MIT Institute for Data, Systems, and Society

It was a productive and exciting year for the MIT Institute for Data, Systems, and Society (IDSS). Encouraging innovative collaborations spanning all five MIT schools, 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 aims to develop new analytical methods to address complex, significant societal challenges in a diverse set of areas such as finance, energy systems, urbanization, social networks, and health.

Technology advances in areas such as smart sensors, big data, communications, computing, and social networking are rapidly increasing the size and complexity of interconnected systems and networks—and at the same time are generating large quantities of data that can lead to new insights and understanding. Research at IDSS seeks to understand and analyze data from across these systems, and gain clear, actionable insights.

Faculty and Leadership

The director of IDSS is Munther Dahleh, the William A. Coolidge Professor in the Department of Electrical Engineering and Computer Science (EECS). For academic year 2017, IDSS leadership included the following:

- Asu Ozdaglar, Joseph F. and Nancy P. Keithley Professor of Electrical Engineering, was appointed as associate head of EECS, effective January 1, 2017, and also was appointed as interim department head of EECS.

- Ali Jadbabaie, JR East Professor of Engineering, was director of the Sociotechnical Systems Research Center and became associate director of IDSS.

- John Tsitsiklis, Clarence J. Lebel Professor of Electrical Engineering, was appointed director of the Laboratory for Information and Decision Systems (LIDS) and associate director of IDSS, effective April 1, 2017.

- Devavrat Shah, professor of electrical engineering and computer science, was named director of the MIT Statistics and Data Science Center (SDSC).

- Noelle Selin, associate professor of IDSS and the Department of Earth, Atmospheric and Planetary Sciences, continued as associate director of the Technology and Policy Program (TPP).

- Elizabeth Sikorovsky was named executive director of IDSS.

There were several changes in IDSS's academic leadership, as follows:

- LIDS Director Professor John Tsitsiklis stepped down from his previous roles as IDSS graduate officer, Social and Engineering Systems (SES) program chair, and SES admissions chair.

- Professor Stephen Graves became IDSS graduate officer.

- Professor Ali Jadbabaie became SES program chair and admissions chair.

- Professor Jessika Trancik will translate her experience as one of IDSS's most prolific advisors to tackling a new role focusing on the monitoring, growth, and support of SES students.

The IDSS faculty and administrative leadership team comprises 11 persons—eight faculty members and four administrative officers. The approximately 80 IDSS faculty members include core and affiliate faculty members from a variety of areas throughout MIT, as well as several visiting faculty members.

The following faculty members joined IDSS in academic year 2017:

- Alberto Abadie, professor of economics (core faculty)

- Saurabh Amin, Robert N. Noyce Career Development Associate Professor (affiliate faculty)

- Alessandro Bonatti, associate professor of applied economics (affiliate faculty)

- Dean Eckles, assistant professor, marketing (affiliate faculty)

- Ali Jadbabaie, JR East Professor of Engineering (core faculty)

- In Song Kim, assistant professor of political science (affiliate faculty)

- Jun Liu, professor in the Department of Statistics, Harvard University (visiting faculty)

- Elchanan Mossel, professor of mathematics (core faculty)

- Tavneet Suri, associate professor of applied economics (affiliate faculty)

Promotions

Noelle Selin and Jessika Trancik

Noelle Selin and Jessika Trancik were both promoted to associate professor with tenure. Professor Selin uses atmospheric chemistry modeling to inform decision making on air pollution, climate change, and hazardous substances such as mercury and persistent organic pollutants. Professor Trancik, the Atlantic Richfield Career Development Associate Professor in Energy Studies in IDSS, evaluates the costs, expected changes,

and environmental impacts of energy-related technologies to accelerate their improvement by relating performance to design and manufacturing decisions.

Awards

Some faculty awards for AY2017 include:

- John Tsitsiklis was named the winner of the 2018 IEEE Control Systems Award.

- Esther Duflo, Abdul Latif Jameel Professor of Poverty Alleviation and Development, was among six MIT professors elected to the National Academy of Sciences.

- Tommi Jaakkola was appointed the Thomas Siebel Professor in EECS and IDSS.

- Three faculty members—Daron Acemoglu, Elizabeth and James Killian Professor of Economics; Richard Nielsen, associate professor of Political Science; and Charles Stewart III, Kenan Sahin Distinguished Professor of Political Science— received high-profile Carnegie grants for research.

- Caroline Uhler, Henry L. and Grace Doherty Assistant Professor of Ocean Utilization, received a National Science Foundation CAREER Award and a 2017 Sloan Research Fellowship.

- Daron Acemoglu won a BBVA Foundation Frontiers of Knowledge Award.

- Daniel Hastings, Cecil and Ida Green Education Professor, Aeronautics and Astronautics, was elected to the National Academy of Engineering.

- Sertac Karaman, Charles Stark Draper Associate Professor of Aeronautics and Astronautics, received the IEEE Robotics and Automation Society Early Career Award.

- Joseph Sussman, JR East Professor of Engineering, received the Department of Civil and Environmental Engineering Distinguished Service and Leadership Award. Sussman also was honored for his 25 years of service as JR East Professor by the East Japan Railway Company.

- Sandy Pentland, Toshiba Professor of Media Arts and Sciences, was named founding member of the board of directors for the United Nations Global Partnership for Sustainable Development Data. Pentland recently presented a keynote talk at the opening events of the Council of the European Union's Estonian presidency, and has been named chief expert at Beijing Normal University School of Economics and Resource Management.

- A 2015 paper co-authored by Professor Richard Larson, Mitsui Professor, Data, Systems, and Society, and TPP alumna Yi Xue won the Best Paper of the Year Award from the US Bureau of Labor Statistics.

Online Education

Data Science: Data to Insights

This online course, first launched in October 2017 and presented twice after that by MIT Professional Education and IDSS, teaches how to apply data science techniques to address challenges and gain actionable insights.

Data Science MicroMasters

A new MIT MicroMasters program in data science is in development. It is scheduled to launch in fall 2018.

Major Events

Launch Event

September 22–23, 2016
This two-day event celebrated the inaugural year of IDSS while also looking ahead to the future, bringing together thought leaders from academia, industry, and government to discuss the opportunities for research at the forefront of society's greatest challenges.

MIT President Rafael Reif speaks at the IDSS Launch Event (credit: Dawn Colquitt-Anderson).

Women in Data Science Conference

February 3, 2017
IDSS co-hosted this event with Harvard University's Institute for Applied Computational Science and Microsoft Research New England.

Jennifer Chayes, distinguished scientist and managing director of Microsoft Research New England, speaks at the Women in Data Science Conference (credit: Dawn Colquitt-Anderson)

Statistics and Data Science Center Day

April 21, 2017
The MIT Statistics and Data Science Center hosted this event, bringing together the statistics community and showcasing data science projects. Discussions covered applications of statistics and data science across a wide range of fields and approaches.

Tamara Broderick talks about assessing the effects of different microcredit programs (credit: Dawn Colquitt-Anderson).

Laboratory for Information and Decision Systems Smart Urban Infrastructures

May 11–12, 2017
This two-day event showcased current work and emerging research opportunities at the intersection of smart services and urban infrastructure systems.

Ongoing

In addition to these major events, IDSS continued to present the following ongoing seminar series:

- IDSS Distinguished Seminar Series

- IDSS Special Seminar Series

- Stochastics and Statistics Seminar Series

- LIDS Seminar Series

Academic Programs

Students in IDSS address societal challenges by combining the fundamentals of statistics, data science, and information and decision systems with a rigorous study of social sciences. IDSS comprises some newer academic programs, such as the Doctoral Program in Social and Engineering Systems (SES) and continues its efforts with the long-running Technology and Policy Program.

Doctoral Program in Social and Engineering Systems

The doctoral program in Social and Engineering Systems (SES) is a unique research program focused on addressing concrete and societally significant problems by combining the analytical tools of engineering and information sciences with social science tools and methods. Its first class entered in September 2016.

Curriculum

The first part of a doctoral student's program consists of advanced, rigorous, and challenging classes covering the fundamentals (three classes), followed by five classes in information, systems, and decision sciences; four classes in the social sciences; and two classes focusing on an application domain. After several semesters of coursework, students take a qualifying exam that includes both a written and an oral portion. Successful completion of the oral exam, generally in a student's fourth to sixth semester, marks the transition from classes to research.

Research

Immersion in research is the centerpiece of the SES program. Student research is characterized by the following traits:

- It is driven by problems of societal interest in areas such as autonomous systems, energy systems, finance, social networks, and urban systems, as well as in policy-related topics.

- It is application-domain-driven with a focus on solving concrete problems while developing methodologies as necessary, as opposed to the development of generic, context-independent methodologies.

- It involves quantitative methods. The program is focused on problems that can be addressed through mathematical modeling, data analysis, and other quantitative methods.

- It relies on real-world data. Research is expected to analyze data from the application domain of interest, and thus training in statistics is part of the program.

- It engages societal aspects of the problem. The research incorporates theories and tools from the social sciences.

Program Milestones

On October 21, 2015, the MIT Faculty voted to create a new doctoral degree in social and engineering systems. In September 2016, SES's first class of 10 students started the program.

Admissions

Total applications to the SES doctoral program in September 2017 numbered 577, with 205 of these being direct and 372 indirect applications. Fourteen students were admitted and two deferred. Ten students began the program in AY2018 and one student deferred to AY2019.

Student Support

Incoming students will be supported through a combination of fellowships and research assistantships. Second-year students will primarily be covered by graduate assistantships and fellowships.

Employment Opportunities

The overall profile and skill set to be acquired by the program participants is one whose value has been rising in recent years. There is growing interest in the systems aspects of autonomy, energy, finance, social networks, and urban science in industry, the public sector, and academia. It is expected that students will have access to a broad spectrum of employment opportunities.

Statistics and Data Science Center

Undergraduate Minor in Statistics and Data Science

As the home of MIT's emerging statistics community, IDSS is working to offer academic programs in statistics to MIT's undergraduate and graduate students. The first of these is MIT's new minor in Statistics and Data Science, which launched in fall 2016. Through six required subjects, this program will provide students with a base of working knowledge in statistics, probability, and computation, and develop their ability to perform data analysis.

Curriculum

Six subjects are required to qualify for the minor in Statistics and Data Science. The curriculum begins with one foundation subject and then advances to two statistics subjects—one each from statistics 1 and statistics 2—and then two subjects in computation and data analysis. After completing these, students take one capstone subject. To offer flexibility with the student's major program, students may petition the statistics minor oversight committee to take a more advanced graduate subject in place of the standard choices.

SDSC is also continuing to develop a PhD program in statistics and data science.

Technology and Policy Program

TPP is an interdisciplinary graduate program, formed in 1975, that educates students focusing on issues at the interface of technology, society, and the sociotechnical aspects of complex systems. TPP is dedicated to educating engineers and scientists who wish to lead in the development and implementation of responsible technology strategies and policies to benefit humankind. Three principles emerging from this mission frame TPP's educational objectives:

- Dual professional excellence in engineering or science and policy analysis and development

- Knowledge and flexibility to manage conflicting interests and values at all stages of the policy process

- Effective leadership and communication skills in the technology policy process

Students

TPP offers a two-year master's of science degree program, and encourages its students to pursue doctoral research in the areas of technology, management, and policy (TMP). TPP's applicant cohort is diverse, with applications coming from graduates of undergraduate programs around the world, many of whom have additional practical work experience. Additionally, approximately one-third of TPP students concurrently pursue a second master's degree or a doctoral degree in another department. The annual program student intake averages 40 students, with more than 40% women and less than 40% international students.

Graduation and Employment

In AY2017, 38 students graduated with an SM degree from the Technology and Policy Program, 11 of whom earned a second MIT SM. This year, four of these graduating students are entering PhD programs, most at MIT. Other graduates take jobs in industry, government service, startups, or consulting. Of the roughly 1,200 graduates of TPP over its 40-year history, about 40% currently work in industry, 20% in consulting, 15% in academia, 12% in government, and the rest in other industries (law, nonprofit, and so on).

Research

Many TPP students are affiliated with the MIT Energy Initiative, where they study the challenges of energy choices, sustainability policy, and environmental responsibility. TPP students also conduct research for many other laboratories and centers across campus, including the Tata Center, the Joint Program on the Science and Policy of Global Change, the Center for Energy and Environmental Policy Research, the Center for Complex Engineering Systems, the Computer Science and Artificial Intelligence Laboratory, the MIT AgeLab, the Humanitarian Response Lab, and a number of research initiatives connected with IDSS, including the Lean Advancement Initiative and the Sociotechnical Systems Research Center.

TPP faculty are engaged with the MIT Portugal Program in bioengineering systems, sustainable energy and transportation, and design-inspired products. Many TPP students are pursuing collaborative international research projects in engineering systems as a part of the MIT Portugal Program. TPP students are also working with Draper Laboratory, Lincoln Laboratory, and with MIT and Singapore University of Technology and Design (SUTD) faculty in the development of new curricula for SUTD (for the International Design Center in particular). On campus, TPP faculty are engaged in research, along with TPP students, under MIT initiatives such as the Environmental Solutions Initiative, the Abdul Latif Jameel World Water and Food Security Laboratory, and more.

Fellowships

TPP students received a number of MIT fellowships, including fellowships from the Legatum Center for Development and Entrepreneurship, the MIT Energy Initiative, the MIT Tata Center for Technology and Design, Lincoln Laboratory, Keil, the Leading Technology and Policy Initiative, and diversity fellowships from the Office of the Dean for Graduate Education. Additionally, TPP students have been awarded external fellowships, including fellowships from the National Science Foundation and fellowships from Japan and Thailand.

Policy Internship Program

Eight TPP students representing four countries traveled to Washington, DC, in March 2017. This annual trip gives students an opportunity to build professional networks with others working at the intersection of science, technology, and policy. TPP alumni arranged and hosted presentations at NASA, Third Way, the Office of Management and Budget, the Federal Emergency Management Agency, the American Association for the Advancement of Science, the US Department of Energy, the US Department of Defense, and the World Bank. During the trip, TPP hosted a networking reception for students and alumni.

During summer 2017, TPP funding provided stipend support for several students with unpaid internships. These students interned at the US Office of Management and Budget, the US Department of Commerce's National Telecommunications and Information Administration, the US Office of Science and Technology Policy, Consorzio Venezia Nuova (a nongovernmental organization in Venice, Italy), and the German Ministry for Economic Affairs and Energy.

Other TPP students participated in paid internships, including Tesla, the Boston Consulting Group, Goldman Sachs, the RAND Corporation, the Sustainability Roundtable Inc., and the National Renewable Energy Lab.

Conferences and Workshops

TPP is a founding member of the Technology Management and Policy Graduate Consortium, which includes programs in North America, Europe, and Asia. The annual meetings of this consortium afford TPP students and IDSS-ES doctoral students the opportunity to share their research and network with students across the globe. More than 50 students and faculty from 11 universities typically participate in the event. This year's TMP Consortium meeting was hosted by Stony Brook University. Through a generous private donation, TPP was able to provide travel funds for four TPP and IDSS-ES PhD students. Sarah Fletcher (TPP '12), ES PhD candidate in IDSS, was given the best presentation award for "Flexible Water Supply Planning Under Multiple Uncertainties: A Differentiated Approach."

The annual MIT Energy Conference, MIT India Conference, MIT Global Startup Workshop, and MIT Energy Night leadership teams featured several TPP students. TPP students are involved in the leadership of several MIT organizations, including the MIT Energy Club, the MIT Clean Energy Prize, the Science Policy Initiative, the Sustainability Initiative, the Mining, Oil, and Gas Club, Graduate Women at MIT, Le4Dev, the Graduate Student Council, the Global Poverty Initiative at MIT, Hacking Medicine at MIT, MIT house committees, English as a second language tutors, the Graduate Student Leadership Institute, and the Transportation Club.

Student Honors and Awards

TPP students received honors and awards from MIT and beyond. During the past year, students won the Jody Endres Student Paper Competition hosted by the Federal Aviation Administration Aviation Sustainability Center; took second prize at the National Fire Control Symposium 2017 Poster Competition; won the Brian Mar Best Student Paper Award at the INCOSE International Symposium 2016; received more than one MIT Clean Energy Prize; won Legatum Seed grants, the MIT IDEAS global challenge grant, and MIT Sandbox grants; were given the Women Power Award (International Development Hackathon 2017); and were given the Schmidt MacArthur Fellowship, the Best Early Stage Idea Award at the Civil and Environmental Engineering Innovation Awards 2016, and an MIT.

TPP Student Society

In March, the TPP Student Society (TPSS) organized a TPP alumni–student reception and dinner in the new TPP student space in E17. In light of its success, TPSS is planning to make it an annual event. Among this year's highlights were the Culture Nights and the iAmbassador series, which gave international students an opportunity to give presentations about their culture and technology policy issues in their home countries. The TPSS Coffee Talks returned for a second year. These events gave students an opportunity to talk to each other about subjects of great personal interest to them. TPSS sponsored thesis-writing sessions during the spring term and provided coffee and donuts for all thesis writers. Additionally, the annual InterYear Retreat continues to be one of the biggest events of the year.

Alumni Engagement

With more than 1,200 alumni, TPP continues to foster a strong alumni community. TPP alumni host students at their organizations during annual DC visits. In the past, alumni have supported student and program initiatives, including funding for summer internships, recruitment and outreach, and support for women in technology and policy.

Leadership

Munther Dahleh, the director of MIT's Institute for Data, Systems, and Society, is serving as TPP's interim director. Noelle Selin, associate professor in Earth, Atmospheric, and Planetary Sciences, serves as associate director. Frank Field is TPP's director of education.

Research

IDSS takes a holistic and data-driven approach to analyzing complex, high-impact systems in society. IDSS research integrates systems thinking, state-of-the art quantitative analysis, and an understanding of human and institutional behavior into its methodologies, aiming to address broad overarching challenges inherent to highly interconnected and data-rich systems. Specifically, IDSS research explores resilience and systemic risk, system design and architecture, sustainability and policy, and data-to-decisions. Below are details about the research laboratories and centers within IDSS.

Laboratory for Information and Decision Systems

The major research laboratory within IDSS, the Laboratory for Information and Decision Systems (LIDS), is an interdepartmental research center committed to advancing research and education in the analytical information and decision sciences. Specific interests include systems and control, communications and networks, and inference and statistical data processing. Throughout its history, LIDS has been at the forefront of major methodological developments in a wide range of fields, including telecommunications, information technology, the automotive industry, energy, defense, and human health. Building on past innovation and bolstered by a collaborative atmosphere, LIDS members continue to make breakthroughs that cut across traditional boundaries.

Munther Dahleh
Director, MIT Institute for Data, Systems, and Society
William A. Coolidge Professor, Electrical Engineering and Computer Science

Statistics and Data Science Center

Statistics and data science are powerful tools across many disciplines represented at MIT—from economics and anthropology to computer science and environmental engineering. The Statistics and Data Science Center was created within IDSS to formalize and consolidate efforts in statistics at MIT. The center serves as an MIT-wide focal point for advancing research and education programs related to statistics and data science by developing new academic programs in this field.

In the current global marketplace, with the increasing availability of unprecedented quantities of both data and computational resources, the science of statistics—making

inferences and decisions under uncertainty—is an increasingly relevant area of study. In particular, the need to process and manage massive amounts of data has become a key feature of modern statistics. This aspect of managing and processing data is popularly referred to as "data science."

The Statistics and Data Science Center's (SDSC) mission, working within the Institute for Data, Systems, and Society is to serve as an MIT-wide focal point for advancing research and education programs related to statistics and data science by developing new academic programs in this field.

Leadership

Professor Devavrat Shah (Electrical Engineering and Computer Sciences) was appointed the center's first director in 2016. Additional leadership comes from members of the center who partially represent the diversity of research foci the center embraces. These include Emery Brown (Brain and Cognitive Sciences), Victor Chernozhukov (Economics), David Gamarnik (Management) and Philippe Rigollet (Mathematics).

Education: Minor in Statistics and Data Science

In spring 2017, the first group of students graduated with the undergraduate minor in Statistics and Data Science. This minor had a six-subject curriculum whose final requirement was the capstone subject IDS.012 Statistics, Computation and Application. Graduating students chose statistics and data science to complement their studies in a number of departments, including Mathematics, Biological Engineering, Electrical Engineering and Computer Science and Mechanical Engineering.

Professional Education Course—Data Science: Data to Insights

The six-week online professional education course, Data Science: Data to Insights was launched in October 2016 with more than 1,200 students enrolled in the first offering of the class. More than 1,000 students earned certificates and more than 900 students earned continuing education units. Subsequent offerings of the course have had similar enrollment numbers. The course focuses on analytics for data scientists, business analysts, engineers, and technical managers in businesses from startups to larger corporations.

Co-directed by Devavrat Shah and Philippe Rigollet, this MIT Professional Education offering incorporates streaming video instruction from MIT faculty members across multiple departments. The curriculum is composed of five modules that engage students with a variety of topics, including recommendation engines, regressions, network and graphical modeling, anomaly detection, hypothesis testing, machine learning, and big-data analytics, with the end goal of learning how to apply data science techniques to effectively address organizational challenges.

Workshops and Conferences

SDSCon 2017

This year featured the inaugural SDSCon, on April 21, 2017. The event featured short talks from most of the faculty in SDSC, along with three longer presentations from outside experts, a brief industry session, and a graduate student poster session. Videos

of the talks were also made available online. The conference was well-attended and generated interest future events.

Plenary speakers included:

- J. Michael Steele, professor of statistics, University of Pennsylvania. Steele discussed new theoretical work related to understanding the Saint Petersburg paradox in relation to algorithms for real-time sequential decision making.

- Jennifer Listgarten, senior researcher, Microsoft Research. Listgarten discussed some of the modeling challenges in finding the genetic underpinnings of disease, and how machine learning approaches were developed to enable more effective CRISPR gene editing.

- James Stock, professor of economics, Harvard University. Stock discussed the value of statistical approaches to the science of climate change, compared with the use of complex models, and how statistical approaches can contribute to the public discussion in ways those models cannot.

Stochastics and Statistics Seminar Series

This signature series of weekly seminars hosted at MIT features top statisticians and data scientists from around the world. Seminars in fall 2016 and spring 2017 seminars included:

- Sparse PCA via Covariance Thresholding—Yash Kiran Deshpande (Microsoft Research)

- Shotgun Assembly of Graphs—Elchanan Mossel (MIT)

- Interpretable Prediction Models for Network-Linked Data—Liza Levina (University of Michigan)

- Influence Maximization in Stochastic and Adversarial Settings–Po-Ling Loh (University of Wisconsin, Madison)

- Matrix Estimation by Universal Singular Value Thresholding—Sourav Chatterjee (Stanford University)

- On the Asymptotic Performance of f_q-Regularized Least Squares—Arian Maleki (Columbia University)

- Eigenvectors of Orthogonally Decomposable Functions and Applications—Mikhail Belkin (Ohio State University)

- Invertibility and Condition Number of Sparse Random Matrices—Mark Rudelson (University of Michigan)

- Theory to Gain Insight and Inform Practice: Re-Run of IMS Rietz Lecture, 2016 — Bin Yu (University of California, Berkeley)

- Less Is More: Optimal Learning by Subsampling and Regularization—Lorenzo Rosasco (University of Genova and MIT)

- Couplings of Particle Filters—Pierre Jacob (Harvard University)

- Invariance and Causality—Jonas Peters (University of Copenhagen)

- Some Related Phase Transitions in Phylogenetics and Social Network Analysis—Sebastien Roch (University of Wisconsin–Madison)

- Testing Properties of Distributions Over Big Domains—Ronitt Rubinfeld (MIT)

- Active Learning With Seed Examples and Search Queries—Daniel Hsu (Columbia University)

- Sample-Optimal Inference, Computational Thresholds, and the Methods of Moments—David Steurer (Cornell University)

- Jagers-Nerman Stable Age Distribution Theory, Change Point Detection and Power of Two Choices in Evolving Networks—Shankar Bhamidi (University of North Carolina)

- Probabilistic Factorizations of Big Tables and Networks—David Dunson (Duke University)

- Robust Statistics, Revisited—Ankur Moitra (MIT)

- Computing Partition Functions by Interpolation—Alexander Barvinok (University of Michigan)

- Estimating the Number of Connected Components of Large Graphs Based On Subgraph Sampling—Yihong Wu (Yale University)

- Causal Discovery in Systems with Feedback Cycles—Frederick Eberhardt (California Institute of Technology)

- Slope Meets Lasso in Sparse Linear Regression—Pierre Bellec (Rutgers University)

- Non-Classical Berry-Esseen Inequality and Accuracy of the Weighted Bootstrap—Mayya Zhilova (Georgia Institute of Technology)

Research Priorities

Faculty members of the Statistics and Data Science Center have wide-ranging research interests. In recent years, these have included:

- Alberto Abadie, professor, Economics: econometrics, casual inference, program evaluation

- Guy Bresler, Bonnie and Marty Tenenbaum Career Development Assistant Professor, Electrical Engineering and Computer Science: graphical model learning, high-dimensional statistics

- Tamara Broderick, ITT Career Development Assistant Professor: scalable, robust Bayesian inference and graphical models, nonparametric Bayesian models and inference, Bayesian unsupervised learning

- Emery Brown, Edward Hood Taplin Professor of Medical Engineering and Computational Neuroscience: state-space and point process models of neural systems, state-space models for spectral analyses, tracking brain states under general anesthesia

- Victor Chernozhukov, professor, Economics: causal inference using machine learning methods, central limit theorems in very high dimensions, quantification of uncertainty in high-dimensional inference

- David Gamarnik, professor, Sloan School of Management: algorithms and optimization in stochastic models, high dimensional statistics, inference in graphical models

- Stefanie Jegelka, X-Consortium Career Development Assistant Professor, Electrical Engineering and Computer Science: combinatorial distributions and models in statistics and machine learning, convex and combinatorial optimization, submodular functions, kernel methods

- Rahul Mazumder, assistant professor, Sloan School of Management: modeling and computation in multivariate statistics with convex and discrete optimization, statistical methods for low-rank modeling, graphical models, variable selection, robust statistics, nonparametric function estimation

- Anna Mikusheva, associate professor, Economics: econometrics, time series, uniform inferences

- Elchanan Mossel, Professor, Mathematics: combinatorial statistics, discrete Fourier analysis and influences, randomized algorithms, computational complexity, MCMC, Markov random fields, social choice, game theory, evolution

- Whitney Newey, Jane Berkowitz Carlton and Dennis William Carlton Professor of Economics: semiparametric estimation, inference in large dimensional models, nonlinear panel data, economic models with functional heterogeneity

- Philippe Rigollet, assistant professor, Mathematics: high-dimensional statistics, statistical and computational tradeoffs, online learning

- Devavrat Shah, professor, Electrical Engineering and Computer Science: nonparameteric framework for recommendation systems, inference and graphs, centralized data center networks

- Caroline Uhler, Henry L. and Grace Doherty Assistant Professor, Ocean Utilization, Electrical Engineering and Computer Science: graphical models and causal inference, algebraic statistics, inferring gene regulatory networks in space and time

- Roy Welsch, professor of Statistics and Management Science, Sloan School of Management: robust statistics and data mining, inference for sparse estimation, repurposing of drugs

Devavrat Shah
Director, Statistics and Data Science Center
Professor of Electrical Engineering and Computer Science

Sociotechnical Systems Research Center

The Sociotechnical Systems Research Center (SSRC) is an interdisciplinary research center that seeks collaborative, multidisciplinary, systems-theoretic approaches to complex societal challenges. The center administers research that brings together faculty, researchers, students, and staff from across MIT to study complex enterprises that span government, industry, the service sector, and health care.

In addition to facilitating world-leading research in sociotechnical systems, SSRC is a major unit within the Institute for Data, Systems, and Society. As such, SSRC plays a key part in shaping and supporting IDSS's most high-profile events. This year, SSRC helped support the IDSS Launch Event, a two-day symposium celebrating IDSS's inaugural year, as well as the Smart Urban Infrastructures Workshop of the Laboratory for Information and Decision Systems, which showcased current work and emerging research opportunities at the intersection of smart services and urban infrastructure systems.

SSRC supports IDSS faculty research and comprises several ongoing research programs. Its total research volume in FY2017 was approximately $9.7 million. SSRC's research partners include the Center for Biomedical Innovation, the Center for Complex Engineering Systems, the Consortium for Engineering Program Excellence, the Ford–MIT Alliance, MIT Connection Science, and the Systems Engineering Advancement Research Initiative. The following sections highlight the key activities of the year for each of these centers.

Center for Biomedical Innovation

The MIT Center for Biomedical Innovation (CBI) integrates the Institute's technical, scientific, and management expertise to solve complex biopharmaceutical challenges and improve the impact of biomedical innovation on society.

Sponsored Non-Research Activities

The center advances cross-stakeholder collaboration and practice through a range of multidisciplinary real-world initiatives. These activities bring parties together for mutual advantage and create system-scale healthcare impact. This year's initiatives included work with new drug development paradigms (NEWDIGS), a biomanufacturing program (BioMAN), and the Consortium on Adventitious Agent Contamination in Biomanufacturing (CAACB).

New Drug Development Paradigms

NEWDIGS is a collaborative "think and do" effort with a mission to enhance the capacity of the global biomedical innovation system to reliably, efficiently, and sustainably deliver new, better, and affordable therapeutics to the right patients. Major NEWDIGS activities this year were the WISDOM Project, which focuses on addressing the challenges associated with generating non-traditional data that will be acceptable to key decision makers in pharmaceutical innovation; and the FoCUS (Financing and Reimbursement of Cures in the US) Project, which addresses the pressing need for innovative financing and reimbursement models for curative therapies that ensure timely access for patients in need, affordability for payers, and incentives for sustainable

innovation by manufacturers. Launched in May 2016, the FoCUS Project was advanced through design labs in October 2016 and April 2017.

Biomanufacturing Program

A global health initiative to expand access to biotherapeutics, BioMAN involves faculty from across a broad range of the MIT community. This year BioMAN hosted two working group sessions (one on product quality control for cell and gene therapy biotherapeutics and the other on process intensification in biomanufacturing); the eighth annual BioMAN Summit (the topic was Transforming Manufacturing to Supply Biologic Medicines for Today and Tomorrow); and co-organized a Vaccines Bioprocess and Commercialization Workshop with University College London.

Consortium on Adventitious Agent Contamination in Biomanufacturing

CAACB focuses on mitigating the risk of adventitious agent contamination in biomanufacturing through collaborative research between MIT and the consortium's sponsors (25 biopharmaceutical manufacturers and technology and service providers). The consortium currently has four major projects, including an industry-wide assessment of viral contamination experiences, best practices in risk assessment, harmonization of media treatment data, and evaluation of the most effective and economic options available. During the past year, CAACB hosted two workshops at MIT: New Technologies for the Detection and Control of Adventitious Agents, and Adventitious Agent Control of Emerging Products.

Research Highlights

CBI was awarded a grant from the National Institutes of Health via the Johns Hopkins and Tufts University Trial Innovation Center to develop and host design labs for exploring the efficacy-to-effectiveness clinical trial strategy and implementation. Two design labs were held this year, in November 2016 and February 2017, as part of the NEWDIGS initiative.

In October 2016, CBI and Sanofi Pasteur kicked off their Continuous Viral Vaccine Manufacturing research project. This $1.5 million project will allow Sanofi Pasteur to work with Professors Richard Braatz (Chemical Engineering) and Anthony Sinskey (Biology), as well as CBI research scientists and postdoctoral associates, to create a process model that will allow the continuous platform process to be used across a variety of cell and virus types to make vaccines faster, better, and more affordable.

The project (Addressing Nontraditional Adulteration of FDA-Regulated Food and Drug Products and Ingredients Emanating from the Global Supply Chain) concluded in December 2016. The project, which had been funded by the Food and Drug Administration for three years and $2.7 million, was a collaboration between faculty, staff, and students from the Sloan School of Management, the Computer Science and Artificial Intelligence Laboratory, and CBI. The project focused on China—the US's third largest source of food imports. CBI, the Department of Chemical Engineering, and the Sloan School have received additional funding ($1.5 million a year) from the Walmart Foundation to continue the research over the next three to five years. The project aims to

create new systemic solutions to predict, monitor, and mitigate risks related to end-to-end food supply chains (e.g., poultry and seafood), particularly economically motivated adulteration risks that present a major threat to the public health, and, more generally, to the public trust in the integrity of the food system.

National Institute for Innovation in Manufacturing Biopharmaceuticals

CBI was instrumental in launching a major new national effort in biopharmaceutical manufacturing, the National Institute for Innovation in Manufacturing biopharmaceuticals (a Manufacturing USA institute). As a public-private partnership focused on innovation in manufacturing processes and the associated US workforce, the National Institute for Innovation in Manufacturing Biopharmaceuticals is the only institute of its type and size in the world.

CBI personnel have played key roles in the institute's development and growth from the start, providing significant support to all structural efforts, including proposal writing, team-building at the local and national levels, fundraising, and partner negotiations. CBI gathered support for the institute from more than 150 industrial, academic, governmental, and nonprofit entities, and continues to drive its design and leadership.

Paula (Gigi) Hirsch, MD, is the executive director of CBI.

The Center for Complex Engineering Systems

The Center for Complex Engineering Systems (CCES) is based jointly at MIT and the King Abdulaziz City for Science and Technology (KACST), Saudi Arabia's national science agency. Since its inception in 2011, CCES has been part of KACST's Joint Centers of Excellence Program. The program's core mission is to foster the research environment necessary to improve competitiveness and capacity for innovation through scientific inquiry, and to participate in a rigorous training program for the most promising young scholars, who are selected from the top 0.5% of applicants from across the Kingdom. CCES has notably high research outputs as well as high acceptance rates to top-tier schools of engineering.

The impact of CCES research is not only in its volume but also in its rigor—and it has been a particularly important resource for policy makers focused on the modernization of Saudi Arabia's infrastructure and its transition to a knowledge-based economy. CCES continues to deepen and expand its relationships with key stakeholders in Saudi Arabia, partnering directly with entities such as the Ministries of Labor, Economy and Planning, and Water and Electricity, as well as the Arriyadh Development Authority.

In spring 2017, CCES concluded a series of six research projects. These projects focused on energy management at the urban, national, and regional scales; the integration and optimization of transportation networks; the expansion of the innovation space within the Kingdom's economy and technology policy; and developing platforms for integrating decision support systems that leverage interconnected aspects of findings across CCES's portfolio.

There are 14 MIT faculty members—from seven academic departments—who serve as principal investigators on CCES projects. The number of research affiliates has also grown significantly in both Cambridge and Riyadh. Currently, close to 100 students, research affiliates, and postdoctoral associates are members of CCES, split nearly equally between Cambridge and Riyadh.

To date, CCES-funded affiliates have authored or co-authored close to 100 publications, including works in progress for peer-reviewed journals and leading conference venues. Many of these publications have been jointly authored by CCES researchers based both at KACST and MIT, demonstrating the successes of the collaboration. Links to these articles, as well as biographical information about the center's affiliates, can be found on the CCES website.

Since January 2017, Professor Kamal Youcef-Toumi has assumed leadership of CCES as the MIT co-director. He replaces Professor Olivier de Weck, who is on a multi-year leave of absence.

Consortium for Engineering Program Excellence

Research efforts within the Consortium for Engineering Program Excellence (CEPE) focus on improving program performance by examining the relationships and interactions between diverse functions and stakeholders involved in complex engineering programs. The research is framed through the lenses of program management, systems engineering and product development, lean management, and organizational change fields. Its strategic partners in this work are the Project Management Institute and the International Council on Systems Engineering. A book, *Integrating Program Management and Systems Engineering* (Eric Rebentisch, editor-in-chief), was completed and published in 2017. It captures insights from CEPE research and from the work done by other contributors in this area. Five conference papers were accepted and presented. Additionally, one conference keynote, four panel presentations, and three global webinars (associated with *Integrating Program Management*) were delivered. During this period, one CEPE-advised PhD dissertation and five master's theses were completed, and another six master's theses were begun.

Professor Warren Seering is CEPE's principal investigator, and Dr. Eric Rebentisch is research lead.

Ford–MIT Alliance

The Ford–MIT Alliance, an Institute-wide initiative, was established in 1998. The alliance is the Institute's longest-running large-scale collaboration with industry. Since 1998, the alliance has funded more than 150 projects across the Institute, with a total investment to date by Ford of more than $50 million. The Ford–MIT Alliance research portfolio is managed by an operating committee that includes two co-directors— Professor Jonathan How and Ed Krause, Ford's global manager of external alliances, Division of Research and Advanced Engineering. The operating committee reports to an executive committee that includes Karen K. Gleason, who is both associate provost and the Alexander and I. Michael Kasser Professor of Chemical Engineering, and Ken Washington, vice president

of research and advanced engineering, Ford Motor Company. The alliance holds executive committee meetings on campus at least once a year. This year, the alliance had a record number of participants from the MIT faculty.

MIT Connection Science

Professor Alex "Sandy" Pentland's MIT Connection Science research initiative continued to receive increased funding for research that utilizes communications networks to access and change real-world human behavior. The group has also made significant progress toward the development of the so-called Trust Networks system—a mechanism for permitting encrypted queries, decentralized identity, trusted computation, attribute exchange, and trusted computation on the internet. The first release of this groundbreaking system is expected to be in fall 2017; it will subsequently be made available under the MIT license. This work supports the emerging personal data ecosystem in which people, organizations, and computers can manage access to their data more efficiently and equitably.

Systems Engineering Advancement Research Initiative

Several research projects with government offices in the US Department of Defense, the Naval Postgraduate School, and the Norwegian University of Science and Technology continues. The Systems Engineering Advancement Research Initiative (SEAri) leads MIT's continuing participation in the US Department of Defense University Affiliated Research Center (UARC), or Systems Engineering Research Center (SERC). SEAri is actively engaged in collaboration with other universities involved in the SERC research program, such as the Georgia Institute of Technology, the University of Southern California, and the University of Virginia. Ten graduate students (at both the master's and the doctoral levels) from several degree programs performed research with the group.

SEAri published and presented four conference papers and two government reports, published one co-authored book chapter, presented two invited talks, and presented at the MIT Industrial Liaison Program 2017 Europe Conference. SEAri received the Brian Mar Best Student Research Paper Award, awarded by the International Council on Systems Engineering. SEAri researchers co-developed and taught in MIT's Professional Education online four-course certificate program in Architecture and Systems Engineering: Models and Methods to Manage Complex Systems. The program, in which MIT collaborated with Boeing and edX, received the 2017 Excellence in Engineering Education Collaboration Award by the American Society for Engineering Education.

Donna Rhodes, PRS, is SEAri's principal investigator, and Adam Ross is a collaborating research scientist.

Ali Jadbabaie
Director, Sociotechnical Systems Research Center
Associate Director, Institute for Data, Systems, and Society
JR East Professor of Engineering