Institute for Soldier Nanotechnologies

Founded in 2002, the Institute for Soldier Nanotechnologies (ISN) is a US Army University-Affiliated Research Center (UARC). The ISN was designed as a three-member team to leverage the unique capabilities of the US Army, industry, and the Massachusetts Institute of Technology. The ISN mission is to help the army and other US military services enable innovative capabilities for soldiers and other warfighters, their platforms, and their systems through fundamental research on nanotechnology and by transitioning promising outcomes of that research in partnership with the army, other US military services, industry, and increasingly with MIT Lincoln Laboratory. This mission includes not only decreasing the weight that soldiers and other warfighters carry but also improving blast and ballistic protection, creating new methods of detecting and detoxifying chemical and biological threats, providing physiological monitoring and medical treatment, and otherwise dramatically enhancing soldiers' capabilities.

Funding for ISN basic research was more than $150 million over its first 15 years, with the majority of these funds having been dispensed through a series of five-year contracts—ISN-1, ISN-2, and ISN-3—that were administered by the US Army Research Laboratory-Army Research Office (ARL-ARO). Nearly $20 million in additional funds were provided by the army to facilitate the transitioning of promising outcomes of ISN research to the next stages of development, with the bulk of these funds distributed to ISN partner companies and army science and technology (S & T) installations. There was also co-investment by industry partners and MIT in ISN basic research.

Following extensive reviews leading to approval by the army in 2017, ISN-4 began January 2018. Unlike with previous renewals, when a single new contract was issued, ISN-4 has two core funding instruments. The indefinite delivery/indefinite quantity procurement contract for ISN-3, which was extended through 2022. This contract continues army funding of the ISN UARC, including support for the ISN headquarters, management and outreach, and research enrichment, including laboratory facilities at 500 Technology Square (Building NE47). As a UARC the ISN is able to accept external funding from the army and the broader US Department of Defense (DOD) for additional projects beyond the core ISN-4 portfolio. Additionally, there is a separate cooperative agreement (CA), new with ISN-4, that was established to fund the research projects that make up the core ISN-4 research portfolio. The CA is structured to simplify army administrative procedures, enabling army scientists to more easily visit MIT for collaborative work with ISN researchers. Due to a cascading series of funding cuts not tied to performance that began during ISN-3, the total amount of army funding from ARL-ARO for ISN-4 core work is projected to be approximately $23.89 million over the five years from 2018 to 2022. Projected total core army funding for year-4 of ISN-4 is now estimated at $4.3 million, down from a nominal average of $10 million per year during ISN-1 (2002–2007).

The ISN continues strong efforts to expand and diversify its sources of outside funding to strengthen its research portfolio and augment its contributions to S & T for soldiers and other warfighters. Examples of these sources include Military Interdepartmental Purchase Requests (MIPRs) from laboratories within the US Army Combat Capabilities Development Command (CCDC) such as the CCDC ARL and the CCDC Soldier Center.

Moreover, with strong support from the MIT Vice President for Research and MIT Lincoln Laboratory leadership, the ISN and Lincoln Laboratory have been developing new collaborative research projects that engage MIT faculty, including faculty previously not affiliated with the ISN and Lincoln Laboratory professional staff members. These combined efforts could increase total ISN research funding to $7 million or more for FY2021.

Twenty-eight faculty members and research scientists representing a dozen MIT academic departments, labs, and centers, as well as an average of nearly 75 graduate students and postdoctoral associates, participate in ISN research each year. ISN research typically results in close to 100 refereed publications annually, with a large portion of those in distinguished scientific journals, such as *Science*, *Nature*, *Advanced Materials*, *Physical Review Letters*, and the *Proceedings of the National Academy of Sciences*. Additionally, under normal circumstances hundreds of people visit the ISN each year for tours and briefings. Prior to the scale back of MIT campus operations due to COVID-19, the ISN hosted visits by the DARPA Service Chief Fellows, Army Futures Command Chief Technology Officer and former astronaut Ronald Sega, and a delegation of senior professional staff members from the House and Senate Armed Services Committees.

Headquarters Team

- Professor John D. Joannopoulos, Director, Francis Wright Davis Professor of Physics, Applied Physical Sciences, National Academy of Sciences of the United States of America
- Professor Raúl A. Radovitzky, Associate Director, Raymond L. Bisplinghoff Professor of Aeronautics and Astronautics
- William A. Peters, Executive Director
- Franklin E. W. Hadley, Outreach and Communications Director
- Joshua Freedman, Assistant Director for Finance and Administration
- Ivan Celanovic, Principal Research Scientist
- Steve Kooi, Principal Research Scientist
- Amy Tatem-Bannister, Laboratory and Facilities Manager, Environmental Health and Safety (EHS) Coordinator
- Nicole Bohn, Surface and Electron Microscopy Instrumentation Specialist
- Kurt Keville, Research Specialist, Soldier Design Competition Coordinator
- Donna Johnson, Research Support Associate, Environmental Health and Safety Representative
- Maureen Caulfield, Finance Assistant
- Marlisha McDaniels, Executive Administrative Assistant
- John R. McConville, Technology Transfer Officer, Army Liaison Officer, Army Research Office, US Army Combat Capabilities Development Command Army Research Laboratory (Department of the Army civilian stationed at the ISN)

Beginning in fall 2018, an extensive search was performed for the successor of longtime ISN team member William DiNatale, who retired. In September 2019, Nicole Bohn joined the ISN as an electron and surface microscopy instrumentation specialist, tasked with both overseeing the ISN's suite of microscopy equipment and teaching MIT students working at the ISN the fundamentals of their use.

Research Portfolio

The ISN's signature interdisciplinary research agenda evolved over the course of its first 15 years into a focused program reflecting the areas where ISN and the army see the potential for especially strong soldier impacts. For ISN-4, this structure was further updated and redefined to better align with, and more efficiently respond to, guidance from the army while working within the constraints of army budget reductions. Team-based innovation is a hallmark of ISN's intellectual course, with new ideas emerging frequently and collaborations with army researchers remaining a high priority. The ISN research portfolio is currently divided into three strategic research areas, which are further divided into 16 core 6.1 research projects.

Each year the ISN submits for review to the Army Research Office a written interim progress report comprising technical and narrative content provided by the principal investigators (PIs) of the 16 core projects. This year, for the first time since the 2018 initiation of the ISN-4 contract, the ISN director and select PIs will also present at a meeting of the army's Technical Assessment Board (TAB) for the ISN, co-chaired by the Director for Technology in the Office of the Deputy Undersecretary of the Army for Research and Technology and the ISN's executive agent, the Director of the US Army Combat Capabilities Development Command's Army Research Laboratory. In addition to its co-chairs, participation by many leaders of the army science and technology community in the 2020 TAB meeting is anticipated. Historically, TAB meetings have been hosted by the ISN at MIT but, under the current circumstances, the upcoming meeting will be held virtually, on August 18 and 19, 2020.

Strategic Research Area 1: Soldier Protection, Battlefield Care, and Sensing

- Project 1.1—Advanced Multiscale Methods for Modeling of Fracture in Novel Nanomaterials
  PIs: Raúl Radovitzky (Aeronautics and Astronautics), Keith Nelson (Chemistry), and Xuanhe Zhao (Mechanical Engineering [MechE], Civil and Environmental Engineering [CEE])
- Project 1.2—Shock Mitigating and Reinforcing Molecular Nanocomposites
  PI: Michael Strano (Chemical Engineering [ChemE])
- Project 1.3—Design and Testing of Polymers for Improved Soldier Protection
  PIs: Keith Nelson (Chemistry), Tim Swager (Chemistry), and Greg Rutledge (ChemE)
- Project 1.4—Superelastic Granular Materials for Impact Absorption
  PIs: Chris Schuh (Materials Science and Engineering [DMSE]), Raúl Radovitzky (Aeronautics and Astronautics), and Kenneth Kamrin (MechE)
- Project 1.5—Rapid Hemostasis for the Treatment of Incompressible Wounds
  PIs: Bradley Olsen (ChemE), Paula Hammond (ChemE), and Shuguang Zhang (Media Lab, Center for Bits and Atoms)

- Project 1.6—Empowering Future Vaccines and Immunotherapies with Nanotech-Based Adjuvants
  PI: Darrell Irvine (DMSE, Biological Engineering)

Strategic Research Area 2: Augmenting Situational Awareness

- Project 2.1—Uncovering Chemical Stability and Charge Transfer Mechanisms at Electrode-Electrolyte Interfaces of Li-Ion Batteries
  PI: Bilge Yildiz (Nuclear Science and Engineering, DMSE)
- Project 2.2—Mid- and Low-Infrared Detector Arrays on Flexible Substrates
  PIs: Tomás Palacios (Electrical Engineering and Computer Science [EECS]), Dirk Englund (EECS), and Jing Kong (EECS)
- Project 2.3—Room Temp LWIR-THz Detection via E-field Enhancement Induced QD Upconversion
  PIs: Moungi Bawendi (Chemistry), Vladimir Bulovic (EECS), Keith Nelson (Chemistry), and Adam Willard (Chemistry)
- Project 2.4—Particulate Fluid Fiber Processing for Fabric Communications
  PIs: Yoel Fink (DMSE, EECS), and John Joannopoulos (Physics)
- Project 2.5—Nano-Plasmonics for Soldier Applications
  PIs: Marin Soljačić (Physics), Jing Kong (EECS), and Steven Johnson (Mathematics)

Strategic Research Area 3: Transformational Nano-Optoelectronic Soldier Capabilities

- Project 3.1—Solid State Power Generation at Millimeter Scales
  PIs: Ivan Celanovic (ISN), Marin Soljačić (Physics), and Peter Fisher (Physics)
- Project 3.2—Toward Specialized Photonic Integrated Circuits for Advanced Computing and Communications
  PIs: Dirk Englund (EECS), Marin Soljačić (Physics)
- Project 3.3—Nanophotonics-Enhanced Systems for the Soldier
  PIs: Steven Johnson (Mathematics), Marin Soljačić (Physics), and John Joannopoulos (Physics)
- Project 3.4—Applications of Novel Topological Phenomena
  PIs: Liang Fu (Physics), Nuh Gedik (Physics), and Marin Soljačić (Physics)
- Project 3.5—Novel Multimaterial Inks for Multiscale 3D Device Printing
  PIs: Yoel Fink (DMSE, EECS), and John Joannopoulos (Physics)

In addition to these 16 core projects, MIPRs projects, and collaborative projects with MIT Lincoln Laboratory (see above), the ISN uses MIT cost-sharing and discretionary funds from industry to support selected seed projects. These seed initiatives allow the ISN to respond swiftly to emerging needs or rapidly developing opportunities.

Transitioning

The ISN places a strong emphasis on fundamental research. However, the transitioning, or technology transfer, of promising outcomes of that research is also a crucial component of the ISN mission. To this end, the ISN works with the army, industry partners, startups, other companies, and MIT Lincoln Laboratory, and with the MIT Technology Licensing Office to help ensure that promising ISN innovations mature beyond the lab and benefit soldiers, other warfighters, and first responders as rapidly and efficiently as possible. The ISN is pleased to count John R. McConville, a CCDC ARL-ARO Technology Transfer Officer (TTO), among our full-time headquarters team. It is the TTO's charge to help maximize the effectiveness and efficiency with which ISN technologies progress from the laboratory bench to more advanced stages of development, with particular emphasis on bringing new technologies to soldiers and other US warfighters.

Throughout its history, the ISN has been the source of several highly important technology transitions. One very notable transition is the Advanced Functional Fabrics of America (AFFOA) Manufacturing Innovation Institute. Founded in 2016 by the US Department of Defense as a part of the National Network for Manufacturing Innovation and based on a proposal spearheaded by MIT, AFFOA is rooted in foundational ISN research that was led by ISN-affiliated MIT faculty member, Professor Yoel Fink. In June 2017, AFFOA unveiled its dedicated facilities a short walk from the main MIT campus, along with a sampling of prototypes containing advanced optoelectronic fiber devices. AFFOA counts among its senior leadership team CEO Sasha Stolyarov, who contributed to ISN research as a student and postdoctoral researcher under ISN PI and AFFOA founding director Yoel Fink, CTO Jason Cox, and Director of Systems Engineering Mihai Ibanescu.

Since the start of the current ISN-4 funding cycle in 2018, at least 30 US patents have been awarded on intellectual property enabled by ISN research. From its founding in 2002, ISN intellectual property has been licensed for further development or commercialization by at least 38 different companies. Moreover, as many as 10 startups were founded specifically to transition innovations from the MIT Soldier Design Competition.

A Small Sampling of ISN Research Accomplishments over the Past Year

Designer DNA Molecules May Result in Future Vaccines

DNA is an extremely useful tool in bioengineering due to its capacity for being adapted and reshaped for a multitude of purposes. ISN-affiliated MIT professor Darrell Irvine of the Departments of Biological Engineering and Materials Science and Engineering, working with newly ISN-affiliated faculty member Professor Mark Bathe of the Department of Biological Engineering, have adapted a process developed at Caltech to harness this flexibility for the purpose of using DNA molecules as a potential vaccine antigen delivery system. By folding the DNA into a viruslike shape and attaching to its surface engineered HIV antigens, Bathe, Irvine, and their teams were able to elicit impressive immune responses in human cells grown in vitro. Described in a recent article published in the journal *Nature Nanotechnology*, this process has already been modified by Bathe to ascertain its efficacy in battling the SARS-CoV-2 virus that can result in COVID-19.

Transparent Graphene Electrodes

For many years, the potential utility of the 2D material graphene has been extensively explored for a vast array of applications. However, a major hurdle to its widespread practical adoption are the substantial limitations to its manufacturability in large, uniform, and workable sheets. A new process developed by an MIT team led by ISN-affiliated faculty members Jing Kong, Tomás Palacios, and Markus Buehler may be a path to overcoming that hurdle. As detailed in a recent *Advanced Functional Materials* article, this new process involves the growth—enabled by chemical vapor deposition (CVD)—of subnanometer thickness sheets of graphene on an easily separated layer of the polymer material parylene, which itself is deposited by CVD on a copper substrate. This new process could open the door to high-throughput, roll-to-roll production of graphene, bringing it one step closer to being a viable alternative to the current means of creating transparent electrodes for such purposes as advanced solar cells, cellphone displays, and other modern electronics. The new parylene layer provides a further benefit in permanently improving the native electrical conductivity of the graphene.

Harvesting Ambient Terahertz Waves for Electric Power

Terahertz (THz) waves are ubiquitous in modern society. These waves, which occupy the spectral range between microwaves and the shortwave infrared (i.e., ~100 GHz-10THz frequencies, or ~3mm-30µm wavelengths), are emitted by almost all objects registering temperatures greater than ~2 kelvins and are generated more strongly by many common electronic devices. New work led by ISN-affiliated Liang Fu, MIT's Lawrence C. (1944) and Sarah W. Biedenharn Career Development Associate Professor of Physics, has resulted in the design of a device that can harvest these ambient terahertz waves and convert them to common direct current. Detailed in an article recently published in the journal *Science Advances*, this device would harness a phenomenon that occurs when THz waves interact with a sheet of graphene that has been combined with the material boron nitride, whereby the waves cause the graphene/boron nitride material's electrons to flow in a particular direction, generating a current. Such a device, known as a rectifier, could be used to power personal electronics, cell phones, medical implants (such as pacemakers), and remote sensors.

Corrosion-Proofing 2D Materials

Two-dimensional materials, such as graphene, hexagonal boron nitride, and molybdenum disulfide, show tremendous promise for novel electronic and optical applications, but their tendency to rapidly corrode in oxygen and water vapor—key ingredients in normal, humid air—can limit their usefulness for many applications. Existing protective coatings suffer from an array of problems. Most are toxic, expensive, permanently applied, several times thicker than the 2D material they are protecting, and so brittle that they are prone to cracking. Recently, however, an international team of experts including ISN-affiliated MIT faculty member Professor Jing Kong of the Department of Electrical Engineering and Computer Science has devised a new coating that seems to overcome these problematic limitations. As detailed in a paper in the *Proceedings of the National Academy of Sciences of the USA*, this new coating can be applied easily and inexpensively in uniform monolayers that are only nanometers thick, and can be subsequently removed by the application of certain acids. In addition to protecting currently used 2D materials from degradation, this new coating technology could open pathways to the development of other new and promising 2D materials that have not been widely explored due to their susceptibility to corrosion.

Engineered Viruses May Help Fight Drug Resistance

Drug resistance in bacteria is a growing problem in medicine, as the antibiotics used to kill potentially dangerous microorganisms become less and less effective. Bacteriophages (naturally occurring viruses that can hunt bacteria), are becoming more common tools but their use is complicated by such factors as the need to identify specific phages that operate to counter specific bacteria. Recent work by ISN-affiliated MIT associate professor of biological engineering and electrical engineering and computer science Tim Lu may help ameliorate some of these complications. As described recently in the journal *Cell*, Lu and his team have demonstrated the ability to quickly program phages to act against particular bacteria, in this case various strains of E. coli. Also, one of the ways that bacteria can evolve to be more resistant to other treatments, including naturally occurring phages, is by the truncation or outright loss of a certain receptor to which such countermeasures can attach. Experiments have shown that Lu's engineered phages can be effective even against such mutated bacteria. Plans are now in place to expand the types of bacteria against which these new phages can act.

The Blackest Black

ISN-affiliated MIT professor Brian Wardle and his team in the Department of Aeronautics and Astronautics have devised a new material that absorbs no less than 99.995% of incoming visible light, more than 10 times that of the next blackest substance. The material, which could have practical applications in a variety of fields ranging from astronomy to military technology, has been used by MIT Center for Art, Science & Technology visiting artist Diemut Strebe to coat a yellow diamond weighing in at more than 16 carats (>3.2 grams) and valued at approximately $2 million. The resulting work of art appears as a featureless void, as it absorbs nearly all illumination that would otherwise display its facets. Some technical aspects of Professor Wardle's work are described in his recent paper in *Applied Materials and Interfaces*, while Strebe's artwork is presented on its website and was on display at the New York Stock Exchange from September 13 to November 25, 2019.

Army Collaboration

Army research partners are vital to the ISN mission. They collaborate with the ISN on basic and applied research, provide guidance on the soldier relevancy of ISN projects, and participate in technology transfer (i.e., transitioning, or the technological maturation and scale up of the outcomes of ISN basic research). A sampling of army science and technology laboratories and centers with which the ISN has collaborated is listed below. (With the 2018 founding of Army Futures Command, the army embarked on a substantial reorganization and restructuring of its science and technology-focused units. In many cases, those groups changed lines of report, names, and acronyms. Only the current names and affiliations are included below, even if an ISN collaboration predates these changes.)

US Army Combat Capabilities Development Command

- CCDC Army Research Laboratory
  - Army Research Office
  - Computational and Information Sciences Directorate
  - Human Research and Engineering Directorate
  - Sensors and Electron Devices Directorate
  - Vehicle Technology Directorate
  - Weapons and Materials Research Directorate
- CCDC Aviation and Missile Research, Development, and Engineering Center
- CCDC Command, Control, Communication, Computers, Cyber, Intelligence, Surveillance and Reconnaissance Center
  - Night Vision and Electronic Sensors Directorate
- CCDC Chemical Biological Center
- CCDC Soldier Center

US Army Corps of Engineers

- Cold Regions Research and Engineering Laboratory
- Engineer Research and Development Center

US Army Medical Research and Development Command

- US Army Institute of Surgical Research
- US Army Medical Research Institute of Infectious Diseases
- US Army Research Institute of Environmental Medicine
- Walter Reed Army Institute of Research

Program Executive Office—Soldier

- Project Manager—Soldier Protection and Individual Equipment

Other Department of Defense and US Government Collaboration

While ISN's first customer remains the soldier, many ISN research projects are relevant to needs of other government agencies. Collaborations or other interactions have occurred with a number of the army's sister services and other US Government entities, including the following:

- Camp Roberts (A California National Guard post)
- Deployed Warfighter Protection Program
- Naval Postgraduate School
- Naval Sea Systems Command
- US Air Force Medical Service
- US Air Force Special Operations Command

- US Department of Agriculture
- US Food and Drug Administration
- US Special Operations Command
- Walter Reed National Military Medical Center

Industrial Collaboration

Industry partners are critical to the ISN mission, helping turn innovative results of basic research into real products and scale them up for affordable manufacture in quantities needed by various end users. Current ISN industry partners are as follows:

- Nano-C
- Raytheon Technologies
- Veloxint
- Xtalic

In addition to these formal members of the ISN industry program, the ISN regularly interacts with other companies and organizations. Examples include the following:

- Advanced Functional Fabrics of America
- Brigham and Women's Hospital
- Kinalco
- Massachusetts General Hospital
- Mesodyne

Outreach Activities

Soldier Design Competition

The ISN Soldier Design Competition (SDC) was established in 2003 to engage MIT undergraduates in the activities of ISN and, in 2004, was expanded to include cadets from the United States Military Academy at West Point. The SDC provides a unique opportunity for students to apply their knowledge and creativity, while gaining hands-on experience in the design and prototyping of technology solutions to problems faced by today's soldier and first responder. Each year, a panel of leaders from the army, industry, and MIT determines winning technology solutions.

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. Army 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 strength, innovativeness, likely military benefit, and feasibility of their prototypes. Competitors are encouraged to further develop and commercialize their inventions.

The finals of SDC16 in April 2019 were attended by a number of senior army officials, including Major General Cedric Wins, Commanding General of the US Army Research, Development, and Engineering Command, who was the senior military guest at the event. The winning team at the finals was a group of MIT graduate students who developed a novel prototype chip-scale optical device that could eventually lead to new, versatile imaging technologies. The team received first prize and $5,000 for their work.

The next cycle of the Soldier Design Competition—SDC17—kicked off in September 2019. Unfortunately, in light of concerns around COVID-19 and taking into account MIT guidelines on large gatherings and events, the decision was made on March 9, 2020 to cancel the SDC17 finals, which were to be held at MIT Lincoln Laboratory on April 28, 2020.

Currently, the hope of ISN leadership is for the AY2021 season of the SDC to kick off in late 2020, with a spring 2021 finals event, although these plans may be amended as circumstances change. While the goal would be for an in-person finals event, ISN leadership will be exploring the potential for an alternative virtual event, as well.

Contributions to the MIT Community

ISN occupies approximately 40,000 square feet of space in a dedicated facility located in the northeast sector of the MIT campus within Cambridge's Technology Square. Since the beginning of the third ISN contract in 2013, more than 3,000 MIT personnel and affiliates have applied for and gained access to ISN research facilities. Prior to COVID-19 (see below) the ISN had approximately 700 registered users.

Users have access to ISN facilities that include wet and dry labs, computer clusters, and mechanical testing and other research instrumentation, including equipment for low- and high-rate mechanical characterization of the dynamic response of materials, and electron microscopy. Additional ISN equipment available to qualified MIT users includes a laser scanning confocal microscope, which provides noncontact, nanometer-scale profile, roughness, and film thickness data on a wide range of materials; an atomic layer deposition system, which is capable of conformal deposition of semiconductors, insulators, and metals on 3D objects; a Zeiss Xradia 520 Versa X-ray tomography system, which compiles a series of very thin 2D scans of an object into a 3D image, performing similarly to the way a CT scan images biological tissue, and a Zeiss Sigma 300 field emission scanning electron microscope with integrated plasma cleaner and solid-state backscattered electron detector. Most notably, the ISN has become home to multiple laser-induced particle impact test (LIPIT) instruments for microparticle-impact experiments. The LIPIT technique, first developed and demonstrated at the ISN, has garnered interest in several academic labs around the world that are building their own setups based on the original ISN concepts. Recent upgrades, including the first LIPIT-in-vacuum instrument, allows for the acceleration of individual microscopic particles of a wide variety of materials and sizes to very high speeds and images them as they strike a target material, offering visualization of impact events as they happen and on nanosecond timescales.

Additionally, since the beginning of its second contract in 2007, ISN has provided more than $10 million in seed and augmentation funding for MIT research projects, supporting research in a variety of different academic departments and research centers.

Furthermore, ISN leadership engages with the broader MIT community through participation in various Institute committees. These have included the Lincoln Laboratory-Campus Interaction Committee, the Committee on Undergraduate Admissions and Financial Aid, the MIT-DOD Engagement Group, the MIT Committee to Evaluate the Innovation Deficit, the MIT.nano Governance Committee, the MIT Administrative Systems Steering Committee, the MIT Cost Sharing Project Team, and the MIT Advisory Committee on Research Administration.

Response to COVID-19

As part of MIT, the ISN has followed and will continue to follow guidelines set forth by MIT senior administration in response to the outbreak of the SARS-CoV-2 virus and the coronavirus disease of 2019 pandemic. Additionally, though, on March 12, 2020, it was announced by the ISN director through an email to all ISN-affiliated MIT professors, research scientists, postdoctoral associates, students, and staff that a series of steps specific to the ISN would be taken beginning March 13, 2020. These steps included the closure of the ISN's conference rooms in order to minimize sizable gatherings of people within confined spaces and emphasize the need for social distancing, the authorization for ISN staff members whose tasks can be performed remotely to do so, a request that researchers with offices at the ISN whose tasks can be performed remotely do so, and instruction that no new experiments be initiated within ISN facilities without the explicit authorization of the ISN laboratory and facilities manager. Furthermore, ISN staff necessary to the functioning of the ISN laboratories would remain on site, but each would be available reduced hours and on a rotating schedule.

Adapting to the rapidly evolving circumstances relating to COVID-19 and the SARS-CoV-2 virus, an update email was sent by the ISN director on March 15, 2020 announcing that, in keeping with MIT policy, the ISN would undergo a significant scale back of all but a very few "critical activities, including the important work to understand and stop the spread of COVID-19." This scale back included the full closure as of 5 pm on Tuesday, March 17, 2020 of ISN facilities to all but those critical activities.

On May 22, 2020, the ISN Research Ramp-Up Committee (RRC) was formed for the purpose of overseeing protocols and procedures relating to the intensification of ISN facilities-based research endeavors as part of the MIT-wide research ramp-up process. Although it initially had a limited membership consisting of the ISN team members responsible for managing the March 2020 scale back of research underway at ISN facilities, the full ISN RRC is composed of the following ISN team members:

Professor John Joannopoulos, Director

William Peters, Executive Director

Steven Kooi, Principal Research Scientist

Amy Tatem-Bannister, Laboratory and Facilities Manager and EHS Coordinator

Donna Johnson, Research Support Associate II and EHS Representative

Nicole Bohn, Electron and Surface Microscopy Instrumentation Specialist

Joshua Freedman, Assistant Director for Finance and Administration

Marlisha McDaniels, Executive Administrative Assistant

On the May 22 date of its limited formation, members of the ISN RRC reached out to the 13 PIs on ISN projects who are assigned dedicated space in ISN facilities for the purpose of learning whether and how those PIs and their group members intended to resume their ISN-located activities. Following a careful review of these plans, the ISN started on June 15, 2020 the first of four stages of Research Ramp-Up (RR), Phase 1.

RR Phase 1, Stage 1 granted access to the ISN only to those researchers whose primary work spaces are within the ISN with the stipulation that they resume their work only in those assigned research spaces. ISN shared-use equipment (i.e., equipment and other facilities that are not dedicated to the exclusive use of one research group but rather provided by the ISN as a service to the community) was not made available at that time. RR Phase 1, Stage 2, started on June 29, 2020, and granted access to ISN shared-use equipment for those researchers who had already been allowed access to ISN facilities in RR Phase 1, Stage 1 on a reservation-required basis. At this time the ISN also permitted access to any researchers working to advance knowledge on COVID-19. RR Phase 1, Stage 3 began on June 30, 2020, when ISN equipment stewards (i.e., proficient users of some pieces of ISN shared-use equipment who contribute to the ISN by providing training to newer users of those pieces of equipment) were allowed to begin making reservations for equipment use whether or not their primary work space is at the ISN. The ISN entered RR Phase 1, Stage 4 on July 16, 2020, when ISN personnel contacted ISN PIs who did not previously have Phase 1 access to inform them that they, their postdoctoral associates, and their students could begin making reservations for the use of ISN shared-use equipment pursuant, as always, to their adherence to MIT campus density social distancing, and other COVID-19 safety mandates.

On July 17, it was announced by the MIT Vice President for Research and the Chair of the MIT Lightning Committee that the successful implementation of RR Phase 1 across MIT meant that preparations could begin for the implementation of RR Phase 2, with an associated increase in research capacity from 25% of regular occupancy to 50% of regular occupancy and a decrease in required research space per occupant from 160 ft^2/person to 125 ft^2/person. Plans are underway to update ISN-specific regulations in order to actualize these new access procedures, including the institution of a new Department Monitoring and Compliance (DMC) committee charged with overseeing adherence to mandated laboratory regulations, especially those regarding capacity and social distancing.

The ISN DMC comprises, as of August 4, 2020, the following ISN staff members:

Professor John Joannopoulos, Director

William Peters, Executive Director

Steven Kooi, Principal Research Scientist

Amy Tatem-Bannister, Laboratory and Facilities Manager and EHS Coordinator

Donna Johnson, Research Support Associate II and EHS Representative

Nicole Bohn, Electron and Surface Microscopy Instrumentation Specialist

Joshua Freedman, Assistant Director for Finance and Administration

Marlisha McDaniels, Executive Administrative Assistant

The ISN began admitting users to the ISN facility under Phase 2 on July 20, 2020, and continues planning for the transition to Phase 3, projected by MIT leadership to be on August 31, 2020.

Future Plans

The ISN mission remains extremely relevant to the needs of the soldier, other US warfighters and first responders, and the nation. Over the coming years, ISN will seek to build and further strengthen partnerships with the army, other US military services and agencies, industry, and MIT Lincoln Laboratory, while adjusting and enriching our fundamental research portfolio to respond to new opportunities and evolving customer needs. Working as an army-industry-university team, we will continue to perform fundamental research and transitioning to enable a range of innovative capabilities to protect and assist US military personnel and civilians in high risk and dangerous situations.

One notable initiative that may bear fruit in the near future is the teaming of ISN personnel with members of the broader MIT community in a competed opportunity to manage a University Consortium on Applied Hypersonics sponsored by the newly founded Joint Hypersonics Transition Office, within the Office of the Undersecretary of Defense for Research and Engineering. A seven-person coordinating team was formed to coordinate MIT's response to this opportunity. Three of the team's members are Professor Raúl Radovitzky, the ISN associate director; William Peters, the ISN executive director; and Franklin Hadley, the ISN outreach and communications director. With the approval and strong support of the MIT Vice President for Research, this team is coordinating MIT's partnering with a broader team led by a major US university and including several other US universities. As of August 10, 2020 this team was awaiting a government decision on a white paper (preproposal) submitted on July 16, to learn if this team will be invited to submit a full proposal to manage the consortium.

John D. Joannopoulos
Director, Institute for Soldier Nanotechnologies
Francis Wright Davis Professor of Physics
Applied Physical Sciences, National Academy of Sciences