nigg
...	Gus Caffrey

PINS Supports Chemical Weapons Clean-up in Utah

The U.S. Army has used the portable isotopic neutron spectroscopy system since 1993 when the Army's Project Manager for Non-Stockpile Chemical Materiel employed PINS to identify the contents of World War I munitions discovered in Washington, D.C. Since that time, PM-NSCM continues to support further PINS research and development. This article reports on an unexpected application of the award-winning technology.

The U.S. Army Deseret Chemical Depot, near Tooele, Utah, is in the process of destroying its stockpile of chemical warfare agents, as required by the 1993 Chemical Weapons Convention. The incineration process used to destroy these agents is heavily regulated and monitored closely by the U.S. Army and state agencies. During a trial burn of the chemical agents, traces of mercury were detected, which – if continued – would be inconsistent with their air permits. Further investigation correlated the mercury contamination with the large ton containers used to store bulk sarin, a nerve agent.

The PINS technology was adapted to detect small quantities of mercury at the bottom of large nerve gas containers (top and right). The team includes from left to right (front row) Bob Gehrke (ret.), Gus Caffrey and Ann Egger; (back row) Steve Frickey, Ken Krebs, Larry Blackwood, Andy Edwards and Ed Seabury. Not pictured are John Zabriskie, John Baker and Cathy Riddle.

But which containers? Direct sampling is time-consuming, extremely costly, not simple, and possibly dangerous. Even in small amounts and diluted, sarin remains extremely hazardous. To meet the deadlines imposed by the Convention, Deseret Chemical Depot needed to continue destroying the contents of containers that contained no mercury.

Enter PINS. The Army had used the portable isotopic neutron spectroscopy system for years to identify the contents of suspect chemical munitions – without breaching the container. Could PINS, they wondered, identify trace amounts of mercury in these large tanks containing the sarin? They asked PINS developer Gus Caffrey to test the system.

"We had to make some changes in our process for several reasons," said Caffrey. "We were looking for small quantities in large containers. We didn't want to miss anything."

Knowing that mercury was 10 times more dense than the nerve agent, Caffrey had a hunch that the mercury, if present, would pool at the bottom of each ton container. INEEL mechanical engineer John Zabriskie designed a special version of the PINS stand, that allowed the instrument to look upward, inspecting the bottom of each container. To meet the Army's window for the measurements, mechanical design and fabrication of the stands took just one week. Jimmy Johnson, Dennis Mechling, and Woody Russell built the stands at the R&D Prototype Engineering Lab.

In the autumn of 2000, the PINS team tested 10 percent of the sarin-filled containers and reported their results. Independent tests confirmed their accuracy and the Army now had a safe method to identify the correct tanks for continued incineration. The Army asked Caffrey to complete assessment of the remaining ton container inventory during the following summer.

Surveying the remaining 90 percent could take a long time. The PINS team had to find methods to speed the process, yet maintain accuracy. During the initial test, they assayed each ton container for 2000 seconds. For this year's effort, if they detected mercury at 500 seconds, they would stop. If no mercury was evident at 500 seconds, they would continue to 1000 seconds.

To insure adequate sensitivity with the reduced assay times, PINS was tested against known quantities of mercury in an experiment conducted at the Test Reactor Area. An actual ton container was used and filled with water to simulate the nerve agent. Statistician Larry Blackwood tallied up the experimental results and calculated the minimum detectable mass of mercury as 2.1 grams.

"We found we could detect a couple of grams of mercury in almost a ton of nerve agent," said Caffrey. "Our three parts-per-million mercury detection level easily met the Army needs."

The supporting spreadsheets and graphical data fill 10 three-inch notebooks. The state is satisfied and Deseret Chemical Depot quickly began incineration of the sarin agent in the non-contaminated ton containers. The agent from the contaminated ton containers was chemically processed to remove the mercury, checked for residual contamination by X-ray fluoresence, and then incinerated. All of the sarin nerve agent at Deseret Chemical Depot has now been destroyed.

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Achievements, Accomplishments, Acknowledgements

Need to Know received a 2002 Apex Award for Publication Excellence. Nominations are selected "based on excellence in graphic design, editorial content and the success of the entry – in the opinion of the judges – in achieving overall communication effectiveness and excellence." This was the first year the National Security newsletter was submitted for consideration.

Mike Occhionero and Julio Rodriguez regularly travel to area schools to talk about robots and engineering. They encourage and inspire students to consider the opportunities in science and math. Recently, they ran a Packbot robot named Bunsen through its paces to the delight of second-graders at Templeview Elementary School. Students showed their gratitude with an outpouring of letters and drawings.

Roberta Jordan received a master's degree in chemistry from the University of Idaho. Jordan earned the degree while working full-time and continuing her outstanding support for the community. She had received the INEEL President's Special Achievement Award in 2000 for her community work.

Sherry Gallup was recognized as 2001-2002 Member of the Year for the Eagle Rock Chapter of the International Association of Administrative Professionals. Gallup has served as president of the Eagle Rock chapter in 2000-2001, secretary for the Idaho-Oregon-Utah Division in 2001-2002, and effective July 1, will serve as president-elect for the Division during 2002-2003. She has represented the chapter at international conferences.

The Director of Information and Special Technologies Programs for the U.S. Department of Energy's Office of Counterintelligence wrote to INEEL Counterintelligence Program Manager Jack Way, "Please pass along my appreciation and thanks to Bonnie (Hong) and Brett (Rasmussen). They have strapped on a very difficult project and are succeeding. The project is not only on track and under budget, but all the feedback I received has reinforced the fact that your staff has been professional, personable and accommodating at each site. It is always a pleasure to work with you and your folks at INEEL."

Dennis Bingham received a patent for "Apparatus for Pumping Liquids at or Below the Boiling Point."

John Grandy received a patent on "Methods of Chemically Converting First Materials to Second Materials Utilizing Hybrid-Plasma Systems."

Ben Perrenoud, Herschel Smartt, Eric Larsen, Rodney Bitsoi, Karen Miller and David Pace received a patent on "Apparatus for the Concurrent Inspection of Partially Completed Welds."

(Clockwise from right) Sherry Gallup was recognized as 2001-2002 Member of the Year for the Eagle Rock Chapter of the International Association of Administrative Professionals. Julio Rodriguez demonstrates a Packbot robot to children at Templeview Elementary School. INEEL's ***Need to Know*** *newsletter won a 2002 Apex Award for Publication Excellence.*

2002 APEX® AWARDS FOR PUBLICATION EXCELLENCE

Cyber Spies

Contributed by: Bonnie Hong

A spy's highest risk of detection often comes during the delivery of stolen information. Traditional techniques such as "brush passes," "car tosses" and "dead drops" are familiar concepts and easily spotted by intelligence professionals. Today, more sophisticated approaches are preferred.

Information, messages, and signals are now transmitted by way of the Internet, floppy disks, CDs, miniature cameras and other electronic media. These techniques have several advantages over the traditional, physical transfer methods. They are fast, much harder to detect or observe, and make it difficult to accurately identify participants. In some cases, information transfer is accomplished through computer worms and viruses with virtually no human participation.

Foreign intelligence services commonly exploit electronic resources to identify potential recruits for spying activities. They access the Internet for computerized credit checks and collect information on spending habits and debt loads; obtain medical records including information on substance abuse; and gather other personal information that can identify potential recruits. This identification process is faster and easier than the historical methods which were based on informants and personal familiarity.

To date, the three largest information security breaches are attributed to John Walker (1985), Aldrich Ames (1994), and Robert Hanssen (2001). Their techniques changed with the times.

According to retired KGB Maj. Gen. Oleg Kalugin, Naval spy John Walker would "drop these big brown bags filled with top secret, classified information, and it took some time [for] us to convince him that this was not right, that he should use miniature cameras and other gadgets."

Aldrich Ames, a former middle-ranking CIA officer, provided the KGB intelligence reports, arms control papers, and Department of Defense cables. During one assignment, Ames delivered a stack of documents estimated to be 15- to 20-feet high.

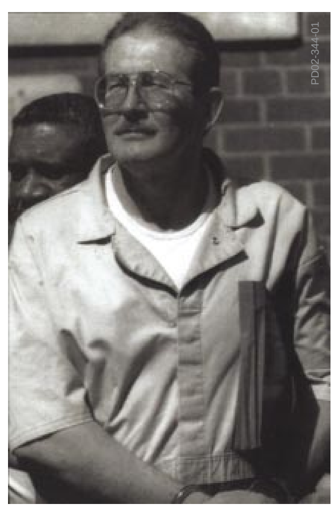
Ames also began passing computer disks to the Soviets that contained information from agency communications. His increased access to information, combined with the compactness of disks, greatly enhanced the volume of data he could carry out of agency facilities with significantly reduced risk of detection.

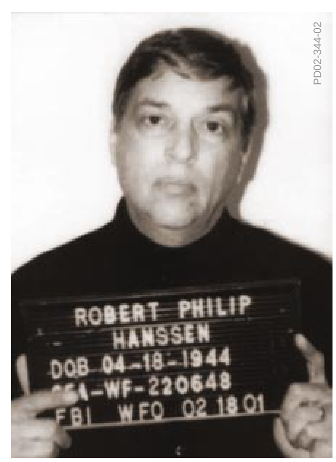
Robert Hanssen, a 25-year FBI veteran, used his computer expertise to hack into government files and databases, and obtain classified documents. Hanssen made extensive use of computer media, including encrypted floppy disks, removable storage devices and a Palm personal data assistant. He used a technique called 40-track mode – making a floppy disk seem to contain slightly less capacity than normal – to allow hidden text in what appears to be a blank disk. Reports indicate that he intentionally hacked into a superior's computer in 1992 to create an alibi if he was ever caught. At the time, Hanssen said he was trying to demonstrate the weaknesses of the system.

What can you do as an INEEL employee to protect sensitive information? The most effective way to protect information is to control access to it – the more difficult it is to get to, the less likely it is to be stolen. Use screen-saver locks on your computers and change computer passwords every six months and ensure passwords are DOE-compliant. Load the company virus scanner on your computer, and log off your computer when you leave for the day. Don't make it easy for someone to get your information.

Within the cyber realm, obtaining and passing information has become easier. The game is the same, but the tradecraft is changing.

If you have any questions, concerns, or information to report, contact the Counterintelligence Office or Security Office. For more information on espionage, visit the INEEL Counterintelligence internal web page.





Aldrich Ames and Robert Hanssen used increasingly sophisticated means to transfer stolen data. Hard to detect electronic transfers are now more common than physical drop points.

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