Institute for Soldier Nanotechnologies

In March 2002 after a competitive solicitation, the US Army announced its selection of MIT to host the Institute for Soldier Nanotechnologies (ISN) as a University Affiliated Research Center (UARC). By definition, UARC's maintain a strategic relationship with the Department of Defense (DOD) and provide or maintain DOD-essential engineering, research, and/or development core capabilities. During the past year, renewal of ISN was approved by the Army. ISN-2, funded by a contract from the Army Research Office will officially begin in July, 2007. The ISN mission is to dramatically advance soldier survivability through basic research and transitioning (technology maturation). ISN is a team comprised of members of academia, the Army, and industry collaborating in basic research to create new materials, devices, processes, and systems, and in applied research to transition promising results toward practical capabilities for the soldier. MIT faculty, students, postdocs, and visiting scientists from the Army and industry conduct basic research to advance the frontiers of nanotechnology. Army members of Team ISN give guidance on soldier survivability needs and the soldier-relevancy of proposed ISN research. Army and industry personnel provide expertise on how to convert promising outcomes of fundamental research into practical products that work in harmony with other soldier technologies, and which can be manufactured affordably in needed quantities. ISN innovations also benefit the Joint Team, i.e., other war fighters and first responders. Thus Team ISN is part of the broader Army Science and Technology community that provides novel soldier survivability technologies for current missions and creates new generations of technologies to protect the soldier of the future. As a UARC, ISN allows the Army to concentrate needed funding levels and engage a large, multidisciplinary team to meet the diverse challenges in developing unprecedented survivability technologies for the soldier. Army basic research funding for ISN totals approximately $50 million over five years. This funding is leveraged by appreciable coinvestment from MIT and ISN industrial partners.

The Challenge

Today's soldier may carry from 60 to over 140 pounds of clothing and related kit and equipment while facing a broad array of lethal military threats such as bullets, blast waves, and shrapnel from improvised explosive devices (IEDs), chemical and biological weapons, and other hazardous materials. Moreover, our soldiers must function in climates, terrain, and operating environments that present significant risk of personal injury or medical problems. Team ISN's challenge is to discover and transition technologies that furnish the soldier with durable, comfortable, lightweight battle dress uniforms that scaffold diverse survivability capabilities. By grounding its research portfolio in nanotechnology, ISN is harnessing innovative power well matched to this challenge. Operationally, nanotechnology can be defined as understanding and harnessing the size-dependence of physical and chemical properties at "tiny" length scales. Tiny means from less than one thousand nanometers (nm) down to a few nm. These sizes are truly minute—the diameter of a single human hair is roughly 80,000 nm by comparison. This size-related behavior opens up potentially paradigm-shifting opportunities to create materials and devices with unique electrical, optical, magnetic, thermal, and chemical properties for soldier survivability. Nanoscale materials and

devices, either directly, or as components of larger products (all the way up to several meters in length) have the potential to incorporate multiple capabilities in tiny, lightweight building blocks. Building on its nanotechnology foundations, Team ISN research also reaches into these larger dimensions that are essential to making soldier protection capabilities work at practical scale.

Research

ISN engages approximately 40 MIT faculty members from 10 academic departments in over 30 basic research projects, training approximately 80 graduate students and 20 postdoctoral associates each year. ISN's basic research portfolio features five Strategic Research Areas (SRAs) focused on soldier survivability:

- SRA-1: Light Weight, Multifunctional, Nanostructured Fibers and Materials focuses on creating survivability capabilities (e.g., sensing, imaging, decontamination, and communications) using fibers, fabrics, particles, coatings, membranes and other "building block" materials.
- SRA-2: Battle Suit Medicine emphasizes improved autonomous medical and combat casualty care through materials and devices for physiological monitoring and controlled delivery of medicines.
- SRA-3: Blast and Ballistic Protection focuses on understanding how blast waves and bullets interact with and damage human tissues, and on creating a new generation of lighter weight yet stronger polymeric, metallic, ceramic, and hybrid materials to protect the soldier from blast and ballistic threats.
- SRA-4: Chem/Bio Materials Science—Detection and Protection provides new foundational understandings to enable sensing of harmful substances in the soldier's environment as well as materials and coatings to protect the soldier from toxins.
- SRA-5: Nanosystems Integration research is creating and knitting together nanoscale and nano-enabled materials and devices to provide capability-enhancing systems for communications and other applications.

Collaborations

Devising unprecedented soldier protection and survivability technologies compatible with the diverse missions and challenging operating requirements of today and tomorrow is a formidable task. Viable solutions demand the best expertise of the Army, academia, and industry. Team ISN includes researchers and managers from the Army Science and Technology community, industrial companies, and MIT. During the past year ISN developed approximately 20 new research collaborations with Army scientists and engineers including colleagues at the Army Research Lab (at Adelphi, MD and Aberdeen Proving Ground, MD), the Natick Soldier Research, Development and Engineering Center, the Night Vision Electronic Sensors Directorate, and the Picatinny Arsenal. Current ISN industrial partners are Battelle, the Center for the Integration of Medicine and Innovative Technology, Dow Corning, DuPont, Foster-Miller, W.L. Gore, Honeywell, ICX/Nomadics, Japan Electron Optics Ltd., Mine Safety Appliances, Nano-C, Raytheon, Triton Systems, Inc., and Zyvex. Battelle, Foster-Miller and Nano-C

became members during the past year. ISN also conducts regular seminars that in the past year were expanded to allow colleagues at Army labs and ISN industry partners to participate via a teleconferencing system.

Soldier Design Competition

During the past year, the MIT Soldier Design Competition (SDC) completed another highly successful year. Twenty-three teams began the competition, with 12 proceeding all the way to the finals in April of 2007, where six teams received industrially-funded cash awards including funding for a tracking system, a virtual mission planner, and a thermal insulation material. The SDC was established in 2003 to engage MIT undergraduate students in the INS, and in 2004 was expanded to include cadets from the US Military Academy. Drawing on the academic, Army, and industry communities that make up Team ISN, the SDC provides students with hands-on experience in the design and prototyping of technology solutions to real world problems faced by the modern soldier and first responder. Teams compete for prize money donated by industrial sponsors— Boeing, Foster-Miller, General Dynamics, L3 Communications, Lockheed Martin, Raytheon, and SAIC. Winning prototypes are determined by a panel of leaders from the Army, the Marine Corps, industry, and MIT. The success of the SDC is seen in the educational experience it has provided to students and in the numerous inventions of SDC teams. To date, the SDC has engaged over 125 students from the two campuses and has spawned 11 startup companies. The SDC provides a unique opportunity for students to apply their knowledge and creativity to make a difference for today's soldier. Teams compete to solve (nonclassified) practical problems identified by representatives of the Science and Technology, Acquisition, and Operations communities of the Army and Marine Corps. SDC participants meet active duty soldiers and marines and develop perspective on how modern technology can help the US military as well as fire fighters, law enforcement officers, and other emergency response personnel carry out their missions more effectively and safely. Army and Marine Corps mentors provide SDC team members with advice on the military relevancy and technical viability of proposed technology solutions. Finalists are judged according to the technical design practicality, innovativeness, likely military benefit, and logistical supportability of their prototypes.

Appointments and Departures

During the past year, one existing member of the ISN staff attained a new position, two new members joined the ISN team, and two ISN staff members departed from MIT:

- Dr. Catherine Byrne resigned her position as laboratory manager of ISN in November 2006 to pursue other professional objectives.
- Mr. Marco Carega, with ISN since July 2005, was named assistant for Headquarters Operations.
- Dr. Jeongsoo Choi joined ISN in September 2006 as a research engineer, but, owing to family matters, resigned his position in April 2007.
- Ms. Marlisha McDaniels joined ISN as executive administrative assistant in January 2007.
- Ms. Amy Tatem-Bannister was hired as laboratory manager of ISN in March 2007.

Future Plans

In the nearer term (two to five years) ISN will continue to work to create and transition novel materials, devices, and systems to provide the soldier with unprecedented survivability capabilities. Examples are: "designer" polymer molecules for sensing hazardous substances; multifunctional opto-electronic fiber devices for communications and sensing; ultra-thin coatings that impart diverse threat detection and protective capabilities to surfaces ranging from micro-electronic devices to fabrics made of tiny threads less than a ten millionth of a meter in diameter; and wireless transmission of electricity over room-size distances. This technology moves electric power by "handshake" interactions between the magnetic fields of symbiotic transmitters and receivers. The resulting devices have the potential to safely transmit electrical energy through open spaces and solid barriers without wires and free of high-energy-density electromagnetic radiation (EMR) that can harm humans or damage electronics. For the longer term, ISN's vision is to help the Army create a multifunctional, high-tech protective suit for the soldier that combines light weight and comfort with an array of built-in capabilities that defend the soldier from military threats and environmental hazards, provides immediate medical treatment if the soldier sustains an injury, and equips the soldier with advanced communications. Additional academic expertise will strengthen Team ISN in 2008 under a new program to engage faculty and students from Historically Black Colleges and Universities and minority institutions in research in support of ISN's mission.

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