MIT INDUSTRIAL LIAISON PROGRAM ILP

INDUSTRY BRIEF

MIT AND DEFENSE INDUSTRIES

Defense industries are addressing the multitude of disruptions and challenges confronting the security and well-being of nations and organizations. Among the challenges to the defense industries are the growing risks of cyber-attacks (including in the area of economies), critical infrastructure interference, the rise of global and political tensions, the impact of climate change on the environment, infrastructures and populations, to name a few. New and advanced technologies in these and related areas offer opportunities to respond to potential disruptions: Artificial intelligence and machine learning, strategic use of big data and analytics, autonomous systems and robotics, blockchain and cryptography, sensors.

What makes MIT unique in its ability to generate advances in the aforementioned fields?

- MIT is a world class research university: The 2018 QS World University Rankings identified MIT as the #1 university in the world in engineering and technology as well as the natural sciences.
- MIT is solutions-focused, entrepreneurial, and impact driven: as of 2014 MIT faculty and alumni had founded more than 30,000 companies and continues to spin-out 80-100 new companies each year.
- MIT is at the center of the Boston innovation ecosystem: its ability to engage and leverage this ecosystem is unmatched.
- MIT is a convener of global thought leadership: through this network MIT helps address strategic and technical solutions to the major challenges facing society.
- MIT's interdisciplinary culture: allowing thought leaders from multiple disciplines and fields to collaborate freely and reach for the previously unimaginable.

MIT Corporate Relations provides access to MIT through two integrated programs, the **MIT Industrial Liaison Program (ILP)** http://ilp.mit.edu/ and **MIT Startup Exchange** http://startupexchange.mit.edu/startupexchange/html/index.html

In the following pages, a selection of MIT centers, departments, groups, and labs are presented. These entities are actively involved with research and education related to topics of relevance to the defense industries listed below.

- Artificial Intelligence, Machine Learning
- Autonomous Systems / Unmanned Vehicles
- Big Data, Analysis, Computation, Modeling, Simulation
- Blockchain, Cryptography, Cybersecurity, Data Security
- Climate Change / Environment
- Communications, Satellites
- Economy
- Government, Geopolitics, International Relations, Political Science
- Materials, Sensors
- Physical & Infrastructure Security (Military, Defense Systems, etc.)
- Robotics

ARTIFICIAL INTELLIGENCE (AI) / MACHINE LEARNING

The **ALFA group: Anyscale Learning** For All studies scalable machine learning technology, evolutionary algorithms, and data science frameworks for large-scale knowledge mining, prediction, analytics and optimization with projects in clinical medicine knowledge discovery, cybersecurity, and MOOC technology.

The **MIT Computer Science & Artificial Intelligence Lab (CSAIL)** has its roots in two MIT computing powerhouses: The Laboratory for Computer Science (LCS) and the Artificial Intelligence Laboratory (AI Lab). CSAIL has played key roles in developing innovations like the World Wide Web, RSA encryption, Ethernet, parallel computing and much of the technology underlying the ARPANet and the Internet. Hundreds of companies have spun out of CSAIL, from Akamai and Dropbox to Boston Dynamics and iRobot. With more than 60 research groups working on hundreds of diverse projects, researchers focus on discovering novel ways to make systems and machines smarter, easier to use, more secure, and more efficient.

The **MIT-IBM Watson AI Lab** is focused on fundamental artificial intelligence (AI) research with the goal of propelling scientific breakthroughs that unlock the potential of AI. The Lab is focused on advancing four research pillars: AI Algorithms, physics of AI, application of AI to industries, and advancing shared prosperity through AI. The collaboration has brought together leading brain, cognitive, and computer scientists to conduct research in the field of unsupervised machine understanding of audio-visual streams of data, using insights from next-generation models of the brain to inform advances in machine vision.

The **MIT Intelligence Quest** will advance the science and engineering of both human and machine intelligence. This effort seeks to discover the foundations of human intelligence and drive the development of technological tools that can positively influence virtually every aspect of society. The Institute's culture of collaboration will encourage life scientists, computer scientists, social scientists, and engineers to join forces to investigate the societal implications of their work as they pursue hard problems lying beyond the current horizon of intelligence research.

The **Probabilistic Computing Project** is building a new generation of computing systems that integrate probability and randomness into the basic building blocks of software and hardware. The group has discovered that this approach leads to surprising new AI capabilities and are exploring them via a combination of academic research and entrepreneurship. The researchers also carry out basic research on the mathematical foundations of probabilistic computation. The group's work is made as freely available as possible via open-source software, public workshops, online educational materials, and collaboration with industry and non-profit partners on applications in the public interest.

The goal of **SystemsThatLearn@CSAIL** is to promote in-depth interactions between industry and academia. Member companies will have the opportunity to be exposed to multiple research projects that span the full spectrum of machine learning/artificial intelligence and analytics. The initiative will collaborate closely with industry to provide real-world applications and drive impact. The group's team of world-class researchers covers the full spectrum of research in systems and machine learning.

AUTONOMOUS SYSTEMS / UNMANNED VEHICLES

The **Aerospace Controls Laboratory** investigates estimation and control systems for modern aerospace systems, with particular attention to distributed, multivehicle architectures. Example applications involve cooperating teams of unmanned aerial vehicles or formation-flying spacecraft. The research goal is to increase the level of systems' autonomy by incorporating higher-level decisions, such as vehicle-waypoint assignment and collision avoidance routing, into feedback control systems. Core competencies include optimal estimation and control, optimization for path-planning and operations research, receding-horizon/model predictive control, and GPS.

The **MIT Laboratory for Autonomous Marine Sensing (LAMSS)** specializes in the development of new distributed ocean sensing concepts for oceanographic science, national defense and coastal management and protection. The faculty and staff, together with a significant number of students, provides a strong multidisciplinary team with expertise in oceanographic sensing and modeling, sonar system technology, computational underwater acoustics, and marine robotics and communication networking.

MIT Sea Grant's AUV Lab is a leading developer of advanced unmanned marine robots. Because the lab's vehicles can function without tethers, cables, or remote control, they have a multitude of applications in oceanography, environmental monitoring, and underwater resource studies. The laboratory also serves as a training ground for graduate and undergraduate students, visiting engineers, and scientists, from around the world, who both learn from and contribute to the lab's research activities.

The **SPARK (Sensing, Perception, Autonomy, and Robot Kinetics) Lab** works at the bleeding edge of robotics and autonomous systems research for air, space, and ground applications. The lab develops the algorithmic foundations of robotics through the innovative design, rigorous analysis, and real-world testing of algorithms for single and multi-robot systems. A major goal of the lab is to enable human-level perception, world understanding, and navigation on mobile platforms (micro aerial vehicles, self-driving vehicles, ground robots, augmented reality). Core areas of expertise include nonlinear estimation, numerical and distributed optimization, probabilistic inference, graph theory, and computer vision.

BIG DATA, ANALYSIS, COMPUTATION, MODELING, SIMULATION

The **Aerospace Computational Design Laboratory's (ACDL)** mission is the advancement and application of computational engineering for the design, optimization, and control of aerospace and other complex systems. ACDL research addresses a comprehensive range of topics including: advanced computational fluid dynamics and mechanics; uncertainty quantification; data assimilation and statistical inference; surrogate and reduced modeling; and simulation-based design techniques.

BigData @ CSAIL researchers are investigating how to transform big data into big insights. The initiative's approach brings together world leaders in parallel architecture, massive-scale data processing, algorithms, machine learning, visualization, and interfaces to explore all the challenges and opportunities presented by big data, from cloud computing, data management, massive scale data analysis, algorithms, data mining, machine learning, security, privacy and visualization to all of big data's applications in fields such as finance, medicine, biology, artificial intelligence and social networking.

The **MIT CTL Computational and Visual Education (CAVE) Lab** is a research and education initiative around the use of interactive visualization to improve supply chain and logistics data visibility, advanced data analytics, and data-driven supply chain decision making. Based on physical lab space equipped with state-of-the-art visualization technology, the lab is working on developing interactive visual interfaces to data and analytical tools, addressing complex supply chain and logistics problems.

DiaMonD: An Integrated Multifaceted Approach to Mathematics at the Interfaces of Data, Models, and Decisions is a U.S. Department of Energy Mathematical Multifaceted Integrated Capabilities Center (MMICC) involving researchers from MIT, Colorado State University, Florida State University, Los Alamos National Laboratory, Oak Ridge National Laboratory, University of Texas at Austin, and Stanford University. DiaMonD's mission is develop advanced mathematical methods and analysis for multimodel, multiphysics, multiscale model problems driven by frontier DOE applications; to create theory and algorithms for integrated inversion, optimization, and uncertainty quantification for these complex problems; and to disseminate the philosophy of a data-to-decisions approach to modeling and simulation of complex problems.

The **Mathematics Department** at MIT is one of the top-ranked mathematics departments in the US— a world center in Pure and Applied Mathematics. In pure mathematics, the department explores exciting current research directions in most of the major fields. The pure math group studies many aspects of algebra, analysis, geometry, mathematical logic and foundations, number theory, probability and statistics, and representation theory. The applied math group focuses on combinatorics, computational biology, computational science & numerical analysis, physical applied mathematics, theoretical computer science, theoretical physics.

The **MIT Institute for Data, Systems, and Society (IDSS)** is committed to addressing complex societal challenges by advancing education and research at the intersection of statistics, data science, information and decision systems, and social sciences. IDSS applies state-of-the-art, analytical methods in information and decision systems, statistics and data science, and the social sciences to address complex societal challenges in a diverse set of areas such as finance, energy systems, urbanization, social networks, and health.

The **MIT Institute for Foundations of Data Science (MIFODS)** is an NSF-funded interdisciplinary effort to develop the theoretical foundations of data science through integrated research and training activities. To achieve this goal, MIFODS stimulates research and educational interactions between mathematics, statistics and theoretical computer science, both within MIT and in the research community at large.

The **Multidisciplinary Simulation, Estimation, and Assimilation Systems (MSEAS) Lab** research vision is to develop and transform ocean modeling and data assimilation to quantify regional ocean dynamics on multiple scales. The MSEAS group creates and utilizes new models and methods for multiscale modeling, uncertainty quantification, data assimilation, and the guidance of autonomous vehicles. The group then applies these advances to better understand physical, acoustical and biological interactions. The study of interdisciplinary coastal ocean dynamics is a curiosity-driven intellectual challenge in itself. It is also vital to society for industry, fisheries, energy, security and conservation, and ultimately for the assessment of human impacts on the ocean's health and climate.

The **Statistics and Data Science Center** is an MIT-wide focal point for advancing research and education programs related to statistics and data science. The Center was created with the goal of formalizing and consolidating efforts in statistics at MIT. Project areas include: nonpara-metric Bayesian statistics, causal inference and applications to learning gene regulatory networks, combinatorial learning with set functions, online learning, and statistical and computational tradeoffs.

The **Stochastic Systems Group (SSG)** is focused on developing statistically-based methodologies for complex problems of information extraction and analysis from signals, images, and other sources of data. Recent applications are in computer vision, mapping of geophysical phenomena, and tracking of multiple vehicles from multiple sensors. Among the most recent advances are new classes of models that represent complex phenomena at multiple resolutions or granularities. An increasingly important component of research is in machine learning for the extraction of statistical models, usually in graphical form, of complex phenomena.

BLOCKCHAIN, CRYPTOGRAPHY, CYBERSECURITY, DATA SECURITY

Blockchain.mit.edu is focused on the marketplaces enabled by crypto tokens and blockchain technology. In 2014, a major field experiment was conducted at MIT where 4,494 participants were randomized into multiple conditions in conjunction with the distribution of $500K in Bitcoin on campus. The study presented unique security, regulatory and technical challenges, but also allowed causal evidence to be generated on key questions about the use of new technology and digital privacy choices that cannot be answered with observational data.

The **Cryptography and Information Security Group (CIS Group)** develops techniques for securing tomorrow's global information infrastructure by exploring theoretical foundations, near-term practical applications, and long-range speculative research. The group aims to understand the theoretical power of cryptography and the practical engineering of secure information systems, from appropriate definitions and proofs of security, through cryptographic algorithm and protocol design, to implementations of real applications with easy-to-use security features.

The **CyberSecurity@CSAIL** approaches security from all sides (programming languages, software verification, computer architecture, crypto, systems, policy) with the goal of creating security "by default" and removing program error as a source of vulnerability. The researchers are designing new theoretical and practical foundations of secure computing that integrate security in the design process. The initiative brings together world-renowned leaders in the security specialties of cryptography, hardware, and software to leverage the existing research portfolio and works collaboratively with industry partners to address the most pressing cybersecurity challenges.

Cybersecurity at MIT Sloan is focusing MIT's uniquely qualified interdisciplinary faculty and researchers on the fundamental principles of cyberspace, cybercrime, & cybersecurity applied to critical infrastructure. Cybersecurity at MIT Sloan is a confidential academic forum in which leaders and managers can benefit from the experiences of CSO/CISOs across multiple sectors.

The **MIT Geospatial Data Center (GDC)** brings together applied computation research in data science, cybersecurity, simulation, augmented reality, the Internet of Things (IOT), blockchain, and educational technology (EdTech). The GDC is researching security, financial, social networks, storage, and general purpose application of blockchains.

The **Trust::Data Consortium** addresses the growing tension between societal data proliferation and data security by developing specifications, software, tools and documentation that help organizations adopt a holistic approach to cyber protection. Trust::Data is building new models for digital identity, data provenance, universal access, and secure privacy-preserving transactions to harness the future potential of global data sharing. The consortium brings together MIT researchers and business vanguards to collaborate on the

development of open-source software that enables better data security and privacy, while also allowing for easier data sharing, and more robust digital identity.

CLIMATE CHANGE / ENVIRONMENT

The **Center for Energy and Environmental Policy Research (CEEPR)** carries out rigorous and objective research for improved decision making in government and the private sector, and secures the relevance of its work through close cooperation with government and industry partners from around the globe. Drawing on the unparalleled resources available at MIT, affiliated faculty and research staff as well as external research affiliates contribute to the empirical study of a wide range of policy issues related to energy supply, energy demand, and the environment.

The **Center for Global Change Science (CGCS)** seeks to better understand the natural mechanisms in the ocean, atmosphere and land systems that together control the Earth's climate, and to apply improved knowledge to problems of predicting global environmental change. CGCS fosters studies on topics as varied as, for example, oceanography, meteorology, hydrology, atmospheric chemistry, ecology, biogeochemical cycling, paleoclimatology, applied math, data assimilation, computer science, and satellite remote sensing. Parallel CGCS activities incorporate the insight gained into climate prediction models, and climate policy analysis, with the aim of providing it in a useful way to decision-makers confronting the coupled challenges of future food, energy, water, climate and air pollution (among others).

The **Environmental Solutions Initiative (ESI)** mobilizes the substantial scientific, engineering, policy, and design capacity of MIT to create solutions to today's environmental challenges through diverse activities in education, research, and convening. ESI's priorities for research fall into three domain areas: Climate Science and Earth Systems, Cities and Infrastructure, and Sustainable Production and Consumption. Each domain draws upon engineers, natural and social scientists, designers, and arts & humanities to understand and address critical challenges. ESI is pursuing collaboration with a diverse array of partners in industry, government, and civil society, with the aim of building robust research programs in all three priority domains.

The **Joint Program on the Science and Policy of Global Change** is MIT's response to the research, analysis and communication challenges of global environmental change. The program combines scientific research with policy analysis to provide independent, integrative assessments of the impacts of global change and how best to respond. The Joint Program's integrated team of natural and social scientists studies the interactions among human and Earth systems to provide a sound foundation of scientific knowledge to aid decision-makers in confronting future food, energy, water, climate, air pollution and other interwoven challenges.

The **MIT Science Impact Collaborative (MIT SIC)** is a research team within the Department of Urban Studies and Planning that is developing and testing new ways to harmonize science, politics and public policy in the management of natural resources and the resolution of environmental disputes. The team's focus is on testing the effectiveness of a range of collaborative planning and decision-making techniques. The tools and approaches for doing this include collaborative adaptive management, joint fact-finding, scenario planning, mediated multiparty negotiation, and the use of role-play simulation exercises.

COMMUNICATIONS, SATELLITES

The **Department of Aeronautics and Astronautics**' research and teaching range from autonomous systems to alternative jet fuels; to skin-tight space suits for hiking about on planets and other bodies in space; to constellations of nano satellites that, in concert, far outperform single, large satellites; to the development of ultra-wide bandwidth communications. These projects will make our environment cleaner and quieter; improve our health and safety; increase our mobility; heighten our efficiency; enable us to explore frontiers far beyond current limitations.

The **Communications and Networking Research Group's (CNRG)** primary goal is the design of network architectures that are cost effective, scalable, and meet emerging needs for high data-rate and reliable communications. To meet emerging critical needs for military communications, space exploration, and internet access for remote and mobile users, future aerospace networks will depend upon satellite, wireless and optical components. Satellite networks are essential for providing access to remote locations lacking in communications infrastructure; wireless networks are needed for communication between untethered nodes, such as autonomous air vehicles; and optical networks are critical to the network backbone and in high performance local area networks.

The **International Center for Air Transportation (ICAT)** research and educational programs discover and disseminate the knowledge and tools underlying a global air transportation industry driven by new technologies. Modern information technology

systems of interest to ICAT include: global communication and positioning; international air traffic management; scheduling, dispatch and maintenance support; vehicle management; passenger information and communication; and real-time vehicle diagnostics. Operations are also areas of great interest to the faculty/researchers and are of vital importance to international air transportation, including airline management, airport security, air transportation economics, fleet scheduling, traffic flow management and airport facilities development.

The **Laboratory for Information and Decision Systems (LIDS)** is an interdepartmental research laboratory. LIDS fundamental research goal is to advance the field of systems, communications, and control. In doing this, it recognizes the interdependence of these fields and the fundamental role that computation plays in this research. LIDS conducts basic theoretical studies in communication and control and is committed to advancing the state of knowledge of technologically important areas such as atmospheric optical communications and multivariable robust control.

The **Research Laboratory of Electronics (RLE)** pursues seven major research themes, which form the major topics that approximately forty research groups, centers and laboratories—most organized around an RLE professor or senior staff scientist—investigate. The major themes include: Atomic Physics; Information Science and Systems; Quantum Computation and Communication; Energy, Power and Electromagnetics; Photonic Materials, Devices and Systems; Nanoscale Materials, Devices and Systems; and Biomedical Science and Engineering.

The **Space Telecommunications, Astronomy and Radiation (STAR) Laboratory** develops instruments and platforms for observing weather systems on Earth and extraterrestrial planets, and for measuring space weather, the flow of highly energetic particles that originate from our Sun. STAR Lab specializes in weather sensors, space weather (radiation) sensors, and communications systems, precision attitude control systems, and technology demonstrations using shoebox-sized spacecraft known as CubeSats. STAR Lab research also focuses on the challenging problem of how to efficiently get collected data from small satellite platforms back down to the ground using high data rate laser communications systems with advanced and miniaturized pointing and tracking capability.

ECONOMY

The **MIT Golub Center for Finance and Policy (GCFP)** serves as a catalyst for innovative, cross-disciplinary and non-partisan research and educational initiatives that address the unique challenges facing governments in their role as financial institutions and as regulators of the financial system. The GCFP is an Institute-wide initiative that is managed by MIT Sloan's finance group. Research initiatives supported by the GCFP are organized into three main tracks: Evaluation and management of government financial institutions; regulation of financial markets and institutions; measurement and control of risk.

The **Department of Economics** faculty is equally committed to graduate and undergraduate education and is at the forefront of both theoretical and applied economics. The faculty have made pioneering contributions from theory to macroeconomics, to finance, to industrial organization, to international trade. The department's scholars have received numerous awards, including four Nobel Prizes. Student dissertation topics span a wide range of issues in microeconomics and macroeconomics, and include economic theory, data analysis, and econometric methodology.

The **Political Economy and Technology Policy** program applies theories and methods from the discipline of political economy to examine issues in science and technology policy. The program studies: Emergent technologies; uncertainty and environmental decision-making; regulation and the management of business risk; and north-south financial and technology transfers. Political economists from the social sciences work closely with MIT technologists and humanists, government, nongovernmental organizations, and private firms, and with academic partners at Cambridge University, the Stockholm School of Economics and Chalmers University, the Swiss Federal Institutes of Technology (ETH) and the University of Tokyo.

The **World Economy Laboratory (WEL)** is organized around the Central Banks-MIT research network, and aims to develop relationships between MIT and central banks. WEL hosts occasional meetings in Cambridge and visits by central bank researchers to the MIT Economics Department. The working group environment of the meetings is aimed at discussing policy issues at a relatively technical level. The meetings are attended by the heads of research of many central banks, as well as faculty and students working on international finance and macroeconomics policy issues.

GOVERNMENT, GEOPOLITICS, INTERNATIONAL RELATIONS, POLITICAL SCIENCE

The **Caltech/MIT Voting Technology Project (VTP)** applies social science and engineering to voting. Work ranges from the functioning of voting machines to the effects of reforms on voter behavior to the assessment of voting systems. This is an interdisciplinary group that both conducts original research in this area and engages in an active program of outreach to the public and election officials.

The **Center for Civic Media** pursues original scholarship and design work that investigates the tight-knit and dynamic relationships between communities, ecologies of media and technology, and the natures of information and power. In particular, the center develops research tools and conducts case studies to help understand media ecosystems, augment civic participation, and foster digital inclusion. The researchers are inventors of new technologies that support and foster civic media and political action; the center is a hub for the study of these technologies, and coordinates community-based design processes locally in the Boston area, across the United States, and around the world.

The **MIT Department of Political Science** views the challenges of globalization and economic uncertainty, immigration, asymmetric security threats, energy dependence and the environment, health care provision, poverty, and polarization of electorates as opportunities to conduct innovative, high-impact research. From voting booths in the U.S. to the villages of Afghanistan and China to town forums in Liberia and Bangladesh, the goal is to advance the dialogue of political science by comparing empirical phenomena with scholarly insights into how societies work. In the process, the faculty are developing alternative uses for existing methodologies and inventing new ones.

Explorations in Cyber International Relations (ECIR) is an interdisciplinary research project between MIT and Harvard University that explores various facets of cyber international relations. The ECIR research program develops an approach to international relations responsive to the cyber realities of the 21st century, integrating social sciences, legal studies, computer science, and policy analysis. Its vision is to understand the mutual and reciprocal interconnections of the cyber and the international relations domains, and create a body of knowledge that is theory-driven, empirically sound, and technically anchored such that it: Clarifies threats and opportunities in cyberspace for national security, welfare, and influence; Provides analytical tools for understanding and managing transformation and change; and Attracts and educates a new generation of researchers, scholars, and analysts.

The **Inter-University Committee on International Migration** has been a focal point for migration and refugee studies at member institutions, which include Boston University, Brandeis University, The Fletcher School of Law and Diplomacy, Harvard University, MIT, Tufts University, and Wellesley College. The committee is chaired by MIT as a program of the Center for International Studies (CIS). During each academic year, the Committee sponsors a seminar series on international migration held at MIT's CIS. The seminars explore factors affecting international population movements and their impact upon sending and receiving countries and relations among them.

The **MIT Election Data & Science Lab (MEDSL)** supports advances in election science by collecting, analyzing, and sharing core data and findings. The lab also aims to build relationships with election officials and others to help apply new scientific research to the practice of democracy in the United States. The MEDSL staff of social scientists, researchers, and students are committed to improving democracy in the United States by promoting the application of scientific principles to the understanding of election administration.

The **MIT GOV/LAB** is a research group of political scientists focusing on innovation in citizen engagement and government responsiveness. The group collaborates with social enterprises, funders, and governments on research that builds and tests theories about how innovative programs and technologies can make governments more accountable to citizens. In each of their projects, they aim to provide operationally useful information to practitioners as well as to contribute to theoretical knowledge.

The **MIT-Harvard Public Disputes Program (PDP)** is affiliated with MIT's Department of Urban Studies & Planning, the Tufts University Fletcher School of Law and Diplomacy, and the not-for-profit Consensus Building Institute. PDP has been involved in testing, documenting, and assessing the advantages and disadvantages of using mediation and other forms of consensus building to resolve disputes at the local, state, national, and international levels over the allocation of scarce resources, the setting of policy priorities, as well as government efforts to specify standards of various kinds (such as regulations regarding health, safety, and environmental protection).

MIT Seminar XXI's mission is to educate current and future leaders in the U.S. government's national security community. The seminar creates a link between the worlds of policymaking and academia, bringing together military and civilian executives with scholars from MIT and other world-renowned institutions. Through this interdisciplinary and intergenerational learning experience, Fellows share their differing viewpoints, challenge each other's assumptions, expand their interagency networks, and develop fresh ways of analyzing the complex national security issues they face each day. Seminar XXI is administered by the MIT Center for International Studies (CIS).

The **Political Methodology Lab (PML)** is MIT's center of activities related to quantitative methods in political science. PML's primary mission is to foster research and education in quantitative political methodology through various channels. PML hosts a speaker series and workshops on advanced quantitative methods, and fund innovative data science projects by students. The core faculty of PML run the Models and Methods (M&M) field for the political science Ph.D. program at MIT.

The **Security Studies Program** at MIT is a graduate-level research and educational program based at the Center for International Studies at MIT. The senior research and teaching staff includes social scientists and policy analysts. A special feature of the program is the integration of technical and political analysis of national and international security problems. Courses emphasize grand strategy, the causes and prevention of conflict, military operations and technology, and defense policy.

MATERIALS, SENSORS

The **Institute for Soldier Nanotechnologies (ISN)** is a team—MIT, the Army, and industry– working together on basic research to create new materials, devices, processes, and systems, and on applied research to transition promising results toward practical products useful to the soldier. Army and industry partners share 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 the quantities needed by our soldiers. The collaborations help identify dual-use applications for ISN-derived technologies for firefighters, police officers, other first responders, and the civilian community at large.

MIT.nano is a new center for nanoscience and nanotechnology at the heart of the campus anticipated to open in summer 2018. It is an advanced facility open to the entire community of faculty, researchers, and students as a convening space to spark collaboration and cross-pollination. MIT.nano will support innovation expressed through other Institute-wide initiatives and centers: the MIT Energy Initiative (MITEI), the Institute for Medical Engineering and Science (IMES), the David H. Koch Institute for Integrative Cancer Research, and burgeoning programs to address water, climate, poverty, and other grave challenges.

PHYSICAL & INFRASTRUCTURE SECURITY (MILITARY, DEFENSE SYSTEMS ETC.)

The mission of the **MIT Humanitarian Supply Chain Lab** is to understand and improve the supply chain systems behind public services and private markets to meet human needs. The primary education and research areas in the Lab are: Emergency response—Supply chains are the critical link in delivering life-saving supplies during crisis triggered by events such as natural disasters, conflict, and disease outbreak; and emerging market development—Supply chains are fundamental in making products that are essential for human needs more affordable, available, and accessible in communities around the world.

MIT Lincoln Laboratory conducts research and development aimed at solutions to problems critical to national security. Research includes projects in air and missile defense, space surveillance technology, tactical systems, biological and chemical defense, homeland protection, communications, cybersecurity, and information sciences. Lincoln Laboratory also undertakes government-sponsored, nondefense projects in areas such as the development of systems that the Federal Aviation Administration relies on to improve air-traffic control and air safety, that the National Oceanic and Atmospheric Administration uses in weather surveillance, and that the National Aeronautics and Space Administration employs in its space science missions. And, the **MIT Lincoln Laboratory Beaver Works Center (Lincoln Beaver Works)** is a joint center chartered by the MIT School of Engineering and MIT Lincoln Laboratory to conduct research and educational programs that strengthen and expand collaborative efforts between Lincoln Laboratory and MIT campus. The facility is open to all MIT students, faculty, and collaborators, and provides a nexus for innovation, collaboration, and hands-on development.

MIT ROTC Programs (Air Force, Army, Naval): Military training has existed at MIT ever since the Institute opened its doors in 1865. More than 12,000 officers have been commissioned from MIT, of whom more than 150 have reached the rank of general or admiral.

The **Naval Construction and Engineering (Course 2N)** program prepares Navy, Coast Guard, foreign naval officers, and other graduate students for careers in ship design and construction. In addition to providing the students a comprehensive education in naval engineering, the program emphasizes their future roles as advocates in ship design and acquisition. The course of study consists of both a two-year program, which leads to a Master of Science degree in Naval Architecture and Marine Engineering, and a three-year program, which leads to the degree of Naval Engineer.

The **Partnership for a Systems Approach to Safety and Security (PSASS)** takes a systems approach to safety and security by applying systems thinking. The goal is to create and evaluate new tools and processes that use systems thinking to provide more comprehensive, more efficient, and more effective results. PSASS uses participation from multiple MIT schools (engineering, management, social sciences, and sciences) as well as collaborators at other universities and industry partners. PSASS affiliates include DoD partners, aviation (aircraft and air transportation systems), spacecraft, medical devices and healthcare, automobiles, railroads, nuclear power, defense systems, energy, oil and gas, and other domains.

The **Strategic Engineering Research Group (SERG)** studies long-lived systems on Earth and in Space. This includes the design and operation of critical infrastructures such as industrial manufacturing, transportation, earth observation, defense, water, energy and food supply systems as well as the challenges of sustained human and robotic exploration and settlement of outer space. We develop validated models and simulations to support strategic decisions under uncertainty, including selection of technologies and system evolutionary pathways.

ROBOTICS

The **MIT Biomimetic Robotics Lab** is focused on bio-inspired robot design by extracting principles from animals. Achievements include the quadruped robotic MIT Cheetah, which has made headlines for its dynamic legged gait, speed, jumping ability, and biomimetic design. The group is developing a third-generation robot with enhancements such as a greater payload capability, wider range of motion, and a dexterous gripping function. The Cheetah III will initially act as a spectral inspection robot in hazardous environment, such as a compromised nuclear plant or chemical factory, then evolve to serve other emergency response needs. Other projects include a teleoperated humanoid robot that provides haptic feedback to human operators, and an early stage investigation into applying actuator technology to address mobility challenges among the disabled and elderly.

The **Center for Ocean Engineering** at MIT is focused on four research areas: acoustics, hydrodynamics, structures and structural dynamics, and design and marine robotics. The Center addresses a number of ocean-related activities, including: observation and exploration of the ocean; naval construction and engineering; ocean resource development; shipping and transportation; ocean energy; ocean acoustics; role of the ocean in the global environment and in climate change; oceanographic engineering; marine robotics; and biomimetics.

The **Distributed Robotics Laboratory** work spans: computational design and fabrication of robots; algorithms for perception, planning reasoning and control with guarantees; algorithms for auditable machine learning; and algorithms for collaborating machines and people. The lab's innovations enable new applications in smart living, transportation, healthcare, manufacturing, monitoring, exploration, and much more. The lab's research addresses the development of algorithms and systems that enable collaboration, increase autonomous capabilities, and rethink the ways in which we design and interact with the physical world.

The **Interactive Robotics Lab** conducts research and develops technology to ease the integration of robotics and autonomous systems into human-centered work environments. This includes the design of algorithms for planning, decision-making, and control of autonomous systems that are modified to support safe, efficient and natural interaction with people. Research applications focuses on high-intensity and safety-critical applications including aerospace manufacturing, disaster response, and space operations.

There are three main thrusts to the research in the **Model-Based Embedded and Robotics Systems (MERS)** group: goal-driven interaction with robots, natural human/robot teaming, and robotic reasoning about the environment. When combined, these research topics enable the group to create cognitive robots that can be talked to like another human, can work with a team member to finish a task, can recover from many failures without assistance, and can collaborate with a human to recover from a failure that the robot cannot solve alone.

The **Robot Locomotion Group** research is to build machines which exploit their natural dynamics to achieve extraordinary agility and efficiency. The group believes that deep connections are possible and is working hard on both optimization

algorithms and control applications. Projects include dynamics and control for humanoid robots, robotic manipulation, and dynamic walking over rough terrain, flight control for aggressive maneuvers in unmanned aerial vehicles, feedback control for fluid dynamics and soft robotics, and connections between perception and control.

The **Robust Robotics Group** aims to build unmanned vehicles that can fly without GPS through unmapped indoor environments, robots that can drive through unmapped cities, and to build social robots that can quickly learn what people want without being annoying or intrusive. The group focuses on problems of planning and control in domains with uncertain models, using optimization, statistical estimation and machine learning to learn good plans and policies from experience.

The mission of the Massachusetts Institute of Technology is to advance knowledge and educate students and others in science, technology, and additional areas of scholarship. MIT is committed to generating, disseminating and preserving knowledge and to working to bring this knowledge to bear on the world's great challenges. As part of its mission, MIT maintains relationships with industrial organizations that enable the exchange of ideas in the context of real-world problems and demonstrate how principles studied at MIT are applied to generate practical benefits for industry and society. MIT's Industrial Liaison Program helps develop these relationships by facilitating industry's access to MIT and its vast resources.