Institute for Soldier Nanotechnologies

Now in its fourth year, the Institute for Soldier Nanotechnologies (ISN) has gained appreciable momentum in its research program and is looking forward to plans for its five-year renewal proposal in March 2006.

Through basic research, and collaboration with industry and the Army in technology development, the ISN mission is to provide a dramatic increase in survivability to the individual soldier through nanoengineered materials and devices in a significantly lighter-weight uniform. This includes reducing the weight soldiers carry, improving blast and ballistic protection, creating new methods for detecting and detoxifying chemical and biological threats, and providing physiological monitoring and automated medical intervention. The ultimate goal is to create a 21st-century battlesuit that combines high-tech capabilities with light weight and comfort.

During the past year, ISN held its first ISN Day symposium, as well as two one-day thematic workshops and several technical seminars. The MIT Soldier Design Competition continued into its second year with the inclusion of cadets from the US Military Academy at West Point (USMA).

ISN's estimated five-year funding now stands at more than $95 million—cash and in-kind contributions—with the Army contributing approximately $47.5 million in basic research (category 6.1) funding and an estimated $12.5 million in applied research (category 6.2) funding (to industry partners and collaborating Army labs), MIT providing $13.9 million (not including the cost of the dedicated facility, which was estimated at $9.3 million), the founding industrial partners contributing $15.3 million, and new industry partners providing approximately $6.7 million. Two additional research contracts began during the period, one for approximately $400,000 from the Army Research Office and one for approximately $600,000 from the Defense Advanced Research Projects Agency (DARPA).

Research

ISN's interdisciplinary research agenda has evolved over the course of the year into a more focused program, reflecting the areas where ISN leadership and the Army see signature contributions emerging. Team-based innovation continues to be a hallmark of ISN's intellectual course, as new ideas and collaborations emerge.

ISN hosted a meeting of its Science Advisory Board in September 2004 as well as the first meeting of its Technical Assessment Board (TAB) in January 2005. The TAB meeting was preceded by a meeting of Army subject matter experts, who made recommendations to the TAB about ISN research directions. More than 35 basic and applied research projects are currently under way. ISN researchers published 35 technical papers during the year, with another 23 submitted and awaiting publication. Invention disclosures to the MIT Technology Licensing Office numbered 13, and eight patent applications were filed. To date, ISN has published 97 research papers and 33 technology disclosures.

Team-based innovation is a key part of ISN's approach to complex problems like protecting tomorrow's soldiers from chemical and biological weapons. Seven research teams address various aspects of the overall challenge; the following subsections discuss the research goals and accomplishments of these teams.

Team 1: Energy-absorbing Materials

Energy-absorbing material systems that will protect the future soldier against ballistic impact and blast waves are a critical piece of the overall ISN mission. Using new polymers as well as designs of nanocomposites and mesocomposites, Team 1 is working to design, synthesize, and fabricate materials that provide revolutionary properties to protect soldiers from blast waves and ballistic fragments and yet are still lightweight and flexible enough to maintain soldier mobility. Such materials must also be capable of integration with and protection of the other components in the future soldier's battlesuit, such as the sensors and biological protection capabilities that Teams 3 and 4 are developing.

Led by Professor Ned Thomas (Materials Science and Engineering), Team 1 faculty investigators are from the departments of Chemistry, Materials Science and Engineering, Mechanical Engineering, and Chemical Engineering. The following paragraphs highlight a few of their accomplishments over the past year.

Professors Ned Thomas and Mary Boyce (Mechanical Engineering), are developing novel microtruss materials for both ballistic and blast protection. Microtrusses are nanoscale versions of the more familiar truss structures typical of bridges and buildings (e.g., the Eiffel tower). Such structures are comprised of a low density set of beams and joints. The Thomas and Boyce team employs 2-D and 3-D interference lithography to design and create epoxy/air microtruss networks. There are many variables available to design new structures with new properties, i.e., the particular truss geometry, the choice of polymer photoresist, the crosslink density, the addition of nanoparticles to create nanocomposite microtrusses. Work to date has concentrated on a stiff epoxy and a soft rubbery material. Mechanical testing and macrotesting have shown exciting new mechanical responses, due to both the truss geometry and the nanoscale feature sizes of the structural members.

Professor Paula Hammond (Chemical Engineering) and Gareth McKinley (Mechanical Engineering) have explored families of polyurethane materials as potential ultratough, lightweight materials. Polyurethanes are multiblock copolymers with soft and hard segments that microphase separate into small nanoscale domains. Inspired by natural spider silk, which exhibits extraordinary mechanical toughness for its size and weight, Hammond and McKinley have synthesized polyurethanes with both semicrystalline soft segments and semicrystalline hard segments. A feature of this team's work is synchrotron X-ray scattering investigations at Brookhaven National Laboratory. Small angle and wide angle X-ray scattering illuminates how the primary microstructure of the soft and hard segment domains controls the resultant mechanical properties. Importantly, the X-ray measurements can track evolution of the material domains in the structures under strain.

Team 2: Mechanically Active Materials and Devices

Team 2, under the leadership of Professor Tim Swager (Chemistry), is developing nanomaterials capable of mechanical actuation and dynamic stiffness. Mechanical actuators embedded as part of a soldier's uniform could permit transformation from a flexible and pliant material to a nonpliant, armor-like material, thus absorbing the impact force of bullets and blast waves. Soft switchable clothing could also be transformed into a reconfigurable cast that stabilizes an injury such as a broken leg. Contracting materials could be made to apply direct pressure to a wound, function as a tourniquet, or even perform CPR when needed. Mechanical actuators might also be used as exomuscles to augment a soldier's physical strength or agility.

There are a number of methods for creating mechanically active materials and professors Paula Hammond and Richard Schrock (Chemistry), work on precisely controlled macromolecular architectures containing field-responsive liquid crystals. Professor Caroline Ross (Materials Science and Engineering) is focusing on chemically switchable magnetic particles. Professors Ned Thomas, Ian Hunter (Mechanical Engineering), and Tim Swager are working on nanostructured conducting polymers.

One particular advance comes from Professor Hunter's group, which has reported recoverable linear strains in excess of 14% at 2.5 MPa (20% max) for polypyrrole activated in the 1-butyl-3-methyl imidazolium tetrafluoroborate liquid salt electrolyte. This advance in conducting polymer actuator technology will impact many engineering fields, where a lightweight, large displacement actuator is needed. Professor Swager has also reported new conducting polymers with novel functionality and structure and, in one case, has discovered that interconnects in their electronic structures (previously thought to be undesirable) can in fact provide superior properties. These results pave the way for the design and creation of high-performance complex structures.

Team 3: Sensing and Counteraction

Team 3 is performing basic research that ultimately will lead to technologies for highly sensitive detection of chemical and biological substances, to be developed in collaboration with the Army and industrial partners. The goal of the team's basic scientific and engineering research is the enhancement of a soldier's awareness of various hazardous substances, including chemical/biological agents, poisons, and other environmental toxins, and protection from them. In collaboration with other ISN teams, members of Team 3 are also developing protective fiber and fabric coatings that will neutralize or significantly decrease bacterial contaminants and other hazardous materials. In addition, novel organic-inorganic hybrid nanocomposites, consisting of nanoparticles and formed using simple dip processing methods, will combine sensing and reactive components. Team 3 is also understanding the science that can provide ways to use infrared monitoring to detect the presence of chemical agents or other threats, based on hollow photonic band gap fibers or nanoparticle quantum dot systems. Team 3, led by Professor Hammond represents collaborations across several departments, including Physics, Chemistry, Chemical Engineering, Electrical Engineering and Computer Science, Materials Science and Engineering, and Mechanical Engineering, and the Biotechnology Process Engineering Center.

The year has led to several new developments in the lab, including the examples given below.

Professors Vladimir Bulovic (Electrical Engineering and Computer Science) and Tim Swager have developed a new concept in chemical sensing wherein sensitivity gains can be achieved by attenuated lasing. They demonstrated the concept in the detection of explosives; however it is more general and can be applied broadly. In this scheme, chemical interactions that influence the efficiency of the emission from molecules change the onset of lasing. Utilizing the lasing signal is found to be over 30 times more sensitive. Critical to this achievement was the development of a transducing polymer with high thin-film quantum yield, a high optical damage threshold in ambient atmosphere, and a record low lasing threshold.

New developments in the research laboratories of professors Angela Belcher (Materials Science and Engineering) and Paula Hammond have led to a novel means of assembling noninfectious virus particles at unusually high densities in flexible thin films. These new 2-D–ordered viral systems contain biological elements that can be genetically engineered to act as sensing elements for a wide variety of chemical or biological systems; a paper on this topic has been submitted to *Nature Materials*. New application areas for this work include dense, flexible battery electrodes using viral-templated cobalt arrays formed with these thin films. Finally, these research teams have published papers describing the development of new nonlithographic nanopatterning techniques for complex polymer nanostructures that can be applied to the viral or other templated array systems and the assembly and patterning of fluorescent quantum dots encapsulated within polyelectrolyte layers.

A project that combined the efforts of professors Hammond and Jackie Ying (Chemical Engineering) and Dr. Heidi Gibson, of the US Army Natick Soldier Center, has been examining the formation of ultrathin polymer nanocomposite films that may act as decontaminants or adsorptive protective coatings on fibers to address exposure to chemical agents. In work with the Natick labs, testing of the ultrathin, low-cost, functional membranes, and the means of controlling the reactivity to various agents, have been carried out. New efforts involve the incorporation of these multilayers on nonwoven fabrics in a newly formed collaboration with the research group of Professor Greg Rutledge (Chemical Engineering).

A collaboration between professors John Joannopoulos (Physics) and Yoel Fink (Materials Science and Engineering) recently reported the design, fabrication, and characterization of fibers made of conducting, semiconducting, and insulating materials in intimate contact and in a variety of geometries. In a paper in *Nature*, they demonstrated that this approach can be used to construct a tunable fiber photodetector comprising an amorphous semiconductor core contacted by metallic microwires, and surrounded by a cylindrical-shell resonant optical cavity. Such a fiber is sensitive to illumination along its entire length (tens of meters), thus forming a one-dimensional photodetecting element. A grid of such fibers was constructed that can identify the location of a laser illumination point.

Professor Ned Thomas and his research group recently demonstrated an efficient and versatile method for selectively generating 1-D and 2-D periodic polymer structures in the submicron to tens of microns range by the directed drying of 1-D photopatterned polymer solutions. The development of photonic structures could lead to new advancements in laser and optical systems for a range of applications.

Team 4: Biomaterials and Nanodevices for Soldier Medical Technology

Team 4, led by Professor Neville Hogan (Mechanical Engineering), focuses on using nanotechnology to improve the detection and treatment of life-threatening injuries, such as hemorrhage, fracture, or infection. With new approaches to soldier triage and with automatic first aid, Team 4's goal is to begin recovery while the patient is still on the battlefield.

Working in collaboration with other ISN teams, Team 4 is developing ways to monitor patient physiology as well as novel materials for wound healing. Battlesuit sensors could relay details about a soldier's location and physical condition to headquarters. New nanosurfaces could detect biological and chemical agents and then protect the future soldier from those threats. Biomedical monitoring might use ultrasound to detect a hemorrhage in the injured soldier and then cauterize vessels to staunch the bleeding. Soldiers' uniforms could become exomuscular devices for medical applications, such as tourniquets and splints for broken bones. And new nanomaterials could instantaneously change their properties by electrical switching, thereby controlling the delivery and release of life-saving medications.

In addition, ISN draws on the interests and work of its industrial partners. Raytheon and DuPont provide electronics and materials platforms to enable the transition from the lab to the future Army application. ISN's collaboration with the Center for the Integration of Medicine and Innovative Technology (CIMIT) is essential as physicians and other scientists from the Massachusetts General Hospital, the Brigham and Women's Hospital, and other Boston-area medical centers develop medical applications for ISN's new devices and materials. Civilian applications of exomuscular devices, for example, could include smart back boards, neck braces, splints, and casts as well as active fabric tourniquets. Nanoscopic approaches to medical treatments will benefit civilians as well as enhance survivability of the future soldier.

Team 4 leadership is planning a workshop on battlesuit medicine, as well as new research to develop the means to prevent the onset of shock caused by blood loss. This would improve survivability in bleeding trauma wounds. Blood loss from extremity wounds is a major cause of preventable battlefield deaths.

Team 5: Processing and Characterization—The Nanofoundries

The mission of Team 5 is to develop the processes and devices required to fabricate and deploy nano-enabled materials that enhance the survivability of the soldier or first responder. Team 5 researchers, under the leadership of professors Rutledge and McKinley, use a multidisciplinary approach to developing the scientific and engineering understanding needed to process nanoscale building blocks into useful macroscale materials and devices. These include: multifunctional fibers and films; multilayered materials; self-assembling materials; microfluidic devices; and field-responsive materials and devices. The goals of Team 5 involve (1) development of novel methods of fabrication to ensure and enhance the performance of new nanomaterials developed by ISN and its partners, (2) fabrication and integration of hierarchically structured materials to achieve multiple and synergistic property combinations within a lightweight, efficient battlesuit, and (3) prototyping and facilitating the transfer of ISN technology to industrial partners.

Over the past year, Team 5 researchers have demonstrated the capability to produce superhydrophobic fabrics through a combination of block copolymer self-assembly and electrospun nanofiber formation. An initiated chemical vapor deposition process developed by this team was shown to impart exceptional surface properties to both electrospun and conventional fabrics; such properties include antimicrobial activity, water and oil repellency, electrical conductivity, and waveguiding. Composite fibers reinforced with single- and multiwalled carbon nanotubes dispersed in a polycarbonate matrix were fabricated and shown to exhibit improved mechanical properties. Electrospun fibers reinforced with exfoliated clay particles were fabricated and shown to exhibit improved flame retardant and heat resistant behavior. Self-actuated folding of 3-D origami structures using bilayers of chromium on silicon nitride was demonstrated, and a working electrochemical storage device was fabricated by this technique.

Team 6: Modeling and Simulation of Materials and Processes

Led by Professor Gerbrand Ceder (Materials Science and Engineering), Team 6 has as its primary goals the modeling, simulation, and prediction of nanoscale phenomena and macroscopic properties; the prediction and optimization of materials response; and the design of novel nanoassemblies to protect the soldier from a variety of adverse loading conditions. Some of Team 6's objectives include developing a fundamental understanding of the structure, property, and processing relationships in nanosystems; developing numerical simulation capability to design and engineer new nanomaterial systems; and developing 3-D constitutive models of soft tissue response in order to design protective materials to protect the human body from trauma. Some particular accomplishments are highlighted in the following paragraphs.

Professors Ceder and Nicola Marzari (Materials Science and Engineering) have developed large-scale ab initio simulation methods to understand the mechanism by which nanoparticles derive their unusual behavior. In particular, Professor Marzari clarified the mechanism for actuation of electroactive thiophene-based polymers, and Professor Ceder's group designed a new material that has the hardness of a ceramic but may be able to absorb large amounts of energy through an unusual electronic mechanism.

Professor Martin Bazant (Mathematics), developed the mathematical approach to study electrochemical systems at very small length scales and large currents. His team is currently experimentally testing a novel method to pump fluids in nanochannels, based on his theoretical work on induced-charge electro-osmosis.

Professors Simona Socrate (Mechanical Engineering) and Raul Radovitzky (Aeronautics and Astronautics) are working on computational models to simulate behind-armor deformation effects on the human body. Professor Socrate has developed a constitutive model for the mechanical behavior of woven fabrics, of importance for the rational design of clothing for ballistic protection.

Team 7: Systems Integration and Technology Transitioning

The overall objective of Team 7 is to illuminate and apply systems integration requirements for using nanotechnologies to protect soldiers. To provide the individual soldier with unprecedented survivability capabilities, ISN envisions a dynamic, multifunctional battlesuit that synergistically integrates diverse nano and other components within a lightweight, comfortable garment. This suit is expected to be a complex system of systems. Therefore, to be effective, the suit components must perform in harmony with one another, *and* the suit must interact synchronously with at least two other complex systems, the soldier's body, and the soldier's operating environment. Team 7 provides understanding needed to assure these systems work together and not at cross purposes.

Under the leadership of Professor Ned Thomas and Dr. Bill Peters, ISN executive director, Team 7's specific objectives are to: (1) develop scientific and engineering understanding to integrate different nanomaterials and nanodevices to provide multiple survivability capabilities in macroscale platforms; (2) derive and improve this understanding through the design, construction, and experimental testing of simple prototypes that contain at least two nanoengineered building blocks; (3) draw inspiration for battlesuit design and operation from other complex systems for life protection, e.g. the human body, extra-vehicle space suits, and desert mammals; (4) formulate design tools and open systems architectures to integrate multiple, nano-enabled survivability capabilities in a battlesuit; and (5) use battlesuit systems architectures to illuminate needs in basic research, applied research, and transitioning.

During the past year, a key focus of their work has been basic research connected to ISN projects on lightweight, high-strength, energy-absorbing materials and on conducting polymer actuators. Their goal has been to develop understanding of nano systems integration by designing, building, and analyzing simple prototype systems. They have studied cooling of surfaces using nanoengineered materials, and inducing color changes by deforming block copolymer gels with polymer actuators. They also formulated a concept for a dynamic systems integration map that, if successful, would assist in the design of systems architectures to exploit nano-scale to macro-scale technologies for soldier survivability.

Team 7 will help define and evaluate battlesuit architectures to exploit the unique capabilities of nanotechnology to provide the individual soldier with multiple survivability capabilities while meeting weight, power, maneuverability, and other performance requirements. These architectures will in turn elucidate design tradeoffs, systems weaknesses and synergisms, basic and applied research needs, and transitioning opportunities.

Industrial Collaboration

Industry partners are critical to the ISN mission because of the need to turn laboratory innovations into real products and scale them up for affordable manufacture at needed throughputs. The ISN Industry Consortium, launched in 2002 with founding partners Raytheon, DuPont, and Partners Healthcare, did not add any new partners during the year. Although ISN did not hold a third Industry Day event in the spring of 2005, selected nonmember companies with an interest in partnership were invited to attend ISN Day in May.

ISN continues to work on expanding collaborative research relationships with its current partners. In January 2005, several faculty members visited Dow Corning in Midland, MI, to explore research areas of mutual interest and possible technology transitioning opportunities. ISN also hosted two seminars in 2005 given by representatives of partner companies: Dr. Greg Blackman from DuPont and Mr. Jon Hannington from Dow Corning.

It is the intent of the Army to make available for competition on an annual basis funding to assist ISN industry partners in performing applied research and development to transition promising ISN basic research results into practical products for the soldier. In 2005, a total of four transitioning proposals from among eight submitted were selected by the Army for funding after review by Army subject matter experts.

Outreach

ISN continued to maintain a busy visit schedule during the FY2005 year, hosting more than 430 visitors, ranging from Army, Marine Corps, and Navy personnel to representatives of industry, international scientists, West Point cadets, prospective MIT students, families of MIT undergraduates, schoolchildren, and members of the general public. Prominent visitors included Gen. Benjamin Griffin, commanding general, US Army Material Command; Dr. Thomas Killion, chief scientist, US Army; Dr. Tony Tether, director, Defense Advanced Research Projects Agency; Sgt. Maj. Kenneth Preston; Lt. Gen. Joseph Yakovac, military deputy/director, Army Acquisition Corps; Lt. Gen. Steven Boutelle, chief information officer, US Army; Mr. Walter Hollis, deputy undersecretary of the army for operations research; Maj.Gen. Roger Nadeau, commanding general, US Army Research, Development and Engineering Command; Maj. Gen. John Castellaw (US Marine Corps), chief of staff, US Central Command; Brig. Gen. James Moran, program executive officer soldier; Mr. Ranch Kimball, Massachusetts secretary of economic development; and Mr. Lester McFawn, executive director of the Air Force Research Laboratory. ISN was also honored to host a visit by Dr. Susan Hockfield, MIT president, in June 2005.

Members of the ISN community visited several Army and other Department of Defense (DOD) installations during the year, including the National Training Center at Fort Irwin, CA; the Marine Corps Systems Command and Warfighting Laboratory in Quantico, VA; the US Military Academy at West Point, NY; and the Army War College in Carlisle, PA. Staff and researchers participated in a booth at the 24th Army Science Conference in Orlando, FL, in December 2004. ISN researchers also presented technical papers and posters at several science conferences throughout the year. In addition, Professor Thomas attended four meetings of the National Academies' Board on Army Science and Technology.

ISN held a major one-day research update symposium on May 19, 2005, entitled ISN Day. More than 100 representatives from the Army, other DOD/government organizations, and ISN's partner companies attended the event at the Cambridge Marriott, which featured several presentations from faculty on leading-edge research as well as a student/postdoc poster session. It is expected that ISN Day will become a regular event, occurring every 12–18 months. ISN also held two thematic workshops in the first half of 2005. A research workshop on Computational Modeling of Textile-based Armor Systems was organized by Professor Socrate, and a workshop to foster collaboration between ISN and the Singapore defense research community was organized by Professor Swager.

The Army Nanotechnology Seminars continued in FY2005 with eight speakers, including Dr. Adam Rawlett and Dr. Rick Beyer from the Army Research Laboratory, Professor Mark Dadmun from the University of Tennessee, Dr. Greg Blackman from DuPont, Professor Alan Windle from the University of Cambridge, Professor Juan dePablo from the University of Wisconsin-Madison, Mr. Jon Hannington from Dow Corning, and Professor Peter Weber from Brown University.

ISN participated in several MIT outreach initiatives, including Family Weekend, Campus Preview Weekend, Research Science Institute, MIT Enterprise Forum, ILP's Research and Development Conference, and the MIT Museum's Family Adventures in Science and Technology program.

Soldier Design Competition

The MIT Soldier Design Competition continued into its second year, building on the momentum of its successful first year. The objective of the competition is to provide an engineering design experience for undergraduates that will address real problems faced by modern soldiers and first responders. USMA cadets joined the competition during its second year, participating as part of their capstone engineering design course and working on the same challenges as the MIT teams. Second-year challenges included a powered rope ascender, body armor cooling system, and battery scavenger and recharge system, among others. Participants could also propose their own challenge and responding invention in an open design category.

Approximately 45 teams from USMA and MIT began the competition in September 2004, and 15 teams participated in the final judging on March 1, 2005. Six teams took away industrially funded cash prizes totaling $16,000:

Raytheon Award of $5,000

Team:	Supercharged
Team members:	Nicholas Berry, Glen Dudevoir, George Nowak, Jeremy Spruce, Walter Velasquez (USMA)
Invention:	Battery scavenger and recharge system

Boeing Award of $3,000
Team: Ancile
Team members: Jamie Dayton, Jeffrey Hermanson, Gregory Isham, Brian Lebiednik (USMA)
Invention: Soldier tracking and warning system

SAIC Award of $3,000
Team: ATLAS
Team members: Nate Ball, Tim Fofonoff, Bryan Schmid, Dan Walker (MIT)
Invention: Powered rope ascender

Charles River Award of $2,000
Team: Joe Proof
Team members: Owen Fogarty, Erich Jordan, John McCaskey, Venkat Motupalli, Jamie Pittman (USMA)
Invention: Hands-free casualty carriage system

Hudson River Award of $2,000
Team: Grapefruit
Team members: John McBean, Kailas Narendran, Rachel Niehuus, Billy Waldman (MIT)
Invention: Battery scavenger and recharge system

Director's Award of $1,000:
Team: Cool Warrior
Team members: Ethan Crumlin, Francisco Cruz, Forrest Liau, Michael Motion (MIT)
Invention: Cooling system for interceptor body armor

Competition participants own the intellectual property rights to their inventions and are encouraged to pursue patents and commercialization. To that end, several of the second-year teams are taking their inventions forward. Most notably, the members of Supercharged and Grapefruit (now Xitome) are working with the Army to supply several hundred of their battery scavenger and recharge units for testing by troops in the field this fall. Team ATLAS has formed a company and is working on the next-generation design of their powered rope ascender.

ISN plans to continue the Soldier Design Competition on an annual basis, with the 2005–2006 competition slated to kick off on September 15, 2005.

Facilities

ISN facilities were designed specifically to foster flexibility—in the form of new or modified equipment and stimulation of interdisciplinary research—and ISN continued to make use of these capabilities. For example, a thermal gravimetric analysis instrument was moved from Professor Swager's laboratory in Building 18 to ISN, where it was coupled with a mass spectrometer for molecular weight/compositional analysis of material decomposition products in air or nitrogen as the temperature is raised to 700 °C. Also, a second atomic force microscope was added and a roll-to-roll chemical vapor deposition unit became operational. Members of the research staff have modified several pieces of equipment to expand capabilities, including the split Hopkinson bar and the laser lab systems.

ISN continues its innovative Equipment Steward Program, designed to assign equipment users part of the responsibility of maintaining the equipment and teaching others how to use it. Approximate 30 stewards, mostly graduate students, are currently assigned to 35 pieces of equipment which are used by more than 450 people.

Appointments and Visitors

During the past year two staff members departed ISN:

- Dr. Jeff Bauer, research engineer, went to work at the Air Force Research Laboratory, Non-metallic Materials Division.
- Ms. Amy Holden, assistant financial officer, went to work in MIT's Office of Sponsored Programs.

Three new headquarters staff members were appointed:

- Mr. Kurt Keville, Soldier Design Competition coordinator and research specialist, October 2004.
- Mr. Abeer Chaudhuri, chemical laboratory technician, January 2005.
- Ms. Maureen Caulfield, fiscal assistant, March 2005.
  ISN appointed a new associate director on July 1, 2005. Professor Karen Gleason (Chemical Engineering), succeeded Professor Swager, who resigned his ISN directorship to become head of the Department of Chemistry. Professor Swager remains an active ISN faculty member as well as leader of ISN Team 2.
  Ms. Joanne Maxwell, formerly executive administrative assistant, was promoted to assistant director for facilities and administrative operations in April 2005.
  Dr. Alex Hsieh and Dr. Tommy Wong, both from the Army Research Laboratory, continued working full-time at ISN as visiting scientists. Professor Vladimir Tsukruk, of Iowa State University, and Professor Shlomo Margel, of Bar-Ilan University in Israel, joined ISN for sabbatical research. Upon return from a tour in Iraq, Maj. Sangeeta Kaushik, of the U.S. Army Research Institute of Environmental Medicine at the Natick Soldier Systems Center, joined ISN for several months as medical liaison officer for the Army Medical Research and Materiel Command.

In addition, several research scientists from ISN's industrial partners now work in ISN's laboratories either part time or full time:

- Dr. Randal Hill, Dow Corning
- Dr. Joongho Moon, Nomadics
- Professor Sonya Shortkroff, Harvard Medical School/CIMIT
- Dr. Kateri Paul, Nomadics

In June 2005, ISN's uniformed army liaison officer, Lt. Col. Charles Dean, stepped down from his post at ISN, reflecting his July 2005 retirement from the army. Lt. Col. William Garland from the Natick Soldier Systems Center took over the position, but due to overseas deployment, will not be working on-site at ISN until November 2005. Col. Stephen Holt, also from the Natick Soldier Systems Center, will fill in as liaison officer from June to November 2005.

Future Plans

In spring 2006, ISN will submit its five-year renewal proposal to the army, documenting its successes to date and outlining plans for years five through 10. ISN's mission remains extremely relevant to current national priorities, and it is expected that key research directions will continue and new research themes will be added.

Edwin L. Thomas
Director
Morris Cohen Professor of Materials Science and Engineering

More information about the Institute for Soldier Nanotechnologies can be found online at http://web.mit.edu/isn/.