

## **Engineering Systems Division**

Now 10 years old, MIT Engineering Systems Division (ESD) represents a bold educational and research initiative aimed at tackling challenges to complex engineering systems by integrating engineering, management, and social sciences approaches, using new framing and modeling methodologies. The vision of ESD is that, in the future, the fundamental principles and properties of engineering systems will be well understood so that these systems can be modeled, designed, and managed effectively. ESD is an interdisciplinary academic unit spanning most departments within the School of Engineering as well as the School of Humanities, Arts, and Social Sciences; the Sloan School of Management; the School of Science; and the School of Architecture and Planning.

ESD brings together students and faculty interested in research that focuses on complex systems of national and international importance involving technology, organizations, and individuals. ESD has chosen to focus on four key domains: extended enterprises, energy and sustainability, critical infrastructures, and health care delivery. While technology is a fundamental part of these systems, so too are issues of managerial and societal interactions. To make sure that the approaches and solutions developed by ESD are relevant, faculty and students have forged novel relationships with partners in industry, government, and academia.

Approximately 60 faculty members, most holding dual or joint appointments within ESD and one of the aforementioned units, are devoted to teaching and research in the field of engineering systems. Approximately 351 students are enrolled in ESD's five master's programs, with another 52 students in our PhD program, and 42 visiting or certificate students. All are working to understand, model, and predict the behavior of technologically enabled complex systems in order to help the engineering profession address contemporary critical issues and better serve society.

### **Faculty**

This year professor Yossi Sheffi continued as ESD director and Olivier de Weck, associate professor of aeronautics and astronautics and engineering systems, continued as ESD associate director. During AY2009, Nancy Leveson, professor of aeronautics and astronautics and engineering systems, oversaw ESD's PhD program, including admissions, and chaired the ESD Education Policy Committee.

Currently, there are 51 ESD faculty members: 36 in engineering; 10 in management; one in science; 2 in humanities, arts, and social sciences; and 2 in architecture and planning. Twenty-four hold dual appointments, 25 hold joint appointments, and 2 hold full-time appointments in ESD only. ESD is also home to 2 professors of the practice. In addition, there are 8 members of the teaching staff, including 2 senior research scientists.

### **New ESD Faculty from MIT**

ESD welcomed two new joint faculty members in January 2009: David Geltner and Christopher Zegras, both from the School of Architecture and Planning. With these appointments, ESD now has faculty from all five MIT schools.

Professor David Geltner is the director of research for the MIT Center for Real Estate (MIT/CRE), as well as the George Macomber professor and professor of real estate finance in the MIT Department of Urban Studies and Planning (DUSP). Professor Geltner served as director of the MIT/CRE from 2003 to 2008 and headed MIT's master of science in real estate development program. His research focuses on measuring real estate investment performance and the related areas of asset valuation and private asset market functioning. Professor Geltner is coauthor of the graduate textbook *Commercial Real Estate Analysis and Investments* and is a former coeditor of *Real Estate Economics*, the leading academic journal in the real estate field. Geltner has been working closely with professor Richard de Neufville on a new joint ESD/DUSP course. Professor Geltner received his PhD from the MIT Department of Civil and Environmental Engineering in the field of infrastructure finance and economics. He also has degrees in urban studies from Carnegie Mellon University and the University of Michigan.

Professor Christopher Zegras is the Ford Career Development assistant professor of transportation and urban planning in DUSP. Professor Zegras's research interests include the influence of the built environment on individual travel behavior, transportation infrastructure and system financing, developing indicators of sustainable transportation, comparative analyses of metropolitan transportation systems, and mitigating transportation greenhouse gas emissions. Along with teaching graduate-level courses in urban transportation planning, statistics, and land use transportation planning in DUSP, he serves as the MIT lead for the MIT Portugal Program Transportation Systems Focus Area. He is also a member of the Campus Energy Task Force of the MIT Energy Initiative. Zegras holds a master's in city planning and a master of science in transportation from MIT and a PhD in urban and regional planning, also from MIT.

### **Promotions Within ESD**

Randolph E. Kirchain was promoted to the position of associate professor without tenure effective July 1, 2009. (Kirchain will be leaving MIT in June 2010.) Kirchain, a dual faculty member of ESD and the Department of Materials Science and Engineering, received a PhD from MIT. His research focuses on the environmental and economic implications of materials selection, specifically looking at the development of methods to model the cost of manufacture, using limited design information and the sustainability of current and emerging materials systems.

John Williams was promoted to the position of full professor, effective July 1, 2009. Williams is professor of information engineering, engineering systems, and civil and environmental engineering and is director of the Auto-ID Laboratory. Williams is internationally recognized in the field of computational algorithms for large-scale particle simulators and wrote two books and over 100 publications. For the past eight years, his research has focused on architecting large-scale distributed simulation systems. He teaches graduate courses on modern software development and web system architecting. Williams holds a BA in physics from Oxford University, an MS in physics from the University of California at Los Angeles, and a PhD from Swansea University.

## Faculty Search

After an extensive faculty search, ESD hired Jessika Trancik, who will join ESD as an assistant professor, effective January 1, 2010. Trancik is a postdoctoral fellow at the Santa Fe Institute and an adjunct associate research scholar at Columbia University's Earth Institute. Her research looks at possible pathways for designing energy conversion and storage devices with low carbon intensity and low costs.

## ESD Strategic Report

In August 2008, ESD published a strategic report that aimed to describe the field of engineering systems; clarify the vision, mission, and values of ESD; and look ahead at the role of engineering systems in the future. The report discusses the four main domains of ESD research (listed above) and also describes ESD's multidisciplinary research approaches, which include humans and technology, uncertainty and dynamics, design and implementation, networks and flows, and policy and standards. The full report can be downloaded at [http://esd.mit.edu/HeadLine/ESD\\_StrategicPlan2008.pdf](http://esd.mit.edu/HeadLine/ESD_StrategicPlan2008.pdf).

## Redesigned and Expanded Website

Building on the look and language of the ESD strategic report, ESD relaunched its website, <http://esd.mit.edu/>, in early June 2009. The new site features extensive new and updated content, bringing to life ESD research and engaging users in thinking about large-scale engineering systems challenges. The site seeks to clearly represent ESD's many academic and research programs, offering comprehensive information and resources to those within and outside the ESD community.

## Ongoing Initiatives

### Graduate Education

As a division, ESD establishes an intellectual home for key programs and centers, engages faculty across departments and disciplines, and fosters discourse about engineering innovation, all oriented around the issues of engineering systems. In addition to the ESD SM, master's-level programs include Leaders for Global Operations (LGO), the Master of Engineering in Logistics (MLOG), System Design and Management (SDM), and Technology and Policy Program (TPP). A PhD is offered in engineering systems. Now in their sixth year, the Engineering Systems PhD and Engineering Systems SM programs admitted the sixth full classes of 12 ESD PhD and one ESD SM students. An additional 26 ESD SMs entered Leaders for Manufacturing (LFM) in June 2009 (class of 2011). Graduating this academic year were 11 ESD PhDs, three ESD SMs, and 17 LFM ESD SMs.

### Undergraduate Education

The Bernard M. Gordon–MIT Engineering Leadership Program, directed by professor Edward Crawley, provides selected undergraduates with a set of leadership-oriented, discipline-building, hands-on engineering activities set in the context of the practice of engineering. The program, housed in the School of Engineering, is designed to develop outstanding MIT students as disciplined, future leaders in the world of engineering practice. For more details, visit <http://web.mit.edu/gordonelp/>.

## Research

In February 2009, the Center for Biomedical Innovation (CBI) joined ESD, allowing ESD and CBI to more closely align their efforts in tackling large-scale challenges in the health care industry. ESD continues to encompass several major research centers, including the Center for Engineering Systems Fundamentals (CESF); the Center for Technology, Policy, and Industrial Development (CTPID); and the Center for Transportation and Logistics (CTL). In addition, the MIT Portugal Program continues to thrive. These research programs are described later in this report.

Also, professor of civil and environmental engineering and engineering systems Fred Moavenzadeh is director of the MIT Technology and Development Program, and along with David Marks, Morton and Claire Goulder Family professor of civil and environmental engineering and engineering systems, he is on executive committees for the Abu Dhabi Cooperative Program and the Masdar Institute. The Masdar Institute is a private, not-for-profit, independent, research-driven institute developed with the support and cooperation of MIT. The Masdar Institute is the centerpiece of the Masdar Initiative, a landmark program announced in April 2006 by the government of Abu Dhabi to establish an economic sector dedicated to alternative and sustainable energy. In January 2009, the Masdar Institute joined the MIT Energy Initiative, directed by Ernest Moniz, the Cecil and Ida Green professor of physics and engineering systems.

## MIT Portugal Program

The MIT Portugal Program, launched in October 2006, is a strategic investment in people, knowledge, and ideas by the Portuguese government to strengthen the country's knowledge base and international competitiveness. This transatlantic collaboration involves MIT, together with government, academia, and industry in Portugal, in the development of education and research programs in engineering systems. The end of AY2009 marked the halfway point in the program's initial five-year funding period. MIT Portugal is hosted by ESD and is led at the Institute by ESD's founding director, professor Daniel Roos, who serves as MIT director of the program. See the MIT Portugal Program report to the president for further information.

## 2008–2009 Personnel Achievements

### ESD Faculty Notes

Joseph F. Coughlin, senior lecturer in engineering systems and director of the AgeLab, was named one of the most creative people in business by *Fast Company* magazine in May 2009. Coughlin received the Maxwell A. Pollack Award for Productive Aging from the Gerontological Society of America.

Mary (Missy) Cummings, who joined the ESD faculty in 2008 as associate professor of aeronautics and astronautics with a joint appointment in engineering systems, continues to lead the MIT Humans and Automation Laboratory, which focuses on the multifaceted interactions of human and computer decision making in complex sociotechnical systems.

Richard de Neufville, professor of civil and environmental engineering and engineering systems and coinstructor of two MIT Portugal Transportation Systems master's degree

courses—one in transport technologies and operations management and another in structured financing of transport projects—was named a Fulbright scholar in fall 2008.

Olivier L. de Weck, associate professor of aeronautics and astronautics and engineering systems, presented the keynote address at the First International Symposium on Symbiotic, Safe and Secure System Design in Japan. He was named associate director of ESD starting July 1, 2008.

Nancy Leveson presented the Mitsui Lecture in Japan in September 2009. The lecture brings nationally and internationally prominent speakers to address issues of concern to China, Korea, and Japan.

Joel Moses, CTPID acting director, was elected a fellow of the Association for Computing Machinery.

Donna Rhodes, Systems Engineering Advancement Research Initiative (SEARI) director and member of the Lean Advancement Initiative (LAI), was appointed to West Point's Advisory Board.

Yossi Sheffi, professor of civil and environmental engineering and engineering systems accepted the 2009 International Aragon Prize on behalf of MIT. Professor Sheffi is director of ESD and CTL.

ESD/Civil and Environmental Engineering professor and LGO-SDM codirector David Simchi-Levi coauthored an article published in *The Wall Street Journal* entitled "[Crude Calculations: Why High Oil prices Are Upending the Way Companies Should Manage Their Supply Chains.](#)"

Joseph M. Sussman, JR East professor and professor of engineering systems and civil and environmental engineering, received the 2008 Joseph A. Martore Excellence in Teaching Award. Professor Sussman again taught ESD.041J Engineering System Design, an undergraduate subject. The class had 30 students, who worked in two teams of 15 on designing a new high-speed rail system for Portugal, linking together the major cities of that nation and linking it to the European Union via a link to Madrid and another to northern Spain. The class is notable for its linkage to the MIT Portugal Program, where research is being conducted on both sides of the Atlantic on this high-speed rail system.

Maria Yang was named the Robert N. Noyce career development assistant professor on July 1, 2008.

### **ESD-Affiliated Faculty Notes**

Visiting professor Dov Dori was general chair and coeditor of the proceedings of the International Conference on Model-Based Systems Engineering, Herzeliya and Haifa, Israel, March 2–5, 2009. He is co-convenor of the ISO Study Group to Explore Object Process Methodology for Modeling Standards.

LGO senior lecturer Steven Spear's book, *Chasing the Rabbit: How Market Leaders Outdistance the Competition and How Great Companies Can Catch Up and Win*, received the 2009 Shingo Prize for Research and Professional Publication.

### **Alumni Honors**

Dr. Matthew Bunn, a graduate of the PhD program, became an associate professor at Harvard University's Kennedy School of Government.

Dr. Ali Mostashari, a graduate of the PhD program, became director of the Infrastructure Systems Program and an associate professor at the Stevens Institute of Technology's School of Systems and Enterprises.

Dr. Sgouris Sgouridis, a graduate of the PhD program, became an assistant professor at the Masdar Institute of Science and Technology.

The journal *Systems Engineering* has given its 2007 Best Paper Award to Dr. Rudolf Smaling (ESD PhD alumnus) and professor Olivier L. de Weck for their paper "[Assessing Risks and Opportunities of Technology Infusion in System Design.](#)"

LGO alumnus Gavin DeNyse '01 and teammates from Hewlett-Packard Co. received the 2009 Franz Edelman Award for achievement in operations research and the management sciences. DeNyse served as the team's master strategist.

LGO alumnus Mark Graban '99 received the Shingo Prize for his book *Lean Hospitals: Improving Quality, Patient Safety and Employee Satisfaction*.

Dr. Sara Metcalf, LGO '01, published an article entitled "Modeling Boundaries of Concern Among Conflicting Stakeholders" in the October 2008 issue of *Leadership and Management in Engineering*, published by the American Society of Civil Engineers.

### **Student Honors**

Entering TPP student, Pamela DeAmicis, received an Ida M. Green Fellowship.

Entering doctoral student, Pearl Donohoo, received a BP-MIT Energy Fellowship.

Entering doctoral student, Don MacKenzie, received a William Asbjornsen Albert Memorial Fellowship.

IntAct Labs LLC, the start-up company of ESD PhD student Matthew Silver, recently received two awards. A semifinalist in the MIT 100K business plan competition, IntAct secured a \$1,000 semifinalist prize. In addition, IntAct was recently awarded an \$80,000 Phase I Small Business Innovation Research (SBIR) grant by the United States Department of Agriculture (USDA) and an SBIR from the National Science Foundation (NSF). IntAct turned down the latter due to overlapping scope with the USDA. The company is further supported by the French Foreign and Interior Ministries under the Young Entrepreneur's Initiative and has received funding from the NASA Institute for Advanced Concepts.

The paper of Matthew Richards (ESD PhD student), Lauren Viscito, Dr. Adam Ross (ESD PhD alumnus), and professor Daniel Hastings (ESD faculty) of ESD's SEArI received this year's Responsive Space Conference Student Award at the April 28 to May 1 conference in Los Angeles, CA.

*Le Tour de Monde des Energies*, cowritten by ESD PhD student Blandine Antoine and published in May 2008 in France, was nominated for Le Prix Roberval, a literary award for books written in French dedicated to communication on science and technologies.

This year's recipient of the Charles "Harrison" Smith III Award was LGO student Jeremy Stewart, who was honored for his contributions to LGO's academic program as well as its social environment. Among other contributions, Stewart was cited for spearheading the effort to develop a sustainable energy track within ESD.

Julie Mitchell received the LGO Best Thesis Award, given for the fourth year by the program. The title of her thesis is "Developing the Business Case for Quality by Design in the Biopharmaceutical Industry." Her research was conducted at Amgen.

A team consisting of LGO '10 Chad Sailer, David Follette, Paul Witinski, and Chris Lin, plus Michael Irwin MBA '10 won first place in Carnegie Mellon University's annual International Operations Case Competition.

Daniel George and Ghassan Awwad, both LGO '09, composed the first-place team for the 5th Annual Operations Simulation Competition cosponsored by MIT Sloan and GM.

A team consisting of LGO '10 Jeremy Stewart, Jonathan Dreher, and Mike Norelli was one of two finalists in the X Prize Foundation's "What's Your Crazy Green Idea?" video competition on YouTube.

The winner of the 2008 SDM Best Thesis Award was David Kim. The title of his thesis is "Generation Gaps in Engineering."

This year's Best Thesis in Technology and Policy was awarded jointly to Ashleigh Hildebrand and Marie-Claude Nadeau. Hildebrand's thesis title is "Strategies for Demonstration and Early Deployment of Carbon Capture and Storage: A Technical and Economic Assessment of Capture Percentage." Nadeau's is "Evaluating Manufacturing Flexibility Driven by Learning."

### **Employee Recognition**

Davicia Neves, ESD/LGO-SDM financial assistant II, received an MIT Infinite Mile Award for Excellence.

Christine Bates, SDM program administrator, and Eve Odiorne Sullivan, senior editorial assistant in the Laboratory for Nuclear Science, were honored with an MIT Excellence Award for cofounding Parents Forum, a grass-roots parenting program concerned with improving communication within families.

## Conferences and Lectures

### International Engineering Systems Symposium

ESD and the Council of Engineering Systems Universities (CESUN) cohosted the second International Engineering Systems Symposium June 15–17, 2009, at MIT. The well-attended event brought together more than 300 participants from academia, industry, and government to discuss significant achievements and challenges in the field of engineering systems. The symposium included approximately 40 speakers participating in eight panel discussions; a poster session; and 50 accepted papers in 12 concurrent sessions covering topics such as energy policy, flexibility, design, and risk analysis. A complete agenda and presentation slides are available at <http://esd.mit.edu/symp09/>. Professors Daniel Roos and Christopher Magee cochaired the symposium planning committee, and Renee Robins was symposium director. The planning committee included Donna Rhodes, senior lecturer in engineering systems, and ESD communications director Stefanie Koperniak.

### Brunel Lecture

Shai Agassi, founder and chief executive officer (CEO) of Better Place, delivered the annual Brunel Lecture on Complex Systems on December 4, 2008, to a full audience in the Wong Auditorium. Agassi's lecture, "From IT to Cleantech: New Sources of Innovation," focused on Better Place's mission to create a sustainable transportation system by building an innovative network of electric cars, batteries, and charging stations—allowing consumers to subscribe to personal transportation as a service, much as they do with mobile phones. The lecture can be viewed at <http://mitworld.mit.edu/video/642/>.

### Miller Lecture

John Krafcik, president and CEO of Hyundai Motor America, delivered the annual Charles L. Miller Lecture on April 8, 2009. In the lecture, entitled "Great Leaps, Persistence, and Innovation: The Evolving Story of Hyundai," Krafcik talked about how Hyundai addressed major challenges using creative and multidisciplinary approaches, becoming the seventh best-selling automotive brand in the US and the fifth-largest car maker in the world. The lecture can be viewed at <http://mitworld.mit.edu/video/665/>.

### Institute of Electrical and Electronics Engineers Systems Conference

The 2009 IEEE Systems Conference was held April 20–23, 2009, at Loughborough University in the United Kingdom. A number of ESD PhD students and faculty presented papers on topics including trade space exploration, human systems integration, and decision making.

## Major Meetings

### Visiting Committee

The ESD Visiting Committee convened at MIT on November 18 and 19, 2008. ESD faculty provided several presentations on ESD programs and research, demonstrating the scope of the division's work. The Visiting Committee's report indicated that ESD had made tangible progress since the committee's previous meeting two years prior and



recommended that ESD continue to “think big” and encouraged MIT to enable ESD growth as opportunities arise.

ESD Visiting Committee members who attended the meeting included Arthur Gelb (chair), Vernon E. Altman, Ursula M. Burns, James A. Champy, Alan M. Dachs, Sheryl L. Handler, Anita K. Jones, Henry A. Lichstein, M. Granger Morgan, Joseph Nemec, Jr., Philip C.T. Ng, John S. Reed, William B. Rouse, Peter L. Slavin, and Elizabeth A. Stock. Members Mary L. Good and Elisabeth Paté-Cornell were unable to attend.

### **Alumni Advisory Council**

The ESD Alumni Advisory Council convened on June 15, 2009, at MIT during the Engineering Systems Symposium. Professor Sheffi gave a brief update on the division, and dean of the School of Engineering Subra Suresh talked about the importance of ESD from the perspective of the School of Engineering. Dedric Carter, assistant dean for development and strategic initiatives for the School of Engineering, also attended the meeting. Alumni Advisory Council members engaged in a discussion about how to best support ESD going forward. The current members of ESD’s Advisory Council include Eric Aboaf, Jason Amaral, Thomas Davis, Moises Goldman, Joseph Harrington, Benjamin Jurewicz, Henry Lichstein, Joseph Martore, John Edward Shephard, Jr., James Shields, Donald Shobry, Matthew Siegel, and Leif Christian Ulstrup.

### **ESD Meetings**

ESD held an off-site meeting on February 6, 2009, at the MIT Faculty Club. The meeting focused on defining and further developing the fundamentals of engineering systems. ESD faculty presented brief vignettes on assorted engineering systems fundamentals, grouped into categories of systems modeling and analysis, complexity, dynamics, flexibility, enterprises, and optimality. ESD PhD students Sidharth Rupani and Erica Gralla presented an analysis of how the research of ESD PhD students has contributed to an understanding of engineering systems fundamentals, quantifying the distribution of this research across ESD’s domains and approaches. The next ESD meeting will be in early September 2009 and will focus on the ESD PhD program.

**Yossi Sheffi**

**Director, Engineering Systems Division**

**Director, MIT Center for Transportation and Logistics**

**Professor of Civil and Environmental Engineering and Engineering Systems**

*More information on the Engineering Systems Division can be found at <http://esd.mit.edu/>.*

## **Master's Programs**

### **Leaders for Global Operations**

On June 1, 2009, the MIT Leaders for Manufacturing (LFM) program announced its new name: Leaders for Global Operations (LGO). Now in its 21st year, this dual-degree program continues to offer an MBA or an SM from MIT Sloan School of Management and an SM from MIT School of Engineering. The two-year LGO experience features a cross-disciplinary curriculum, a global orientation, significant internship opportunities, and an emphasis on leadership and teamwork.

LGO partners include ABB Ltd.; Amazon.com, Amgen Inc.; The Boeing Company; Cisco Systems Inc.; Dell Inc.; Flextronics International; General Dynamics; Ford Motor Company; General Motors Corporation; Genzyme Corporation; Harley-Davidson, Inc.; Honeywell International Inc.; Inditex, S.A. (Zara); Intel Corporation; Kimberly-Clark Corporation; Motorola, Inc.; Northrop Grumman Corporation; Novartis AG; Raytheon Company; Spirit AeroSystems; and United Technologies Corporation.

### **Academic Program**

The LGO Fellows Program class of 2009 had 46 graduates in June 2009 and one projected for September 2009. Each graduate completed a six-month internship at a partner company during 2008, either February through August (eight fellows) or June through December (39 fellows). Internships are focused projects of concern to the partners, accomplished by interns with company support and MIT faculty guidance. Representative projects this past year included strategic sourcing, lean in product development, lean assessment and implementation in manufacturing, and supply chain and inventory modeling. Recommendations and results from the projects have been integrated into companies' operations as well as course curriculum. For the classes of 2010 and 2011, internship process improvements are being implemented to further increase the benefit for all stakeholders, which include an improved matching process and program deliverable dashboard integrated into the LGO virtual community database.

Another 48 students (class of 2010) completed their first year of on-campus studies and started their six-month internships. Forty-seven new students (class of 2011) were admitted and began an intensive summer session in June 2009. The class of 2011 has an average of five years of work experience. The class of 2011 has the highest percentage of women in the program's history.

Faculty codirectors for the LGO and SDM programs are professor David Simchi-Levi from the School of Engineering and professor Tom Allen from the MIT Sloan School of Management. Don Rosenfield serves as the program director of LGO. Vahram Erdekian became industry codirector in September 2008. He brings more than 30 years of manufacturing and operations experience to LGO, including executive leadership positions at several leading technology companies, and serves as distinguished executive in an advisory role to the global supply-chain management organization at Cisco, where he has been an operations executive since joining the company in 2000. Vicki Mach also joined as the program's admissions and career development coordinator.

LGO's academic program consists of a mix of management and engineering courses, which can be viewed online at <http://lgo.mit.edu/mba-courses.html>.

The entering LGO 2011 class by engineering discipline is as follows:

- aeronautics and astronautics: 2
- biological engineering: 1
- chemical engineering: 4
- civil and environmental engineering: 2
- electrical engineering and computer science: 5
- engineering systems: 26
- materials science and engineering: 2
- mechanical engineering: 5

LGO applications increased 21 percent (from 197 to 239) within the past year, indicating a strong return on the recent marketing investment.

### ***China Leaders for Manufacturing***

Established in 2006 to help US companies compete more effectively in the global arena, the China Leaders for Manufacturing (CLFM) is modeled after MIT's highly successful LGO (formerly LFM) program. The first CLFM class matriculated in September 2007, with the second cohort matriculating in September 2008. This past January, professor Tom Allen, LGO codirector from MIT's Sloan School of Management, led CLFM's first review committee. The committee made recommendations in three broad areas—program leadership, engineering/management balance, and CLFM vision and mission. The group traveled to Shanghai and met with Shanghai Jiao Tong University (SJTU) deans, faculty, students, and staff over a two-day period. A report was then sent to the SJTU deans responsible for CLFM, and professor David Simchi-Levi and LGO program director Don Rosenfield made a follow-up visit in June to monitor progress. The review committee plans to return to Shanghai in early 2010.

Students from LGO visited Shanghai in November to meet with their CLFM counterparts on the LGO/CLFM synergy committee as a follow-up to the initial joint plant tour to Shanghai in March 2008. In March 2009, LGO and CLFM students jointly worked on a "Dragon Team" project in Shanghai for a multinational electronics company. There continues to be good synergy between the two groups, with more events planned in the 2009–2010 academic year, including a joint plant tour in Shanghai in spring 2010.

Twenty-two SJTU faculty members have been trained at MIT using the Sloan School's teach-the-teacher model, the primary activity of CLFM. Visiting CLFM faculty closely observe how LGO classes are taught, which curricula and technologies are used, and how LGO students and faculty interact. They reflect more broadly on how LGO trains leaders to address the most challenging operations problems, based on a keen management perspective and substantive technical knowledge. At the end of their stay, they present plans to incorporate what they have observed in courses they teach in Shanghai.

### ***LGO Alumni***

The LGO 2008 Alumni Conference took place this past year at MIT. The conference theme, “Manufacturing and Operations 20/20, Celebration of the Past and Vision of the Future,” was scheduled in conjunction with LGO’s 20th anniversary celebrations. More than 150 alumni gathered to see presentations by MIT faculty Tom Magnanti (founding codirector of LGO/LFM), Rebecca Henderson, and Mehmet Fatih Yanik. LGO alumni speakers included Matthew Bromberg (vice president and general manager, global materials solutions, Pratt & Whitney), Robert Nicol (director, sequencing operations, Broad Institute), Jon Strimling (president and founder, American Biomass Corporation), and Mark MacLean (vice president of operations, American Biomass). Industry presenters included Shane Tedjarati (president and chief executive officer, Honeywell China and India) and Dick Johnston (vice president, corporate operations, Raytheon). Plant tours went to see operations at Boston Scientific, Legal Sea Foods, Haemonetics, EMC, the Broad Institute, and Raytheon. Raytheon provided generous support for the alumni conference. Aaron Raphel, LGO ’05, continued as the official voice of the alumni on the LGO operating committee. His two-year appointment ends June 30, 2009. A new alumni representative will be selected by a vote of the full alumni body.

LGO and SDM continued to schedule monthly webcasts presented by MIT faculty and various LGO and SDM alumni. The alumni have also been instrumental in setting up an infrastructure to support LGO. Through an organized fundraising effort, the alumni have established three funds to support the program: the William C. Hanson and Don W. Davis Leadership Fund, the Alumni Annual Fund, and the Endowed Discretionary Fund.

This year, parts of the Alumni Annual Fund were used for immediate needs and distributed as follows:

- Scholarships to LGO ’09 class: \$27,000
- Domestic and international plant tours: \$8,000
- Total funds raised: \$36,546

### ***Proseminar Speakers***

On campus, LGO students attend weekly seminars with faculty and industry experts to learn about current manufacturing leadership and business issues that are local, national, or international in scope. Speakers in fall 2008 and spring 2009 included Rob York (LGO ’95), director, Mac Enclosure Operations, and Aaron Raphel (LGO ’05), manager, iPhone Enclosure Operations, Apple, Inc.; Amanda Taplett (LGO ’07), 787 preflight and delivery supervisor, and Mike Carnette (LGO ’96), 777 manufacturing superintendent, the Boeing Company; Tom Taylor (LGO ’91), vice president, fulfillment, Amazon.com; Len Baxter, global chief engineer of manufacturing, Global Luxury RWD Team, and Grace Overlander (LGO ’08), work group manager, General Motors Corporation; Tom Greenwood (LGO ’02), director, strategic initiatives, Spirit AeroSystems; Joe DeSarla, vice president of integrated supply chain for automated control solutions, Honeywell International Inc.; Tom Culligan, executive vice president, Raytheon Company; Alan MacCormack, associate visiting professor, MIT Sloan School of Management; Vah Erdekian, vice president, manufacturing operations, Cisco Systems,

Inc. and LGO industry codirector; Kimball Hall, Rhode Island site vice president Amgen Inc.; Jamie Bonini, general manager, supplier commodity engineering, Toyota Motor Engineering and Manufacturing North America, Toyota Motor Corporation; Steven Spear, senior lecturer, MIT and senior fellow, Institute for Healthcare Improvement; Bradley Morrison, senior lecturer, MIT; Bill Krueger, senior vice president for manufacturing, supply chain management, purchasing, and total customer satisfaction, Nissan Motor Company; and Jeremie Gallien, associate professor of operations management, MIT Sloan.

### ***Plant Tours***

This past year, local plant tours were held at Axcelis, Genzyme, Novartis, and Raytheon. Students also participated in the annual two-week plant trek that included visits to Boeing in Seattle, WA; Intel in Portland, OR; Amazon.com in Reno, NV; Harley-Davidson and Ford Motor Company in Kansas City, MO; and Cisco Systems and Flextronics International in Austin, TX. The LGO International Plant Tour went to Poland, the Czech Republic, and Germany and visited Sikorsky (United Technologies Corporation (UTC)), ABB, Škoda (Volkswagen), and Adidas.

### ***Career Development***

LGO students, sponsored and nonsponsored, continue to be highly sought after upon graduation from the program. Partner Companies, as well as other organizations, take a special interest in LGO students, as indicated by their active participation in the proseminar session and recruiting week. To date, 72 percent of the class of 2009 have accepted positions within manufacturing and operations companies and 55 percent have accepted positions within partner companies.

### ***Internships and Research***

There were a record number of international internships for the LGO '10 class that include the United Kingdom, Switzerland, Italy, Germany, Peru, and Taipei. In addition, the LGO '10 class has the largest number of off-cycle internships (12) in the history of LGO. Some partner companies use off-cycle internships to match with their business cycle and get more immediate impact from the research projects. The program has capped the off-cycle internships at 25 percent of the class to maintain the integrity cohort. Matching students to partner internships and faculty advisers is a complex process that the program has managed from inception. The LGO internship matching process continues to use a two-way matching process that explicitly captures company preferences. The method requires significantly less lead time and it led to greater satisfaction from the different constituents; companies and students had more than 80 percent matches within the top five choices. The LGO '10 class was a challenge due to the limited number of internships and last minute funding for some internships causing the internship interviews being extended beyond the normal matching period. Fortunately, we were able to obtain a match with all funded internships. We are continuing to link internships for the LGO 2010 class to company–faculty–student research groups. These groups allow for cross-internship learning and the development of common themes. In particular, the class of 2010 developed a new engineering track on energy and sustainability that includes cross-internship linkage.

## **Governance**

LGO is run by a governing board consisting of the managing partner companies' senior officers, program codirectors, and MIT deans. It is cochaired by Dick Johnston of Raytheon and Larry Loftis of Boeing. The operating committee handles ongoing management of the program and includes company representatives, faculty, and directors. The focus of the operating committee, chaired by Vah Erdekian, LGO's new industry codirector, is a series of standing committees that include companies, faculty, and students. Several companies moved from limited partner status to managing partner by contributing \$1 million to the program via internship fees, partnership fees, and any other contributions to the program. New managing partners, who thus have a seat on the governing board, include Amgen, Cisco Systems, Novartis, and Spirit AeroSystems.

## **New Partners**

An active student, staff, and company committee has been very successful at bringing new partners to LGO. New partner companies that have joined in the past several years include General Dynamics, Cisco Systems, Amgen, Novartis, and Zara (Inditex), the Spanish clothing manufacturer and retailer.

**Tom Allen**

**Codirector**

**Howard W. Johnson Professor of Management, Emeritus**

**Professor of Engineering Systems, Emeritus**

**David Simchi-Levi**

**Codirector**

**Professor of Civil and Environmental Engineering and Engineering Systems**

**Vah Erdekian**

**Industry Codirector**

**Don Rosenfield**

**Director, LGO Program**

*More information about the Leaders for Global Operations Program can be found at <http://lgo.mit.edu/>.*

## **Master of Engineering in Logistics**

In spring 2008, 35 students were selected from more than 200 applicants to join the center's MLOG program as the class of 2009. MLOG is an intensive nine-month degree track that prepares graduates for supply chain management careers in various industries including manufacturing, distribution, retail, transportation, and logistics services. The MLOG class of 2009 was geographically dispersed, with half coming from outside the United States, representing 10 countries. In a very difficult economy, more than two-thirds of the students were still able to secure a position by graduation. The success is

due in large part to increased efforts of the new full-time MLOG career development and company recruiting coordinator, who arranged interview sessions directly for MLOG students with 55 companies (33 on campus, 22 through online resume drops).

### ***Master of Engineering in Logistics Alumni Interaction***

CTL held its third annual MLOG reconnect event in March 2009. This two-day event—which is open to MLOG alumni, current MLOG students, and incoming MLOG students—featured an update of CTL and MLOG/ZLOG (the sister program in Zaragoza, Spain) programs by the directors, presentations by CTL researchers, and a professional development keynote by Carlos Garcia, senior client partner, Korn/Ferry International. The event incorporated 42 alumni and 16 current students.

The following alumni interacted directly with the current students through participation in a fall speaker series: Brian Lebl, Wyeth Pharmaceuticals; Guatum Kapur, Deloitte Consulting; and John Parsons, McKinsey & Co. In the spring, nearly 250 alumni completed a detailed survey on their career progression since graduation. These data will be analyzed to understand the impact of MLOG graduates on the profession and also used in creating ideas to expand interaction with alumni.

### ***Master of Engineering in Logistics at IAP***

During Independent Activities Period (IAP) 2009, MLOG and ZLOG sponsored the [Supply Chain Innovation and Leadership Series](#).

### ***Supply Chain Education Partners Program***

This year, 12 companies participated in the Supply Chain Education Partners Program, which promotes supply chain knowledge sharing among leading executives and students in the MLOG program. A team of students is assigned a jointly scoped-out project that has both practical and research aspects. This year's projects included:

- Impact of long tails on transportation rates, CH Robinson
- Analyzing the level of service and cost trade-offs in transportation, Chiquita Brands International
- Merchandising demand planning using internal prediction markets, General Mills
- Pricing for supply chain risk in an uncertain world, General Motors
- Supply chain strategy, Lockheed
- Comparison of channel costs, Pfizer
- Managing second tier suppliers, Philips Healthcare
- The value of a responsive supply network, Procter & Gamble
- Inventory location heuristics for distribution network, Schlumberger
- Competitive service strategy analysis, Solutia

- Analysis of multicountry logistic hubs for fast-moving consumer goods, Unilever Andina
- Transportation portfolio optimization, Walmart Stores

In addition, the following pro bono projects were conducted with nonprofit organizations:

- Structuring strategic decisions through the analytical hierarchy process: warehouse location for WFP–Ethiopia, World Food Programme
- Humanitarian aid in less secure regions: an analysis of WFP–Ethiopia, World Food Programme
- Costs of multiplicity in public health supply chains in Burundi, World Health Organization, DFID

*More information about the Master of Engineering in Logistics can be found at <http://mit.edu/mlog/>.*

### **System Design and Management**

MIT's System Design and Management (SDM) Program was created in 1996 in response to industry's need to develop the next generation of leaders in product design and systems engineering. SDM combines cutting-edge courses from the MIT Sloan School of Management and MIT's School of Engineering, enriching the experience with innovative distance learning, flexible matriculation options, and an interdisciplinary perspective. The centerpiece of SDM's portfolio is its rigorous 13- to 24-month graduate program. Built on a foundation of core courses in system architecture, systems engineering, and system and project management—and integrated with classes in engineering and specially designed courses in management—this program leads to a master of science degree granted jointly by the School of Engineering and the MIT Sloan School of Management.

### **Distance Education Delivery**

SDM continues to evaluate its distance education delivery with the goal of increasing the quality of the remote learning experience while reducing costs, both for MIT and for sponsoring companies. This process includes streaming all classes on the web so that students who cannot attend a session can view the video of it almost immediately, without having to wait for a videotape to be mailed to them.

Pat Hale continues as director for his fifth year. In January 2008, Pat assumed the role of president of International Council on Systems Engineering (INCOSE), after serving as president-elect for two years. This role has provided the program a high level of visibility in an organization of industry and educational institutions highly aligned with the SDM academic mission. Pat's tenure as INCOSE president ends in January 2010. Codirectors for the program are David Simchi-Levi from the School of Engineering and Tom Allen from the MIT Sloan School of Management. John M. Grace is SDM's industry codirector.



### ***Student Statistics***

In January 2009, SDM admitted its 13th class, enrolling 68 students, two of whom are dual degree students from the Navy's 2N Naval Engineer degree program. As was done in FY2008, SDM held information evenings in August, September, October, and June for local MIT alumni and others interested in SDM as a way to recruit prospective students for SDM '08. In addition, SDM hosted a special information evening in March for members of the local chapter of the Society for Women Engineers (SWE). These successful events brought more than 100 prospective students to campus or suburban locations, where they heard presentations on the program from faculty, students, and alumni. In addition, SWE presented SDM with a certificate of appreciation at its annual awards banquet in June.

#### **System Design and Management Student Statistics**

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Admitted	58	47	50	37	27	36	37	62	58	61	56*	64
On-campus	16	6	14	8	7	18	27	44	44	47	40	34
Self-supported	1	2	5	2	1	6	25	42	34	40	36	27
Research assistant	12	2	4	3	1	10	0	0	2	1	4	0
Distance education	42	41	36	29	18	17	10	18	14	14	16	19
Company-sponsored	45	43	41	32	25	20	12	20	24	21	20	37

\* In addition, seven naval officers from 2N were admitted for a second degree program

### ***Sponsoring Theses of Self-Funded System Design and Management Fellows***

In the past few years, companies have also engaged the program by using self-funded fellows for research internships that they develop into SDM theses. Support typically involves identifying a thesis topic and naming a company mentor to work with a student and MIT faculty member on a topic of pressing concern. Thesis sponsorship allows a company to expand its presence within SDM at a modest cost, work with an SDM fellow and MIT expert on a relevant project, and favorably position the company for a broader relationship with SDM and MIT.

### ***SDM Industry Partners***

SDM has continued its cultivation and interaction with various industrial firms. The activities undertaken are focused on developing mutually beneficial relations between industry and MIT/SDM. Industrial firms support the education of students and bring real-world problems to the program. In return, they employ the graduates of the program and receive the results of the research they support. More details are available at [http://sdm.mit.edu/industry\\_involvement.html](http://sdm.mit.edu/industry_involvement.html).

One area that has been a focal point for the industry program effort in recent years is the development of additional options for industrial firm competency development. Options range from partial support of students to support of thesis work to participation in the certificate program. The latter activity consists of a one-year distance program involving one principal SDM course per semester and a capstone project. The courses in the certificate program, taken simultaneously with the SDM student courses, are systems architecture, systems engineering, and product design and development. There is also an optional adjunct to the certificate program, the organizational leaders workshop, especially tailored to supervisors of certificate students.

The certificate program, formed with the strong and continued support of UTC, has been operational for eight years. It has nearly 200 graduates scattered throughout various firms. It has been growing in strength with additional participation from Deere Inc., Instrumentation Laboratory, Cummins Inc., and a diverse set of financial and software firms. This program not only increases the flow of trained systems thinkers into a firm's engineering ranks but is also becoming an excellent feeder to the full SDM master's program.

### ***MIT Industry Partners System Engineering (Certificate) Program***

This past year was the eighth for the MIT Industry Partners Systems Engineering Program. Partners included UTC, John Deere, Cummins, Draper Laboratory, and Instrumentation Laboratory to build a systems engineering core competency. This unique program targets three key populations: experts enrolled in the SDM program, experts enrolled in the Systems Engineering Certificate Program, and the organizational leaders of those experts. The program has been very successful, with 171 students completing the certificate program and more than 100 organizational leaders completing the six days of content in the organizational leaders workshop. With its active participation in all levels of the program, UTC now has more than 250 employees who have benefited from the SDM program.

### ***Career Development for SDM Self-Sponsored Students***

Led by career development director Helen Trimble, SDM has provided career services to its self-funded students for the past five years. These services include individual career consultation and coaching in presentation skills; resume writing; networking and negotiating; interviewing; company, career, and opportunity research; and government regulations for foreign nationals. Preliminary data indicate that this year's graduates will achieve the same success as in previous years—100 percent employment in industries and organizations as diverse as nonprofits, aerospace, and financial services and in technology consulting and leadership roles in product development, business strategy, and operations. Recent students are tending toward start-ups and venture capital firms.

### ***MIT Conference on Systems Thinking***

In the past, SDM has held an annual conference for SDM alumni only that was both planned and executed by our alumni. In 2008, the decision was made to open the conference to all in order to give SDM and the field of engineering systems wider visibility. On October 23–24, 2008, SDM sponsored the MIT Conference on Systems

Thinking for Contemporary Challenges, which was attended by approximately 230 participants including faculty and students from MIT and other universities, SDM alumni, and industry executives. This event was developed by SDM alumni and staff. A second conference is planned for October 22–23, 2009.

**Tom Allen**

**Codirector**

**Howard W. Johnson Professor of Management, Emeritus**

**Professor of Engineering Systems, Emeritus**

**David Simchi-Levi**

**Codirector**

**Professor of Civil and Environmental Engineering and Engineering Systems**

**Jack Grace**

**Industry Codirector**

**Pat Hale**

**Director, SDM Fellows Program**

*More information about the System Design and Management Program can be found at <http://sdm.mit.edu/>.*

### **Technology and Policy Program**

TPP is an interdisciplinary, graduate-level program 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 development and implementation of responsible technology strategies and policies to benefit humankind.

TPP offers a two-year master's of science program and supports the ESD PhD doctoral program by encouraging dissertation research in the areas of technology, management, and policy (TMP). While TPP receives most of its applications from outside MIT, several internal admits (i.e., students already enrolled in other MIT graduate programs) join TPP each year; roughly one-third of TPP students concurrently pursue a second master's or a doctoral degree in another department. Each entering class numbers around 40 students (39 in fall 2009), comprising approximately 40 percent women, 40 percent international students, and 3 percent from underrepresented minorities. This year, 40 students graduated with master's degrees in technology and policy, and seven TPP degree candidates or alumni were accepted to continue their studies at the ESD doctoral level.

Fellowship funding was provided to several incoming students in order to attract the top TPP candidates to MIT. This year these funds came from the Rabinowitz and de Neufville funds as well as a tuition-only Keil Fellowship. The Office of the Dean for Graduate Education also provided matching fellowship funding to TPP students this year, specifically for URM students. These fellowships continue to allow us to recruit

and retain excellent students. With these funds, TPP has achieved a high yield of our admitted URM students over the past five years. Additional funds have been generously provided by TPP alumni and donors for several student or programming initiatives, including funding for summer internships, recruitment and outreach, support for TPP women student events, and support for some of the costs associated with the TPP visiting speaker series and alumni relations.

The Technology and Policy Student Society (TPSS) is one of the most active student groups on campus. TPSS holds yearly elections for officers representing the broad spectrum typical of TPP students. The society not only organizes talks, workshops, and social events but also plays an important role in the annual TPP open house for the admitted incoming student class. Generous donors have made it possible for the TPP to recognize TPP students for leadership. Current TPP students also lead many organizations and clubs across the Institute, most notably the MIT Energy Club, which comprises more than 1,200 MIT student, alumni, faculty, and staff members.

This year's January trip to Washington, DC, included meetings at the World Bank, National Aeronautics and Space Administration (NASA) and the Environmental Protection Agency, the White House Office of Science and Technology Policy, the Center for Democracy and Technology, the Nuclear Regulatory Commission, and ICF Consulting International. Several of our students found internships in Washington this summer at the Department of Energy, Office of Management and Budget, SRI International, and NASA, while others are working elsewhere in the United States or abroad, including at the Far East Organization in Singapore, Transport for London, Exxon Mobil, the Organization for Economic Cooperation and Development, the US Embassy in Uganda, and for nonprofit groups in Colombia and Ethiopia. Students whose internships were unfunded were able to earn valuable experience by taking advantage of living-cost funding provided by TPP alumni and donors—including Larry Linden, Francis Chin, Donald Cooke, and the Far East Organization—in order to make their internship experiences possible. Our fall semester internship seminar provides an opportunity for returning students to report back on their internships and to share information with first-year students who are planning for next summer.

Each year TPP students nominate faculty members and researchers for their TPP Appreciation Award. This year's recipients were principal researchers Sergey Paltsev of the MIT Energy Initiative and Ricardo Valerdi of the Center for Technology, Policy, and Industrial Development.

TPP maintains ties to its roughly 1,000 alumni and works to foster a strong alumni community through biannual publication of the alumni directory and regional gatherings in Washington, DC, and Boston. Approximately 50 people, including more than 25 local alumni, attended last January's gathering in Washington, DC. Other TPP alumni receptions are also held regularly in Boston, New York, Paris, and Tokyo.

In recent years, TPP initiated and continued to cultivate a much closer working relationship with our MIT Washington office. Dr. William Bonvillian has been a pleasure to work with, and he and professor Dava Newman meet at every opportunity to ensure

a science, technology, and policy agenda and opportunities for MIT students at both the undergraduate and graduate levels, especially the summer policy internship program. The events TPP endorsed and helped facilitate this past year included our summer technology and policy internship program in Washington, DC; faculty panel discussions at MIT; and the IAP, spring, and summer offerings of science, technology, and policy boot camp, which Dr. Bonvillian offers.

This past year ESD.10 Introduction to Technology and Policy was taught by TPP director of education Frank Field and professor David Marks. A course that is undergoing constant revision to reflect the evolution of our student body and the field itself, this year's course was revised to challenge the students to think more deeply about the role of modeling in the formulation of policy research, with a particular emphasis on systems modeling. The rate of adoption of 14.003 Microeconomic Theory and Public Policy as an alternative to 15.011 Economic Analysis for Business Decisions for the economics requirement continues to be extremely heartening, and TPP is working to balance the load between these two primary economics options. TPP also supported a new energy course in urban studies and planning (11.369J Energy Policy for a Sustainable Future) taught by Jonathan Raab and offered the telecommunications policy course in its half-term incarnation. An additional energy course, enabling energy efficiency, is also in development for next year. Each year, TPP's leadership course, ESD.801—led by professor Dava Newman—organizes a leadership lunch series, bringing practitioners to MIT to speak with our students. Participants in this year's lunch series were Dr. Peter Diamandis and Dr. Patricia M. Dehmer. TPP alumni Ajit Kambil, Eric Amundsen, and Karina Funk participated in the TPP alumni leadership panel discussion. Partha Ghosh also conducted a leadership class during IAP.

TPP is a founding member of the Technology, Management, and Policy Graduate Consortium, which includes programs in North American, European, and Asian universities and allows TPP master's students and TMP-track ESD doctoral students to share their research and network with students in similar programs. At the Consortium's eighth annual conference, hosted by Simon Fraser University and the Technical University of Delft in Utrecht, the Netherlands, June 21–24, 2009, seven MIT students presented their research, with TPP student Zoe Szajnfarber winning the best master's student presentation award.

Although financial support from the Cambridge–MIT Institute has ended, TPP maintains a special relationship with the Technology Policy Master of Philosophy program at Cambridge University, a consortium member. Professor Newman has served as the external examiner of the Cambridge University TPP for the past four years.

TPP has continued its participation in the collaborative and interdisciplinary Program on Emerging Technologies (PoET), along with ESD; the Program in Science, Technology, and Society (STS); the Center for International Studies (CIS); and Political Science. Currently funded by a five-year, \$2.97 million grant from the NSF's Integrative Graduate Education and Research Traineeship (IGERT) program, PoET aims to improve responses to emerging technologies by increasing understanding of the economic, security, environmental, and cultural implications of technological advances and the uncertainties

surrounding them. As the program enters its closing year of NSF funding, we are working to find ways to maintain this important area of inquiry. PhD students from ESD, CIS, and STS are funded by PoET IGERT traineeships. Visit <http://poet.mit.edu/> for more information.

TPP sponsored an IAP seminar series that included three sessions on current topics in technology and policy led by MIT researchers in the field: “Carbon Efficient Supply Chains” by Edgar Blanco of CTL, “Optimization and Multi-Stakeholder Objectives for Air Transportation Systems,” by Hamsa Balakrishnan of Aeronautics and Astronautics and ESD, and “On the Road in 2035: Reducing Transportation’s Petroleum Consumption and GHG Emissions” by John Heywood of Mechanical Engineering.

With the completion of our sixth year in the academic space on the third floor of E40, the Muckley Building, TPP continues to find extraordinary value in having a home for its educational and research efforts. Having a physical focal point for TPP activities and student events (formal and otherwise) has become even more important with the increasing geographic spread of key research labs across the MIT campus, including the move of the MIT Energy Initiative into E19 and the move of MIT Portugal into E38. The TPP space in E40 continues to give TPP students a home base from which they can develop their skills, scholarship, and community.

**Dava Newman**

**Director**

**Professor of Aeronautics and Astronautics and Engineering Systems**

*More information about the Technology and Policy Program can be found at <http://web.mit.edu/tpp/>.*

## **Research Programs**

### **Center for Biomedical Innovation**

CBI was formed in 2005 as a collaboration among the School of Engineering, the MIT Sloan School of Management, the School of Science, and the Harvard–MIT Division of Health Sciences and Technology to address challenges within the pharmaceutical, biotechnology, diagnostics, and medical devices industries involving innovation, productivity, costs, and predicting and managing risks. Led by executive director Gigi Hirsch, MD, and faculty director professor Anthony Sinskey, ScD, CBI’s mission is to improve global health by overcoming obstacles to the development and implementation of biomedical innovations.

#### ***Research at CBI***

CBI encompasses two research programs: drug safety, focused on drug development and health care delivery, and biomanufacturing, focused on improving technologies and systems in the manufacturing of biologic products in pharmaceutical innovation. These two programs have been further defined throughout the year and have individually launched new initiatives.

### ***Drug Safety Research Program***

Members of the drug safety working group completed a year-long future scenario planning initiative (“Drug Safety Futures 2020”) in the spring. Building on insights gained from this effort, two major research programs were launched.

New Drug Development Paradigms (NEWDIGS) focuses on designing and implementing transformation improvements to systems of therapeutic product innovation in health care. Specific objectives include reducing cost and time to market, improving knowledge about the benefits and risks of new products, and producing products that are more effective than existing therapeutic options. CBI is working with MIT professor Deborah Nightingale, PhD, to lead the NEWDIGS working group through a systematic assessment of the therapeutic product innovation enterprise, including a current state assessment, a future state vision, and a gap analysis between these two.

An engineering systems approach to improving pharmaceutical safety focuses on enhancing our understanding of the complex interplay of forces within the drug development system that lead to suboptimal decisions, actions, and outcomes related to safety. This research is very timely in light of a number of major process and policy innovations taking shape within the industry. CBI is working on this important project with professor Nancy Leveson and her research team, including professor John Carroll and senior research scientist Stan Finkelstein, both from ESD, among others.

### ***Biomanufacturing Research Program***

The objective of the Biomanufacturing Research Program (BioMAN) is to develop innovative tools and technologies that reduce the cost of manufacturing processes and improve our ability to deliver safe high-quality biopharmaceutical products. BioMAN draws on the strengths of the engineering and science communities at MIT, the biomanufacturing industry, and the regulatory and standards communities (e.g., Food and Drug Administration and National Institute of Standards and Technology) to optimize bioprocessing and manufacturing technologies in a meaningful way. To that end, this year CBI launched a collaborative project, led by professors Anthony J. Sinskey and Rajeev Ram to validate disposable microscale bioreactors systems developed at MIT in collaboration with CBI industrial members.

BioMAN is conducting an ongoing research project that examines emergent regions for offshore biologics manufacturing and the impact of economic and political instability on siting decisions. In addition to obtaining industrial funding, BioMAN submitted a major proposal to the Alfred P. Sloan Foundation in support of these activities. The cross-disciplinary team of co-principal investigators involved in this research includes professors Anthony J. Sinskey (MIT), Jeff Macher (Georgetown University), David Simchi-Levi (MIT), Scott Stern (Northwestern University), Roy Welsch (MIT), Rajeev Ram (MIT), and Reuben Domike (University of Prince Edward Island).

BioMAN completed a future scenario mapping initiative this year to obtain consensus on and define impactful, transformative research critical to the industry’s future performance. The initiative involved high-level representation from MIT, industry, and government; identified major change drivers and plausible scenarios for the next

generation of biomanufacturing (2030–2035); and ultimately allowed the working group to determine areas in which it will be imperative that we move technology forward and to specifically define collaborative research opportunities that are needed.

### ***CBI Research Projects***

In addition to research programs, CBI supports research projects centering on improving innovations within drug development, biomanufacturing, and health care delivery.

### ***Stratified Medicine Research Group***

This research group, led by professors Ernst Berndt and Mark Trusheim, seeks to develop a semiquantitative decision framework for use by corporate decision makers in biotechnology, pharmaceutical, and diagnostics companies as well as by policymakers. The initiative grew and gained recognition this year for its work. The team added two graduate students and received financial support from The Merck Foundation and Eli Lilly and Co. Ernst Berndt and Mark Trusheim have been invited speakers at major biopharma companies, one of which has created a new stratified medicine department inspired by the initiative's work. In addition, the team was invited to speak at two industry conferences in early 2009.

### ***Strategic Global Trials Program***

In November 2008, the Strategic Global Trials Research Program received word that it was being awarded financial support from the Sloan Foundation. In December, the Merck Foundation announced that it would extend its research support for another year, beginning January 2009. This funding enables initiation of the second phase of the research project, which will be based on collaborations with industry and government officials in the United States and internationally. The team is setting up an interview program with professionals playing key roles in the global development of biopharmaceuticals, while expanding the database of global clinical research operations.

### ***Events***

In October, CBI sponsored a forum with ESD and the New England Healthcare Institute to explore the implications of the US Food and Drug Administration's Sentinel Initiative and efforts to create a "learning health care system." This forum brought together a panel of experts moderated by Johnson & Johnson corporate vice president Garry Neil, MD. On March 10 and 11, CBI coorganized a conference entitled Future of Biomanufacturing: Streamlining Biopharmaceutical Development with the MIT Industrial Liaison Program that showcased biomanufacturing-related research at MIT.

### ***New Senior Advisors***

CBI added five members to its strategic advisory team:

- Burt Adelman, MD, former executive vice president of research and development of Biogen Idec, Inc., and a distinguished fellow at CBI. He is a lecturer in medicine at Harvard Medical School and a member of the Hematology/Oncology Division of the Department of Medicine, Brigham & Women's Hospital.



- John Alam, MD, PhD, a distinguished fellow at CBI. He recently retired from Vertex Pharmaceuticals, where he had been executive vice president, medicines development, and chief medical officer.
- Howard L. Golub, MD, PhD, a distinguished fellow at CBI and independent consultant and a senior lecturer in the MIT–Harvard Joint Program. He has an adjunct appointment at the Boston University School of Public Health in biostatistics and epidemiology and has been the principal investigator on two large National Institutes of Health trials.
- Jim Leung, PhD, a visiting scientist at MIT participating in biomanufacturing research projects in the Biology and Chemical Engineering Departments. He provides strategic input into CBI's manufacturing program.
- G.K. Raju, PhD, the founder, chairman, and chief executive officer of Light Pharma Inc. and chairman of CBI's Biomanufacturing Research Program's steering committee. He is executive director of the Pharmaceutical Manufacturing Initiative and the Consortium for the Advancement of Manufacturing of Pharmaceuticals.
- Wayne A. Rosenkrans, Jr., PhD, a CBI distinguished fellow and health care industry policy consultant. He focuses on health care strategy and policy issues working through affiliations with academic, industry, and advocacy groups to advance science-based agendas benefiting the quality of US health care.

### **Education**

CBI is committed to educating students and professionals as leaders in biomedical innovation through its graduate courses and executive education programs, integrating technical excellence with business acumen and regulatory and managerial expertise. Our programs are designed and delivered by experts from academia, industry, and government, providing powerful platforms for exploring current and potential approaches to innovation within the biomedical industry. For more information, visit <http://web.mit.edu/cbi/education/index.html>.

### **Center for Engineering Systems Fundamentals**

This was a year of producing significant research results for CESF. PhD, master's, and undergraduate students are working directly on CESF-related research projects, and some of these efforts are leading to journal and book chapter publications. More MIT faculty members are becoming involved in the research, especially as a result of the path-breaking Energy Box work being supported by the MIT Portugal Program and also the pandemic flu research—now supported by a major five-year grant from the Centers for Disease Control and Prevention (CDC) in conjunction with the Harvard School of Public Health and also still supported by the Sloan Foundation. Much of this work is linked to IBM-affiliated initiatives to establish a new applied discipline, “service science.” Also, 2008–2009 was an academic year providing the third offering of the required ESD doctoral subject, ESD.86 Models, Data, and Inference for Socio-Technical Systems (now with professors Roy Welsch and Mort Webster).

MIT LINC, Learning International Networks Consortium, this past year initiated its largest education project to date: BLOSSOMS, Blended Learning Open Source Science or Math Studies. Including LINC, MIT Portugal, the CDC, BLOSSOMS, and the Sloan Foundation, the total of commitment of funds for CESF this year exceeds \$2,000,000.

### ***ESD.86: Continuing Developments on a New MIT Subject on Fundamentals***

Toward the end of a three-year subject development plan, ESD.86 was taught for the third time during spring semester 2009. With the coteaching of professor Roy Welsch, the subject is now jointly listed with the Sloan School of Management as subject 15.078J. This year 18 students took the subject for credit and several others were listeners. Continuing development of engineering systems fundamentals, leading to ever-newer materials for this subject, is being supported in part by the MIT Portugal Program. We are pleased to report again that the educational materials of this subject are ported to MIT's OpenCourseWare system and are available on its web pages.

### ***CESF Research and Educational Outreach Initiatives***

We have had an active year pursuing CESF research and educational initiatives, involving numerous MIT faculty members—both within and outside ESD. In selecting promising targets of research opportunity, we were guided by the ESD mission that our work is focused at the intersection of traditional engineering, management (broadly defined), and social sciences.

We benefited this year from the following support:

Research in engineering fundamentals—MIT ESD Portugal Project, \$100,000

Demand-side electricity management—MIT ESD Portugal Project, \$100,000

The Sloan Foundation of New York—Pandemic Influenza: Social Distancing & Hygienic Policies to Reduce Its Prevalence, \$350,000

A five-year cooperative agreement with the CDC, grant number 1 PO1 TP000307-01, LAMPS (Linking Assessment and Measurement to Performance in PHEP Systems), awarded to the Harvard School of Public Health Center for Public Health Preparedness and MIT CESF, \$8,000,000 total and approximately 25 percent for the MIT effort

BLOSSOMS, Blended Learning Open Source Science or Math Studies, funded by the William and Flora Hewlett Foundation (\$300,000), the Sloan Foundation of New York (\$45,000), and the Lord Foundation of Massachusetts (\$40,000)

### ***Presidential Elections***

ESD research affiliate Dr. Alexander Belenky and professor Richard Larson have continued studying queuing at election precincts during US presidential elections. This past year that effort expanded to consider the mathematics, logic, and tradition of presidential elections worldwide, culminating in a major book on presidential elections, edited by Dr. Belenky, and published before the US presidential elections in November 2008. The book, published by Elsevier, is entitled *Systems Studies of Voting Systems and Elections*. This year, under the direction of Dr. Belenky, professor Arnold Barnett of the MIT Sloan School of Management and Professor Larson of CESF and the Sloan School

cohosted the most significant national workshop ever given on presidential elections and the electoral college. This event was held October 17, 2008, and is covered on the CESF website <http://cesf.mit.edu/electoral/>. External funding was provided by the Carnegie Corporation of New York.

### *Social Distancing in an Influenza Pandemic*

CESF is in year 3 of a multiyear research project, Decision-Oriented Analysis of Pandemic Flu Preparedness and Response, with principal investigator Richard Larson and co-principal investigator Stan Finkelstein. The research support was initiated with an IBM faculty research award, followed by funding by the Sloan Foundation, and now by a substantial five-year grant from CDC in conjunction with partners at the Harvard School of Public Health. For the latter grant, Dr. Finkelstein is principal investigator and Professor Larson is co-principal investigator.

This research focuses on decision alternatives—from individuals, to families, to workplaces and employers, to governments at all levels—to control and reduce the prevalence of a virulent flu, once it is introduced into the population. We have met with flu planning leaders from 12 states, and held an all-day review session with our panel of distinguished medical and health services experts—serving as advisory board to the project. MIT invited our most senior doctoral student on the project, Karima Nigmatulina, to take a lead role in developing MIT’s plan for pandemic flu response. The project benefited from the active participation of internationally known flu historian John M. Barry, who now serves as expert consultant on our expanded pandemic influenza research project. In this new capacity, his first paper—“White Paper on Novel H1N1: Prepared for the MIT Center for Engineering Systems Fundamentals”—was published as a working paper at <http://cesf.mit.edu/abstracts/070609.htm> and has received international recognition.

Professor Larson has been invited to serve on two boards of the Institute of Medicine (IOM): the IOM Standing Committee on Emergency Management and Medical Response Integration (renamed the IOM Standing Committee on Medical Readiness) and the IOM Health Sciences Policy Board. They first met in April 2009 and met twice during the academic year.

### *Hurricane Decision Making: Example of Disaster Preparedness and Response*

Fifth-year PhD student Michael Metzger has been working with Professor Larson, creating a quantitative planning model to frame and formulate rational policies for preparedness and response to hurricanes. This work has already been reported at four national research conferences. The CESF “hurricane team” included Maurice Davis Murphy, a master’s student in ESD’s TPP and at the Operations Research Center. He completed and submitted his master’s thesis, entitled “Tropical Cyclone Preparedness and Response: Opportunities for Operations Research.”

### *The Energy Box*

Supported by the MIT Portugal Program, the Energy Box is being designed and created as an Open Source software system to manage silently in the background—from an available desktop computer—the electricity usages of a home or small business. The ideas build from concepts first proposed by MIT’s professor Fred Schweppe in the 1980s and brought algorithmically to early prototype stage by MIT doctoral student Panos

Constantopoulos in his doctoral thesis (cosupervised by Professors Schweppe and Richard Larson). Supported by the Energy Focus Group of the MIT Portugal Program, the Energy Box envisages a world in the not-too-distant future in which electricity is priced in accordance with near-term supply and demand. We are in the third year of Energy Box research. An extended team of students and faculty members, both at MIT and in Portugal, has made substantial progress. At CESF, the two key PhD students are Daniel Livengood and Woei Ling Leow.

### *Urban Traffic Congestion: Congestion Pricing for Parking*

Drivers in urban neighborhoods who patrol streets seeking inexpensive on-street parking create a significant fraction of measured traffic congestion. The pool of drivers patrolling at any time can be modeled as a queue, where queue service is the act of parking in a recently vacated parking space and queue discipline is SIRO (service in random order). We developed a queuing model of such driver behavior, allowing impatient drivers to abandon the queue and to settle for expensive off-street parking. We then related the model to the economic theory of congestion pricing, arguing that price differentials between on-street and off-street parking should be reduced in order to reduce traffic congestion. Reducing the number of patrolling drivers often can reduce urban road congestion significantly, in some cases as effectively as technologically expensive road pricing schemes that cordon off the center city, as occurs for instance in Singapore and London. Our work has been buttressed with extensive on-street data collection in Boston and Cambridge and by collaboration with a research colleague at Carnegie Mellon University. Mr. Katsunobu Sasanuma, a TPP master's student at ESD, will complete this research as part of his master's thesis in August 2009, supervised by Professor Larson.

### *MIT Learning International Networks Consortium*

LINC, a volunteer effort housed in CESF, is a society of leaders worldwide who believe that, with today's computer and telecommunications technologies, every young person can have a quality education. Our fifth LINC conference, LINC 2010, is scheduled for May 24–26, 2010. Plans are under way, and as of this writing several distinguished educators have accepted our invitation to be featured plenary speakers, including Dr. Charles M. Vest, president of the National Academy of Engineering and former MIT president.

### *BLOSSOMS*

BLOSSOMS represents Blended Learning Open Source Science or Math Studies. Professor Dan Frey is co-principal investigator, Ms. M. Elizabeth Murray is project manager, and professor. Richard Larson serves as principal investigator. In the BLOSSOMS initiative, volunteers of MIT's LINC are cocreating with educators from Jordan and Pakistan an Open Educational Resources repository of openly licensed, blended learning, video modules for high school mathematics and science classes. Over the two-year schedule of this pilot project, started on September 1, 2008, university educators in each of the three participating countries will produce 15 modules, for a total of 45. All 45 modules will then be used and evaluated by high school math and science teachers in all three countries. The Hewlett Foundation funds the BLOSSOMS effort with additional funding from the Sloan Foundation of New York and the Lord Foundation of Massachusetts. In October 2008, we launched the project in Jordan, with MIT's professor of physics Walter Lewin, Elizabeth Murray, and Professor Larson returning from Amman and a set of kick-off meetings. A similar set of kick-off meetings occurred in Lahore, Pakistan, in January 2009.

During this first year of the project, 25 BLOSSOMS modules have been created in Jordan, in Pakistan, and at MIT. Two of these modules—“The Flaws of Averages” and “Building Cryptosystems”—were done by three MIT doctoral students (Dan Livengood, Rhonda Jordan, and Dan Sturtevant) who were winners of an MIT-wide BLOSSOMS student contest we held during IAP (January 2009). Three other BLOSSOMS modules were created by MIT doctoral students. There are BLOSSOMS modules in English, Arabic, and Urdu. Eventually, using voiceover translation, each of 45+ BLOSSOMS modules will be available in all three languages.

### ***Service Science, Management, and Engineering***

In spring 2008, CESF convened a series of meetings to see how ESD might focus more research on the services industries. Twenty faculty members signed up to attend the meetings and enter the discussion. There is widespread interest in pursuing health care as a major service industry for ESD. Several faculty members already work in that area, and certain synergies and economies of scale are now becoming apparent. This effort is carried out in conjunction with a nationwide program supported by IBM and others to motivate more graduate students to become experts in the analysis of services industries.

### ***Outreach***

There were many public CESF presentations this past academic year (July 1, 2008, to June 30, 2009). Among them are:

Bellman Equations Applied to Hurricane Decision Making, Richard Larson and Michael Metzger, INFORMS National Conference, October 12–14, 2008, Washington, DC

BLOSSOMS: Blended Learning Open Source Science or Math Studies, Richard C. Larson and M. Elizabeth Murray, INFORMS National Conference, October 12–14, 2008, Washington, DC

Revisiting  $R_0$ : The Basic Reproductive Number for Pandemic Influenza, Richard C. Larson, INFORMS National Conference, October 12–14, 2008, Washington, DC

Operations Research at the Intersection of Math, Management, and Social Sciences, R. C. Larson, Arizona State University, Tempe, AZ, February 12 and 13, 2009

BLOSSOMS, R.C. Larson and M.E. Murray, Hewlett Grantee Meeting, Monterrey, CA, March 3–6, 2009

Operations Research at the Intersection of Math, Management and Social Sciences, R.C. Larson, University of Iowa, Iowa City, IA, April 17, 2009

The Energy Box, R.C. Larson, D. Livengood, and W. L. Leow, June 17, 2009, CESUN presentation at MIT, June 17, 2009

Teaching Duets: Using “Interactive” Video Lessons in Your Math and Science Classes, R.C. Larson, June 27, 2009, MIT BLOSSOMS presentation to East Coast high school math and science teachers, MIT Science and Engineering Teachers Program

### **Other International Outreach**

CESF undertook additional activities leading to international outreach related to complex systems.

Operational Research: Applying Math and Physics to Everyday Real World Problems, Richard C. Larson, lectures presented to the University of Jordan (Amman, Jordan) and also to the Jordan University of Science and Technology (Irbid, Jordan), November 2008

BLOSSOMS, lecture presented to the University of Jordan, Amman, Jordan, November 2008

BLOSSOMS, lectures presented to several universities and to Pakistani high school math and science teachers, Lahore, Pakistan, January 2009

Operations Research at the Intersection of Math, Management, and Social Sciences, R.C. Larson, University of Toronto, Toronto, Ontario, Canada, April 3, 2009

Full-day workshop on Demand-Side Energy Management, D. Livengood and R.C. Larson, Lisbon, Portugal, May 30, 2009

Professor Larson and two other senior MIT faculty members have served on the senior Advisory Board of Lahore University of Management Science, School of Science and Engineering (SSE LUMS); LUMS is a major private university in Pakistan patterned after MIT and the India "IITs." The new SSE school at LUMS opened on September 1, 2008.

#### **Richard Larson**

**Director, Center for Engineering Systems Fundamentals**

**Mitsui Professor of Engineering Systems and Civil and Environmental Engineering**

*More information about the Center for Engineering Systems Fundamentals is available at <http://cesf.mit.edu/>.*

### **Center for Technology, Policy, and Industrial Development**

CTPID focuses on contemporary problems at the nexus of social, natural, and technological systems and the dilemmas that emerge from interactions among these systems. CTPID examines the opportunities and challenges these dilemmas offer our enterprises as well as the constraints they impose on the scope and extent of their activities. CTPID is funded by 19 industry sponsors and nine government agencies for a total research expenditure volume of about \$4.4 million and a total administered research volume of \$6.4 million. FY2009 projects included the Ford–MIT Alliance (administered by CTPID), the International Motor Vehicle Program (IMVP), LAI, Materials Systems Laboratory (MSL), MIT Information Quality program (MITIQ), Systems Engineering Advancement Initiative (SEARi), and Technology and Law Program.

The acting director of CTPID is professor Joel Moses, institute professor and professor of computer science and engineering systems. Lissa Natkin is the CTPID administrative officer. CTPID's administrative offices are located in E40-227.

### ***Highlights of the Year***

IMVP researchers continued to be active pursuing research, writing, participating in academic conferences, and other activities. Members of the IMVP research network are currently involved in projects across all elements of the automotive value chain. The LAI Phase V research program is designed to accelerate lean enterprise transformation, design future lean enterprises, and evolve adaptive lean enterprises. The group continues to make significant contributions to supporting lean enterprise transformation across the aerospace industry, within the US Army, and in the health care domain.

LAI has just completed a five-month phase of intensive workshops with the leadership of the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) and the Army Materiel Command (AMC). The follow-on phase, which began in late June, focuses on helping the Army develop the capability to address complex systems issues that the team identified during the first phase.

LAI and its international Educational Network (EdNet) both welcomed new members. LAI's newest member is the US Naval Sea Systems Command (NAVSEA), the Navy's largest command. New EdNet members include Central Community College, Indiana University, University of Salerno, Northland College, Western Illinois University, and Colorado State University. LAI offered successful knowledge exchange events for 140 participants at sites around the country.

MSL has played a key role in developing the Engineering Design and Advanced Manufacturing (EDAM) degree programs to be offered by the MIT Portugal Program.

### ***Awards and Recognition***

Christopher Roberts, Matthew Richards, Adam Ross, Donna Rhodes, and Daniel Hastings of the SEArI group received the IEEE Systems Conference Best Paper for Student Research.

### ***Ford-MIT Alliance***

The Ford-MIT Alliance, an Institute-wide initiative, was established in 1997. During the past year of economic constraints for the global automotive industry, Ford requested that MIT honor its corporate requirement to cut services by 30 percent. In response to this request, Ford elected to drop its membership in the Energy Initiative and also implemented a 30 percent cut in the management budget for operating the Alliance. The research portfolio was not affected; however, through an amendment to the Alliance agreement, Ford asked that MIT accept the annual payment as three separate checks for this year in the sum of \$2.1 million. Ford has had organizational changes, and replaced Ford's resident director of the Alliance, Simon Pitts, with Edward Krause who visited the campus several times to learn about Alliance activities in the last quarter of 2008.

The portfolio is managed by an operating committee, including codirectors professor John Heywood and Ed Krause for Ford and Elaine Savage as MIT's Alliance executive director. The operating committee reports to an executive committee, including MIT's leadership champion, chancellor Phillip L. Clay, and works in close partnership with

Ford's key executives, including the chief technical officer and vice president of research for Ford. The Alliance hosts the executive committee on campus three times annually. This year, the first meeting occurred in Dearborn, MI.

The Alliance houses approximately 20 active projects at any time with an emphasis on collaborating with principal investigators from Ford and exchanging personnel, including students. MIT researchers involved in Alliance projects come from various departments, labs, and centers at the Institute, including Mechanical Engineering, Materials Science, CTL, Laboratory for Information and Decision Systems, and Computer Science and Artificial Intelligence Laboratory (CSAIL). Research projects are beginning that involve newer technologies such as information technology in the vehicle and a closer partnership between Ford and MIT researchers.

### ***International Motor Vehicle Program***

IMVP is the oldest and largest international research consortium aimed at understanding the challenges facing the global automotive industry. Founded at MIT in 1979 and headquartered at MIT (with most day-to-day administrative functions based at the Wharton School, University of Pennsylvania), IMVP has evolved to become a network of professors and researchers engaging with managers and executives in the global automotive industry. IMVP researchers are based at universities around the world.

IMVP leadership remains the same as in the previous academic year. Professor John Paul MacDuffie, Wharton School, University of Pennsylvania, continues to serve in his role as IMVP codirector and shares that responsibility with professor Charles Fine, MIT Sloan School of Management. Professor Daniel Roos continues to serve as chairman of the IMVP advisory board, although the board did not meet during AY2009. The part-time role of IMVP senior director for global strategy and sponsor development continues to be filled by Glenn Mercer, a former member of McKinsey's automotive practice.

IMVP is fully funded by industry sponsors. Our current financial situation is challenging. We met that challenge by reducing research grants and administrative expenses and obtaining outside funding for several researchers' meetings held in 2009. Internationally, we continue to pursue sponsorship with companies such as Renault and Hyundai. Multiple companies, including Ford and Toyota, have said we should return to them to discuss funding once economic conditions improve, which we hope will occur during fiscal year 2010. We plan to explore possible funding through NSF and other governmental sources.

IMVP continues a partnership with the World Economic Forum's Automotive Program. At the annual meeting in Davos, Switzerland, each January, the CEOs of automotive original equipment manufacturers and first-tier suppliers gather to discuss the state of the industry. IMVP codirector John Paul MacDuffie and senior director Glenn Mercer work with World Economic Forum staff to develop the agenda and program for Davos, drawing on IMVP research to provide intellectual content and empirical findings to support the forum's program of events and initiatives for its partners and member companies in the global automotive industry.



IMVP formally affiliated with the new Industry Studies Association, created to take over from the Sloan Foundation Industry Studies Program. IMVP codirector John Paul MacDuffie and IMVP researcher Susan Helper are board members of this new association.

Thanks to the generous support of universities associated with key IMVP researchers around the world, IMVP was able to hold two researcher meetings and public forums in 2009, one in Japan and the other in the Detroit area. For more details about IMVP events, go to <http://www.imvpnet.org/events.asp>.

IMVP researchers continued to be highly productive in their publication of scholarly papers in respected academic journals. For publications, visit <http://www.imvpnet.org/publications.asp>.

Several IMVP researchers achieved academic promotions this year, including:

- Francisco Veloso—promoted to associate professor, Carnegie-Mellon, and named Sloan Industry Studies Fellow
- Matthias Holweg—promoted to reader at Cambridge University
- Arnaldo Camuffo—promoted to chair at Bocconi University
- Susan Helper—promoted to chair at Case Western Reserve University
- Ki-Chan Kim—promoted to dean of development at Catholic University of Korea
- Mari Sako—promoted to dean of faculty, Said Business School, Oxford University

In addition, Dongsheng Ge successfully defended his dissertation at University of Tokyo and is now doing postdoctoral research at Tsinghua University in Beijing, Nicholas Berente completed his doctorate degree and is now doing postdoc research at the University of Michigan, and Jianxi Luo completed his doctoral qualifying exams at MIT.

### ***The Lean Advancement Initiative***

LAI continues to make significant contributions to supporting lean enterprise transformation across the aerospace industry, within the US Army, and in the health care domain. LAI's newest member, NAVSEA, is the largest of the Navy's five systems commands, and its mission is to develop, deliver, and maintain ships and systems on time and on cost for the US Navy.

Now in its fifth phase of operations (September 1, 2005, to August 31, 2010), LAI continues to evolve its focus on lean enterprise-level transformation and produce a unique body of research, methodologies, products, tools, and curricula. Phase V strategic imperatives are detailed at [http://lean.mit.edu/index.php?option=com\\_content&view=article&id=619&Itemid=635](http://lean.mit.edu/index.php?option=com_content&view=article&id=619&Itemid=635). As a membership-based consortium representing industry, government, and academia, LAI works as a neutral broker to develop, identify, and share best practices, common goals, and strategic tools built on collaborative member experience. LAI's operating model combines knowledge creation, deployment, and collaboration to enable enterprise excellence and deliver value to its stakeholders.

LAI engages its members and delivers new findings and information through a series of knowledge exchange events, conferences, workshops, and tutorials.

LAI EdNet translates LAI research findings and practitioner knowledge into university-level curricula. EdNet includes more than 40 universities in the United States, United Kingdom, Italy, and Mexico that have signed a no-cost collaborative agreement with MIT. Members leverage their collective resources to develop, test, deliver, and continuously improve curricula and share best practices. EdNet produces a cadre of young professionals educated on lean issues.

### *LAI Leadership*

LAI is governed by a group of cochairs from government, industry, and academia. They include Blaise Durante (Office of the Assistant Secretary of the Air Force), institute professor Sheila Widnall (MIT), and Thomas Farmer, president, Pratt & Whitney Military Engines (industry). LAI's codirectors are professor Deborah Nightingale, MIT Department of Aeronautics and Astronautics and ESD, and professor John Carroll, MIT Sloan School of Management and ESD. Richard B. Lewis II is LAI's executive director.

### *LAI Research*

The LAI Phase V research program is designed to accelerate lean enterprise transformation, design future lean enterprises, and evolve adaptive lean enterprises. LAI research seeks to provide knowledge, insight, and tools to enable true enterprise transformation. LAI's Phase V program is structured around four collaborative research teams headed by both an MIT faculty member and a research lead and include associated faculty advisers and graduate student researchers. More information can be found at [http://lean.mit.edu/index.php?option=com\\_content&view=article&id=411&Itemid=563](http://lean.mit.edu/index.php?option=com_content&view=article&id=411&Itemid=563).

### *LAI and the US Army*

LAI continues an ongoing engagement with the US Army, an LAI member, as it works to transform itself into a more strategic, effective, and resilient enterprise. Specifically, LAI has just completed a five-month phase of intensive workshops with the leadership of the Office of the Assistant Secretary of ASA(ALT) and AMC. LAI led them through its Enterprise Strategic Analysis for Transformation (ESAT) methodology. The follow-on phase, which began in late June, focuses on helping the Army develop the capability to address complex systems issues that the team identified during the first phase.

The last workshop concluded on May 1 with an outbrief to the principles, Mr. Dean Popps, acting assistant secretary of ASA(ALT), and General Dunwoody, commanding general of AMC. The ESAT team presented a transformation plan that outlined the scope, intent, future state vision of this enterprise, and a number of goals and objectives. General Dunwoody said that both she and the Army's chief of staff have already noticed the positive results of increased collaboration, and Mr. Popps expressed his wish that the rest of the government could benefit from the level and quality of analysis and work done by the LAI team.

### *Events*

LAI's 2009 Research Summit in January at MIT presented LAI members with an overview of LAI's latest findings and ongoing research.

LAI's annual conference in Baltimore, MD, in March attracted more than 100 participants from the United States and the United Kingdom.

LAI offered successful knowledge exchange events for 140 participants at sites around the country and will continue to update and expand these offerings. Offerings included:

- ESAT, US Army, Alexandria, VA
- Sharing Success Stories of Lean Enterprise Change (Case Studies), Pratt & Whitney, East Hartford, CT
- LAI Lean Academy®, MIT, Cambridge, MA
- Metrics and Continuous Improvement, Raytheon Company, Andover, MA
- Using LESAT for Enterprise Transformation, MIT Campus, Cambridge, MA
- Sustaining Lean Practices Through Organizational Education Programs, Boeing IDS, Seal Beach, CA

LAI offered these courses through MIT professional education:

- Architecting the Future Enterprise, May 2009 (25 participants from six countries)
- Value-Drive Tradespace Exploration and System Design, June 2009
- LAI Lean Academy®, July 2009

### *Educational Network Activities*

LAI's EdNet released Version 6.0 of its Lean Academy® course in January. The course is available on OpenCourseWare and is the first widely available open introductory curriculum for lean six sigma principles, practices, and tools. The Lean Academy® course was offered during IAP at MIT for credit and was filled with both undergraduate and graduate students. LAI also offered its first Lean Healthcare™ Academy in June 2009 to 39 senior Veterans Hospital Administration staff from across the country at VHA headquarters in Bedford, MA. The course was extremely successful and LAI is in discussion with the VHA, the nation's largest health care system, on further training and engagement. The US Air Force approved the Lean Academy as a mechanism for AFSSO 21 certification.

EdNet partnered with the University of Minnesota's Carlson School of Management and the Lean Educators Academic Network to cohost a successful third annual Lean Educator Conference.

### *Other Highlights*

LAI codirector Deborah Nightingale represented LAI at the Boeing Lean+ Conference in Anaheim, CA, and the BAE International Lean Conference in Fort Wayne, IN.

LAI executive director Dick Lewis represented LAI at the Lean Management Conference at the University of Zagreb, Croatia.

EdNet director Earll Murman was named a 2009 Honorary Fellow of the American Institute of Aeronautics and Astronautics (AIAA), the group's highest distinction.

LAI researcher and SEAr director Donna Rhodes was appointed to West Point's Advisory Board.

LAI researcher Ricardo Valerdi was recognized by the MIT TPP Student Society for exemplary mentorship of dual degree candidate USAF 1LT Craig Blackburn.

LAI collaborated with the Technical University of Braunschweig on an international survey, Efficient Introduction of Lean in Product Development. The survey was available in English and German and results and insights will be shared in late summer 2009.

Former LAI student Dr. Caroline Twomey Lamb led the volunteer effort that resulted in the launch of a new web resource, <http://www.askPolaris.org/>. The site, which was launched in May and is hosted by AIAA, is designed to reach out to high school students interested in aerospace careers.

LAI published eight electronic issues of *LAI News* and *LAI Research Highlights*.

### *LAI Products*

LAI's newest product, ESAT, has evolved from 15 years of enterprise research, practical experience, and member best practices. ESAT is a process for:

- assessing the current state of an enterprise
- establishing goals for a desired future state
- developing a strategy and roadmap of specific actions to enable transformation to the desired new state

ESAT was introduced in a knowledge exchange event in Huntsville, AL, in August 2008.

The LAI tool suite is regularly expanded, updated, and revised; a comprehensive list is available at <http://lean.mit.edu/>.

### *LAI Moving Forward*

As LAI moves into its final year of Phase V, it focuses on strengthening and expanding the consortium to effect and support international enterprise transformation efforts. LAI will continue to conduct research, share knowledge, and support members in their ongoing transformation efforts. LAI will deploy new findings, information, and tools through new knowledge exchange events, site visits, curriculum building, short courses, and case studies with consortium members.

EdNet's first product, the LAI Lean Academy® course, has been offered to more than 1,000 students by 30 qualified instructors and has been adopted by about 10 schools. Building on this product's maturity, the EdNet community will focus on developing more targeted curricula in lean product development, lean health care, and enterprise value stream mapping.

*More information about the Lean Advancement Initiative can be found at <http://lean.mit.edu/>.*

### ***Materials Systems Laboratory***

MSL is internationally recognized for its innovative work analyzing the competitive position of materials and the strategic implications of materials choice. The lab's recent emphasis has been on automotive applications. MSL has eight researchers (two professors, three full-time research staff, and three postdoctoral associates,) nine graduate students, and three undergraduates. MSL graduate students come from a number of departments and programs at MIT, including ESD, TPP, the Department of Materials Science and Engineering, and the Department of Mechanical Engineering. AY2009 saw two completed PhDs and three completed master's degrees and three undergraduate theses. In the coming year, we expect to have three continuing PhD students, three continuing master's students, and three new master's students.

#### ***MSL's Role in the MIT Portugal Program***

MSL has played a key role in developing the EDAM degree programs to be offered by the MIT Portugal Program. This involvement has drawn on MSL's considerable experience in conducting joint research activities with universities in Portugal and our role in developing an advanced automotive design and engineering center in the north of Portugal. Joel Clark (professor in the Department of Materials Science and Engineering and ESD) is codirector of the EDAM education and research activities. Jeremy Gregory (research scientist in the MIT Energy Initiative) has coordinated the curriculum development and other activities related to both the advanced master's and PhD degree programs. With the aggressive plans for deployment of both a master's and a PhD program, many MSL staff are actively working on curriculum development with Portuguese partners and are making excellent use of the badly needed space allocated for the program by MIT.

Richard Roth (research associate at CTPID) has directed a multiuniversity program (in conjunction with Instituto Superior Technico of Lisbon, Faculdade de Engenharia da Universidade do Porto, and the University of Minho) to develop innovative design solutions using advanced materials for automotive body applications. This work has included interaction with Volkswagen/AutoEuropa in Portugal as well as the automotive design center, Centro para a Excelência e Inovação na Industria Automóvel. Other joint research projects initiated as part of the MIT Portugal Program include projects involving the investigation of improved methods for material selection, cost assessment for microinjection molding, and reaction injection molding, tool design and use strategies, and improved recycling systems.

#### ***Collaborative Research Laboratory with General Motors***

MSL's research sponsors include major automakers and materials suppliers. A five-year agreement with General Motors established the Collaborative Research Laboratory in Materials and Manufacturing Systems Analysis. This lab gives MSL a basis for conducting more in-depth research into the strategic implications of materials and processing developments for the automobile industry, focusing in particular on issues of the strategic position of new automotive technologies from economic and environmental standpoints. As part of this collaborative research arrangement with General Motors, MSL currently has research projects in the areas of flexible automobile manufacturing, lightweight materials and automotive design, learning in general assembly, mass decomposing or secondary weight savings, and the economics of the vehicle launch process.

### *Sustainable Materials Systems*

Several MSL research efforts explore the notion of sustainability in the context of materials systems. These projects (detailed in the four categories below) include an examination of the economics of recycling, the role of sustainability metrics in engineering design, the implications of resource scarcity for firms, and the exploitation of compositional statistics in scrap remelting to increase the use of scrap materials.

Researchers Randolph Kirchain (associate professor in the Department of Materials Science and Engineering and ESD), Frank Field (senior research associate at CTPID), and Jeremy Gregory have been working to understand current recycling practices and to develop an economic model for improving product design and recycling technology. They worked closely with a number of industrial partners, including Hewlett Packard.

MSL's efforts in the past year have focused on exploring the kinds of design signals that can be extracted from the current crop of life-cycle analysis tools to help product developers make material choices—or, more precisely, characterize the degree to which different tools yield different signals. Projects with industrial partners led by Randolph Kirchain, Jeremy Gregory, Jeffrey Dahmus (postdoctoral associate in the Materials Processing Center), and Elsa Olivetti (postdoctoral associate in the Materials Processing Center) have been an important element of this research. These projects include a partnership with P&G-Gillette evaluating the environmental impact of shaving and the implications of the impact on guiding a firm sustainability strategy. Another project is supported by NEMA, an industry trade group for electrical and electronics products manufacturers, and is exploring the economic and environmental impact of different alkaline battery collection and recycling strategies.

As an outgrowth of past work for Supply Chain 2020, MSL has been working to explore the specific implications of resource scarcity on the operation and planning functions of the firm. Current work has focused on the platinum materials system. Future work will likely address lithium and rare earth materials in response to changing demand likely to be seen as a result of increasing electrification of the automobile.

A final topic in this area of sustainable materials systems is a continuation of an effort to explore the application of modifications of conventional methods for devising furnace charges in metal foundries. Work to date has evaluated opportunities within real foundry facility cases in partnership with Alcoa and has been expanded to other metals recyclers as well as other materials systems. Analytical exploration of these algorithms by Randolph Kirchain, Frank Field, and Elsa Olivetti not only has enabled opportunities to improve recycling through explicit incorporation of the uncertainty present in any secondary materials system but has also suggested the potential for increased use of bio-derived, renewable materials within industries such as tire manufacturing.

### *Microphotonics/Optoelectronics*

Professor Randy Kirchain worked closely with the Communications Futures Program and the Communication Technology Roadmap within the Microphotonics Center to understand the economics and market drivers behind a variety of microphotonics applications. He and Richard Roth have been working on a number of research

activities aimed at gaining a better understanding of the materials and processes used to manufacture a variety of critical components for the microphotonics industry. Through close interaction with the Center for Integrated Photonics Systems and sponsoring companies such as British Telecom and a number of microphotonics components suppliers, they have developed models to address questions of network architecture and the influence of new component technology on network deployment strategies. In particular, this work has led to a better understanding of future optical network deployment strategies from both an investment and an operating cost perspective.

Richard Roth is director of MSL. Joel Clark is the program's principal investigator.

More information about MSL can be found at <http://msl.mit.edu/>.

### **MIT Information Quality Program**

MITIQ develops new knowledge in the information quality field. Launched in 2002, MITIQ conducts research on all aspects of information quality, such as how to manage information as a product, how to develop an information product map, and how organizations adopt information quality over time.

#### **MITIQ Accomplishments**

This spring, Dr. Richard Wang, MITIQ director, became the Army's chief data quality officer through an Intergovernmental Personnel Act mobility program. Under the leadership of the new director, professor Stuart Madnick, MITIQ has continued the MITIQ Consortium and embarked on new initiatives—for example, potential collaboration with the Army and the Defense Intelligence Agency in addition to MITIQ's traditional sponsors such as Acxiom, Lockheed Martin, and UTi. A new member, Freddie Mac, joined the consortium this past year.

Professor Madnick and Professor Yang Lee of Northeastern University, who are the founding coeditors-in-chief of the new *ACM Journal of Data and Information Quality* (JDIQ), published the inaugural issue in spring 2009, ushering in a new era for the information quality field. JDIQ, along with many other initiatives in the information quality field, was a direct result of the activities of the MITIQ program.

In November 2008, MITIQ hosted the 13th International Conference on Information Quality (ICIQ-2008) at MIT. ICIQ-2008, the premier conference in the information quality field, presented a forum for researchers and practitioners to exchange information quality knowledge and ideas. More than 150 participants from academia and industry worldwide took part. To further establish the information quality field, ICIQ-2009 will be held in Germany, and ICIQ-2010 will be held at the University of Arkansas at Little Rock.

Another recent initiative of the MITIQ program was establishment of the MIT Information Quality Industry Symposium (IQIS), which is held at MIT and designed to bring together practitioners, vendors, and academics to address information quality issues. MITIQ is sponsoring the second IQIS, to be held July 15–17, 2009 (<http://mitiq.mit.edu/IQIS/>). The symposium will include topics such as industry tutorials, invited presentations, and industry practices, complementing the ICIQ Conference (<http://mitiq.mit.edu/ICIQ/>).

***MITIQ Funding***

The MITIQ consortium received \$95,000 sponsorship from Freddie Mac, but due to the economic recession, Lockheed Martin and UTi Worldwide suspended their sponsorship. It is expected that Freddie Mac will renew sponsorship and other leading organizations and participants in the ICIQ Conference and IQIS Industry Symposium may also join the consortium, as they realize benefits gained from the MITIQ Consortium.

*Additional information about MITIQ can be found at <http://mitiq.mit.edu/>.*

***Systems Engineering Advancement Research Initiative***

SEArI brings together a set of sponsored research projects and a consortium of systems engineering leaders from industry, government, and academia. The mission of SEArI is to advance the theories, methods, and effective practice of systems engineering applied to complex sociotechnical systems through collaborative research.

***Research Portfolio***

SEArI performs collaborative research to address advanced systems engineering challenges using theory-based and practice-based approaches to develop prescriptive research outcomes. The research group has a strong foundation in the space and aerospace system design and architecture domain, with more recent work branching into the transportation and infrastructure systems domain. Five areas of the research portfolio are described in detail at [http://seari.mit.edu/index.php?option=com\\_content&task=view&id=15&Itemid=29](http://seari.mit.edu/index.php?option=com_content&task=view&id=15&Itemid=29).

***Highlights***

Several research projects continued with selected government agencies in the United States and in Singapore, with involvement of 12 graduate and six undergraduate students.

SEArI continued its research effort within the MIT Portugal Program, hosted a visiting PhD student from Portugal, and taught three seminars at Portuguese universities.

SEArI held its annual research summit in October; 12 sponsors from government agencies and corporations attended.

An MIT professional short course on value-driven system design was held in June, and SEArI also taught three tutorials at conferences this year.

Twenty conference papers were presented at eight events, including two conference best paper awards.

SEArI authors Ross, Rhodes, and Hastings received the 2008 Best Paper Award from INCOSE's *Systems Engineering Journal*.



*SEAr Publications**Journal Articles:*

A.M. Ross, D.H. Rhodes, and D.E. Hastings. "Defining Changeability: Reconciling Flexibility, Adaptability, Scalability, Modifiability, and Robustness for Maintaining Lifecycle Value." *Systems Engineering*. 11:3, pp. 246–262, fall 2008. Best Paper for 2008.

D.A. Broniatowski and A.L. Weigel. "Articulating the Space Exploration Policy-Technology Feedback Cycle." *Acta Astronautica*. 63:5–6, pp. 649–656, September 2008.

D.A. Broniatowski, M. Cardin, S. Dong, M. Hale, N. Jordan, D. Laufer, C. Mathieu, B. Owens, M. Richards, and A. Weigel. "A Framework for Evaluating International Cooperation in Space Exploration." *Space Policy*. 24:4, pp. 181–189, November 2008.

*Conference Papers (selections from 20 published papers):*

D.H. Rhodes and A.M. Ross. "Anticipatory Capacity: Leveraging Model-Based Approaches to Design Systems for Dynamic Futures." 2nd Annual Conference on Model-Based Systems, Haifa, Israel, March 2009.

T. Mikaelian, D.E. Hastings, D.H. Rhodes, and D.J. Nightingale. "Model-Based Estimation of Flexibility and Optionability in an Integrated Real Options Framework." 3rd Annual IEEE Systems Conference, Vancouver, Canada, March 2009.

C.J. Roberts, M.G. Richards, A.M. Ross, D.H. Rhodes, and D.E. Hastings. "Scenario Planning in Dynamic Multi-Attribute Tradespace Exploration." 3rd Annual IEEE Systems Conference, Vancouver, Canada, March 2009. Best Paper Award.

A.M. Ross, D.H. Rhodes, and D.E. Hastings. "Using Pareto Trace to Determine System Passive Value Robustness." 3rd Annual IEEE Systems Conference, Vancouver, Canada, March 2009.

D. Chattopadhyay, A.M. Ross, N. Borer, and D.H. Rhodes. "Demonstration of System of Systems Multi-Attribute Tradespace Exploration on a Multi-Concept Surveillance Architecture." 7th Conference on Systems Engineering Research, Loughborough University, UK, April 2009.

J. Nickel, A.M. Ross, and D.H. Rhodes. "Trading Project Costs and Benefits in Multi-Attribute Tradespace Exploration." 7th Conference on Systems Engineering Research, Loughborough University, UK, April 2009.

M. Richards, Z. Szajnarfarber, M. O'Neill, and A. Weigel. "Implementation Challenges for Responsive Space Architectures." 7th Responsive Space Conference, Los Angeles, CA, April 2009. Student Award.

A. Ogawa and D.H. Rhodes. "How Do Cultural Differences Affect Utilization of the ICE Approach?" Proceedings of the Asia-Pacific Conference on Systems Engineering, Keio, Japan, September 2008.

M.G. Richards, A.M. Ross, N.B. Shah, and D.E. Hastings. "Metrics for Evaluating Survivability in Dynamic Multi-Attribute Tradespace Exploration." AIAA Space 2008, San Diego, CA, September 2008.

A.M. Ross, H.L. McManus, A. Long, M.G. Richards, D.H. Rhodes, and D.E. Hastings. "Responsive Systems Comparison Method: Case Study in Assessing Future Designs in the Presence of Change." AIAA Space 2008, San Diego, CA, September 2008.

*Theses:*

D. Chattopadhyay. "A Method for Tradespace Exploration of Systems of Systems." Master of Science Thesis, Aeronautics and Astronautics, MIT, June 2009.

T. Mikaelian. "An Integrated Real Options Framework for Model-Based Identification and Valuation of Options under Uncertainty." Doctor of Philosophy Dissertation, Aeronautics and Astronautics, MIT, June 2009.

M.G. Richards. "Multi-attribute Tradespace Exploration for Survivability." Doctor of Philosophy Dissertation, Engineering Systems Division, MIT, June 2009.

L. Viscito. "Quantifying Flexibility in the Operationally Responsive Space Paradigm." Master of Science Thesis, Aeronautics and Astronautics, MIT, June 2009.

J.M. Wilds. "A Methodology for Identifying Flexible Design Opportunities." Master of Science Thesis, Technology and Policy and Aeronautics and Astronautics, MIT, September 2008.

More information about SEArI can be found at <http://seari.mit.edu/>.

### **Technology and Law Program**

The Technology and Law Program (T&L) offers research opportunities and graduate-level courses that focus on the interface of law and technology. Research activities include the design and evaluation of policies that encourage technological change for the prevention of chemical pollution through regulation, liability, and economic incentives; promoting environmental justice by involving communities in governmental decisions that affect their health, safety, and environment; and addressing the effects of globalization on sustainability.

T&L offers a two-semester sequence in environmental law and policy that is co-listed in Engineering and Urban Studies. Law, Technology, and Public Policy, a core subject in TPP, and Sustainability, Trade, and Environment are listed jointly with the School of Engineering and MIT Sloan. Originally part of the Cambridge–MIT Institute, the latter course continues to be offered at Cambridge University; it is also taught at the Harvard–Cyprus Institute of the Environment in Nicosia. A course in European and international environmental law is also taught at the Harvard–Cyprus Institute. As a result of the program, the MIT perspective on environmental law and sustainability has achieved international recognition.

A book manuscript is in preparation to be submitted to the MIT Press for publication in 2010: *Technology, Globalization, and Sustainable Development* by Nicholas A. Ashford and Ralph P. Hall. TPP professor Nicholas Ashford is director of T&L. Charles Caldart participates as a lecturer in T&L course offerings.

More information about T&L can be found at <http://web.mit.edu/ctpid/www/tl/>.

### **Joel Moses**

**Acting Director**

**Institute Professor, Professor of Computer Science and Engineering Systems**

More information about the Center for Technology, Policy and Industrial Development can be found at <http://web.mit.edu/ctpid/www/index.html>.

## **MIT Center for Transportation and Logistics**

For more than 30 years, CTL has been a world leader in supply chain management, logistics, and transportation education and research. The center's world-renowned research programs directly involve more than 75 faculty and research staff from a wide range of academic disciplines as well as researchers in various affiliate organizations around the world. In education, MIT is consistently ranked first among business programs in logistics and supply chain management.

### **Research**

During the past academic year, many new research projects were added to the ones carried over from previous years on the CTL website. Major projects and initiatives are described below. We had 155 active projects in FY2009.

#### ***MIT Global SCALE Network***

The MIT Global SCALE (Supply Chain and Logistics Excellence) Network continued to grow this past year. As the only international alliance of leading research and education centers dedicated to the development of supply chain and logistics excellence through innovation, the SCALE Network promises to increase the center's research and education reach and reputation. Currently, the SCALE Network spans North America, Latin America, and Europe and consists of the CTL in Cambridge, MA; the Zaragoza Logistics Center (ZLC) in Zaragoza, Spain; and the Center for Latin-American Logistics Innovation (CLI) in Bogotá, Colombia (see following section). Work exploring additional centers in Mexico, China, and India has begun.

Most of the effort this past year was on launching the latest center in Bogotá. In January 2009, the first Global SCALE Network poster session was held at MIT with students from across the network presenting their research. This event also brought together the CTL Supply Chain Exchange members. This event will be expanded in 2010 with addition of the new Graduate Certificate in Global Logistics and Supply Chain Management (GCLOG) students.

### *Center for Latin American Logistics Innovation*

In February 2008, CTL and LOGyCA, a Colombia-based logistics nonprofit organization, signed an agreement worth \$19 million creating CLI, a research and education center for supply chain and logistics in Latin America. CLI joined CTL and ZLC in Spain as the third member of MIT's growing international network of centers dedicated to supply chain education and research, which now spans the US, Europe, and Latin America.

CLI will help Latin American businesses and individuals compete in local, regional, and global markets by delivering leading-edge research, technology, and educational programs in logistics, transportation, and supply chain management. The center will also become a major force in academia within Latin America and across the globe.

LOGyCA, which boasts the most robust supply chain technology infrastructure in the region, houses CLI in its Bogotá headquarters. CLI researchers and students will have access to the infrastructure and knowledge base that helped Colombia establish the largest collaborative technology platform in Latin America. CLI will also connect with its counterparts in the United States through CTL and in Europe through ZLC in Spain.

The partnership between CTL and LOGyCA is based on a 10-year agreement, which officially began on March 1, 2008. The \$19 million deal includes a \$4 million gift from LOGyCA to CTL. Central to the strategy of CLI is development of academic partnerships in the region. To date, CLI has 13 academic partners in six countries, including leading institutions in Brazil (USP) and México (ITESM). To date, CLI has hosted two workshops with academic partners to discuss academic programs, research projects, and a long-term vision of the center. The third academic workshop is scheduled for August 24–25 in Sao Paulo, Brazil (hosted by INSPER and USP).

The flagship educational program of CLI is GCLOG. This program is open for advanced master's students enrolled in approved programs at academic partners. The first class of GCLOG students started the program on July 4, 2009. Fourteen students from nine schools and three Latin American countries spent three weeks at CLI headquarters in Bogotá, Colombia. The summer session included lectures from MIT faculty, MIT CTL research staff, and a guided visit to the Panama Canal. The students are next scheduled to be at MIT in January 2010 where they will join MLOG and ZLOG students.

In addition to the GCLOG program, CLI has hosted four key academic activities during its first year of operation, all resulting in very high satisfaction levels:

- Demand Management Event in Medellín, Colombia: 400 participants
- Supply Chain Risk Event in Cali, Colombia: 240 participants
- Supply Chain Executive Education in Bogotá, Colombia: 13 participants
- Líderes 2009 at LOGyCA: over 400 participants, a high-level event that included five speakers from MIT (professor Yossi Sheffi), ZLC (Dr. Santiago Kraiselburd), DHL (Dr. Keith Ulrich), IBM (Jayne Franchino), and Brightstar Corporation (Marcelo Claire)

CLI has developed a membership program for corporate outreach, leveraging the expertise from MIT-CTL. During its first year, CLI has secured 10 strategic partners. Each partner contributes US \$250,000 for a 10-year membership. Partners to date include Grupo Mundial, Colombina, Almacenes Exito, Alpina, Argos, Alianza Team, Almacenas-Almagrán, Olímpica, City of Bogotá Development Group, and Grupo Nacional de Chocolates. The focus of the first year was to develop local capabilities and develop a research agenda. Two LOGyCA employees were accepted into the MLOG and ZLOG program and in 2009 joined the CLI team.

Four strategic lines of research were selected after consultation with academic and corporate partners: sustainability, logistics enablers, supply chain in emerging markets, and health care. Fourteen initial projects were identified to launch research activities (see details below). In 2009, CLI has secured approximately \$750,000 in research grants to support active projects.

1. Sustainability: carbon footprint (CLI), transportation emphasis
2. Logistics enablers: logistics benchmarking Latin America (CLI and Aeronautics and Astronautics), emphasis on integration; Latin America logistics map (CLI and Aeronautics and Astronautics), transportation emphasis; logistics platforms (CLI at ZLC); and transportation regulation (CLI)
3. Supply chain in emerging markets: SC network design (CLI and MIT); retail distribution strategies in emerging markets (CLI); cellphone technology for SC fragmentation (CLI and MIT); electronic product code/radio frequency identification in textiles, liquids, and metals (CLI-Colciencias); visibility in transportation (CLI-SENA); SC innovations in commodities (CLI at MIT-CTL); and SC2020 case studies (MIT).
4. Healthcare: patient security (MIT) and demand and distribution planning (to be determined)

Finally, CLI has been designated as “Centro de Desarrollo Tecnológico” in the area of logistics and supply chain, a national distinction for a center of excellence in research and development.

#### *MIT-MLC (Mexico Logistics Center)*

In May 2009 CTL and COMECyT (the Mexican Council on Science and Technology) signed an agreement for CTL to perform a feasibility study on establishing a new center for supply chain and logistics in the State of Mexico (Edomex). Mexico is completing the development of a new highway system to connect its ports and primary cities and is building a major logistics hub along the new highway just north of Mexico City. To attract foreign investment, COMECyT has asked MIT to expand its Global SCALE Network and create the MIT-MLC (Mexico Logistics Center). The center would provide two types of master’s degrees: MTEACH, a master’s in supply chain and logistics to train faculty for local universities in Mexico; and MIND, a master’s in supply chain and logistics to train logisticians for industry in Mexico. The center will also conduct master’s and PhD-level research with local companies and government agencies. Finally, the center will provide executive education courses for companies doing business in Edomex. CTL is creating a design for the new center and will determine its feasibility. Results of the study will be known in August 2009.

### *MIT-Zaragoza International Logistics Program*

CTL has a multiyear partnership with the government of Aragón, Spain, to help create the leading European education and research program for logistics and supply chain management in its capital city of Zaragoza. MIT works with ZLC, a research institute associated with the University of Zaragoza, on research, graduate education, executive training, and outreach events for the international community. In recognition of CTL's role in establishing ZLC and the MIT-Zaragoza Program, the government of Aragón awarded MIT the Premio Aragón Internacional 2009, which was presented to Yossi Sheffi on April 23, 2009.

The number of ZLC faculty expanded this year to 25 including full-time, adjunct, research staff, and ad honorem members. Overall, the ZLC full-time staff now numbers 44, consisting of people from 15 countries. The ZLC finalized plans to move to the PLAZA logistics park near Zaragoza during August 2009.

The education programs continue to grow at ZLC. In 2009 the fifth class graduated from the MIT-Zaragoza international master's degree program (ZLOG). ZLOG is an intensive nine-month program modeled on MIT's MLOG program. The class of 2008 consisted of 26 students selected from more than 200 applicants. The MIT-Zaragoza doctoral program also grew to a total of nine, with three additional students starting in fall 2009. The new PhD students will visit MIT in FY09 to enhance their education. ZLC also began offering a new executive education program with its partner institution INCAE. ZLC also hosted its first PhD summer academy in summer 2008, featuring the following professors: Yehuda Bassok (Marshall School of Business at University of Southern California), Dorothee Honhon (McCombs School of Business of the University of Texas at Austin), Rogelio Oliva (Mays Business School at Texas A&M University), Richard Pibernik (European Business School), Nils Rudi (INSEAD), Douglas Thomas (Smeal College of Business at Penn State University), and Tom van Woensel (Technische Universiteit Eindhoven). The PhD Summer Academy 2009 is set to include seven academic and two industry speakers.

ZLC continued its leadership of the Spanish National Center of Excellence on Integrated Logistics (CNCLI) and its work on the singular strategic project for research in logistics. CNCLI played the coordination role for the national technology platform for integrated logistics, which engages industry and research institutes to define research and development priorities and action plans on strategically important issues for Spain's future growth and competitiveness. The number of funded research projects continued to grow with new partners such as the Bill & Melinda Gates Foundation, Medicos Sin Fronteras (Doctors Without Borders), the Transpirenaica Foundation, the Spanish Agency for International Cooperation in Development, and the World Bank.

ZLC organized two major outreach events during FY09: the Global Health Supply Chain Summit was held November 6-7, 2008, in Zaragoza and the International Workshop on Secure Supply Chain Collaboration was held June 2, 2009, in Barcelona. The MIT-Zaragoza Distinguished Speaker Series again this year had a large number of talks from leading academics between July 2008 and June 2009.

### *Renewable Energy Delivery*

The Renewable Energy Delivery project (which emerged from the Hydrogen Supply Chain mentioned last year) focuses on designing supply chain systems for cost-effective renewable energy delivery to end consumers. The first key area is infrastructure design—optimizing networks to determine the size and location for generation and storage and the key links for transmission line expansion. System optimization models are being developed through a funded project with Acciona Energy, the largest wind park developer in the world. The context for this initial study is delivery of hydrogen that is produced by electrolysis using wind and grid energy to satisfy demand for future scenarios of fuel-cell vehicles. The second key area is dynamic electric grid management to enable growth of renewable generation. A master's thesis was completed in May 2009 analyzing operating policies for battery storage linked to wind generation in New England. Extensions of this work with ISO New England (the grid operator) are being discussed. A white paper on this topic was completed in March 2009 and a webinar was conducted in June 2009.

The Supply Chain 2020 (SC2020) project is a multiyear, pioneering research effort to identify and analyze the factors that are critical to the success of future supply chains, one that will map out the innovations that underpin successful supply chains up to the year 2020. By looking further into the future than most business research initiatives do, the project hopes to deliver practical breakthroughs on the design and management of future supply chains. The project also aims to help companies understand the forces that are changing supply chains, so they can be better prepared for the future.

Initiated by the MIT–Zaragoza International Logistics Program, the global research project involves dozens of faculty, research staff, and students at MIT and other institutions around the world. Two advisory councils composed of 44 supply chain executives from more than 40 leading companies—the Industry Advisory Council and the European Advisory Council—routinely meet to play a crucial role in helping shape the work and generate new ideas. To date, seven advisory council meetings have been conducted.

The objective of this project is to provide us with actionable results to solidify our learning and formalize the SC2020 strategy development approach. To this end, we are engaged in implementing the methodology using the tools developed so far. We have successfully met the targeted research goals for AY2009. We finished two key phases of implementation at one of the main case study organizations, which led to valuable insights and findings. Going forward, we will work closely with multiple organizations and at various stages of progress. Two ESD doctoral students are involved in carrying out these implementations, and this work will form the basis of their doctoral research.

We are using the learning from the SC2020 project to address the broader theme of dealing with the challenge of process design under uncertainty. We are in the process of defining specific experiments that can be interwoven with the SC2020 project seamlessly.

*MIT Efficient Healthcare Delivery Research Group*

The MIT Efficient Healthcare Delivery Research Group (MEHD) is a consortium that seeks to improve health care delivery by fostering innovation in health care supply chain management. The MEHD consortium was officially launched on July 1, 2007. Founding members of the consortium include CVS, Pfizer, Cardinal Health, and AHRMM.

Under the aegis of this effort, we have accomplished multiple specific research objectives. We looked at the problem of ascertaining the supply chain costs in the pharmaceutical industry, which is not well understood in the pharmaceutical industry domain due to its unique attributes. This subject was the topic of a master's thesis. Another thesis was written on dealing with the role of primary care physicians in managing cost pressures in the overall health care system. We looked at innovative primary care facility models and studied their effectiveness by using simulation techniques. The project is funding one doctoral and one master's student and focused on raising the awareness of a strategic focus on the importance of delivery costs in a rapidly changing health environment.

*Supply Network Risk Management*

The Supply Network Risk Management project was launched during AY2008 and completed in June 2009. The key objective of the project was to explore the challenge of supply network risk in a holistic manner and leverage the expertise of CTL in this domain. The project proceeded along three different directions over the course of the research—internal perspective, designing and managing a company supply network; extended perspective, global risk practices; and market perspective, business performance and financial implications of risk.

The project was divided into two phases. The first phase of the research focused on the internal perspective and was anchored by a research project with a large consumer packaged goods company. This phase was successfully accomplished in June 2008. Phase II of the project was initiated in June 2008, anchored by the same consumer packaged goods company that supported Phase I. This phase of the research focused on modeling the supply chain flows and risk to study the interaction and propagation of risk downstream and its impact on an organization's overall objectives. We used data provided by the company and external sources to create a discreet event simulation model to explore the topic. This phase was successfully completed in June 2009.

*MIT-Volpe Transportation Human Factors Research Program*

The MIT-Volpe Transportation Human Factors research program was created in FY2007 to initiate active research collaborations in several areas. The program has been awarded four projects since inception: Human Factors Pertaining to Uncertainty and Dynamic Contradictions in Air Traffic Flow Management, professor Amadeo Odoni; Locomotive Cognitive Alerter Technology Development and Evaluation, Dr. Charles Oman; Pilot Computer Model Development and Aircraft Computer Model Integration, Dr. Charles Oman; and Instrument Procedures Research, Professor R. John Hansman.



*FreightLab*

FreightLab continued research on a number of fronts, all related to freight transportation. A roundtable on fuel price volatility was held October 22, 2008, at MIT. Executives from 15 companies participated in the discussion and debate. This meeting resulted in a report and a webinar on the topic held on January 28, 2009.

Work continued on the distribution strategy optimization project with IPC/Subway Stores. This project included modeling and developing trade-offs between the different flow strategies.

Additional work began this year on the Transportation Portfolio Management Project with Walmart Stores. The project is focused on developing an optimization model that determines where different types of transportation resources should be deployed in a large distribution network. The variability of the demand is being taken into consideration in the decision-making process. The project team consisted of four master's students, a postdoctoral fellow, and two researchers.

*New England University Transportation Center*

In August 2006, the US Department of Transportation (USDOT) Research and Innovative Technology Administration named MIT as the lead university of the New England University Transportation Center. CTL is the Institute's host department for the New England Center, which is one of 10 university centers set up in each of the standard federal regions by USDOT to provide a national resource for research and education in both freight and passenger transportation.

This leadership appointment comes with a \$6.25 million grant for the New England Center, to be awarded over three years. The award was made for proposed research on strategic management of disruptive change on transportation systems. This area of inquiry builds on research currently being done by the CTL AgeLab on aging and transportation—specifically, on the impact of disruptive demographics. Dr. Joseph F. Coughlin, founder of CTL's AgeLab, is also the director of the New England University Transportation Center.

Partner universities of the New England University Transportation Center led by MIT include Harvard University and the state universities of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. Funding this year from the USDOT grant has enabled CTL to engage and fund research with colleagues in CSAIL, DUSP, and Civil Engineering.

*AgeLab*

AgeLab continues to grow and influence the expanding field of aging, technology, and innovation. It is recognized by researchers, industry, and government as the leader in bringing a multidisciplinary multidomain approach to translating aging into an opportunity to invent how we will all live tomorrow. The lab's mission is to develop new ideas that improve the quality of life of older adults and those who care for them. Working with researchers across MIT, including DUSP, CSAIL, Brain and Cognitive Sciences, Microsystems Technology Laboratory, Aeronautics and Astronautics, and others, AgeLab has developed a robust research agenda that addresses transportation,

health and wellness, and longevity planning. In 2008, AgeLab began revising its web content and outreach activities. Events in 2008 included symposia on information seeking and advice by older adults, transportation safety, and financial planning. New sponsors of AgeLab in AY2009 include Eli Lilly, Lincoln Financial, General Mills, and Allstate Insurance.

### ***CTL Outreach***

CTL's outreach program works primarily with corporations to generate revenue in support of our research and outreach activities, to establish relationships with a wide range of organizations that can serve as research collaborators and ready sources of real-world input, and to foster rapid adoption of supply chain management innovations developed by CTL.

The foundation of our corporate outreach is the Supply Chain Exchange, a nonresearch corporate membership program designed to foster interaction and networking—the “exchange” inherent in the name—among CTL researchers, our corporate members, and industry at large. We believe the exchange to be the largest and most active membership program in the supply chain management field. Since mid-FY2004, new exchange members have paid an annual fee of \$25,000. Membership in the exchange is a prerequisite to deeper interactions with CTL, including directed research projects, sponsorship of MLOG thesis projects, and membership in higher tiers of the outreach model (research partner and strategic partner). The current list of exchange members is available at <http://ctl.mit.edu/index.pl?id=3476&isa=Category&op=show>.

### ***Corporate Relations***

The ongoing, two-part strategy that drives our outreach program is to increase the number of CTL's partner organizations via membership in the exchange program and to deepen our engagement with individual partners by growing their participation in our educational and research activities.

During FY2009, seven companies terminated their memberships in the exchange: APL, BT Group, EMC Corporation, GE Energy, MTA New York City Transit, Sealed Air Corporation, and Tata Steel. In addition, CVS—a company at the strategic partner level—withdrawed due to extraordinary workloads related to their acquisition of Longs Drug. On the plus side, six new partner companies were added to the program: Heineken USA, Hewlett-Packard, Lockheed Martin Space Systems Company, Maersk Logistics, Tempus Group, and Transplace.

The recession has been a significant factor in the ability of new companies to join our exchange program and of existing exchange members to engage their personnel in our on-campus events. Even profitable companies like Monsanto and EMC have implemented layoffs as well as freezes on discretionary spending. We are seeing companies continue tight fiscal policies as they begin their 2010 budgeting cycles. In anticipation of a recovery commencing in 2010, we have extended some terms of partner memberships in order to sustain active relationships with our partners as they weather this difficult financial period.

### *Outreach Events*

In FY2009, CTL organized symposia, roundtables, workshops, conference sessions, and a research fest to achieve our varied outreach objectives.

This year's CTL Crossroads Conference, which took place on March 26, 2009, focused on managing supply chains in turbulent times. More than 150 executives convened on the campus of MIT for the fifth annual crossroads event this year to examine the ways the global economic crisis is affecting supply chain performance, strategy, and practice. The sessions were designed to address key questions such as "How will the crisis change the way supply chains are designed and managed in the long term?" and "How is the supply chain community responding to the global economic meltdown?" The proceedings are available to CTL partners via the CTL partner gateway.

CTL held two major supply chain management executive education courses during the year, on January 6–9 and June 9–12, 2009. Titled Supply Chains Driving Strategic Advantage, the courses provided executives with the cross-functional and global perspective they need to leverage their supply chains for lasting strategic advantage. Taught by MIT faculty and researchers, the four-day courses use the center's global research on industry-leading supply chain practices and future challenges. Using a mix of management exercises, case studies, and interactive sessions, the courses tackled key supply chain issues, including management of uncertainty, carbon efficient supply chains, strategic scenario planning, strategy alignment, and supply chain resilience. In June, CTL added a supply chain financial module to the course. The module was composed of several lectures and an interactive case study. We anticipate that in future CTL may offer a separate supply chain financial workshop or module as part of the existing course.

On January 22, 2009, MLOG held its first annual poster session and networking night event during IAP. There were 42 corporate attendees from more than 20 companies; 100 percent of the attendees completed our survey and stated that the event was a success and that they would participate in an event like this again. MLOG/ZLOG Reconnect 2009 took place in March 2009; it provided a premier networking opportunity for MLOG alumni and current students.

On May 20–21, 2009, CTL invited members of the center's supply chain exchange to get an insider's look at the innovative research being done by students in CTL's MLOG program. During this day-and-a-half-long review, MLOG students presented their thesis projects, many of which have been sponsored by CTL partners. This year, Research Fest included presentations on topics that included transportation planning, inventory optimization, supply chain design, green supply chain, humanitarian logistics, forecasting, health care supply chain, and risk management.

CTL created and hosted a main session and a hot topics afternoon session at the supply chain industry's Council of Supply Chain Management Professionals annual conference held in Denver, CO, on October 5–8, 2008. The main session, attended by all conference delegates, was presented by CTL's Dr. Mahender Singh and was based on the latest SC2020 research on ways to excel in a highly uncertain business environment. A two-

hour hot topics session later that day elaborated on this theme with a panel discussion on the effects of rising costs and globalization on supply chains. The afternoon session also involved a case study.

MIT CTL offers open-enrollment executive workshops in scenario planning and strategy alignment. These highly interactive events can be brought on site to companies by using real business cases from within that organization. MIT CTL also offers general workshops at MIT. The strategy alignment workshop presents participants with a set of scenarios—each a specially constructed model of a distinct, plausible view of the future. The purpose is to highlight large-scale, driving forces that push the future in different directions. By working within the bounds of these scenarios, participants think productively about contingencies and alternatives and learn to work with uncertainty rather than try to eliminate it from forecasts. The strategy alignment workshops walk executives through the process of developing strategically aligned supply chains through the use of real supply chain case studies from inside their own companies.

### *CTL's Web Presence*

The development of CTL's web presence and web communications strategy continues to evolve and expand. This fiscal year saw the expansion of CTL's partner gateway, a repository for exclusive partner-only content that allows CTL partners to be a step ahead of the competition with access to the latest in CTL research initiatives. Additionally, CTL launched the [Last Wednesday Webinar series](#) for our corporate sponsors.

Development of the new CTL website continues to be under way. Much of the discovery phase is completed, and in the coming months the center will be actively hiring an outside firm to help with the design and implement a new content management system. This year, the center also launched a new customer relationship management web service called Salesforce.com. This service platform supports the center's strong focus on corporate partner relationships. The center also rolled out a new events management tool in conjunction with this.

### *Personnel Changes*

There have been several new hires in FY2009: Dr. Bruce Arntzen, senior research director; Ineke Dyer, MLOG academic administrator; Tara Faulkner, director of communications; Katie Godfrey, technical associate; Dr. Stephanie Jernigan, research associate; Wendy Lin, web communications manager; Jonathan Pratt, MLOG recruiting and career development coordinator; Dr. Amanda Schmitt, postdoctoral associate; Mary Fletcher, visiting military scholar; Dr. Rosemary Berger, Dr. Mustafa Çağrı Gürbüz, Dr. Edgar Gutierrez, Dr. Mika Karilahti, and Dr. Sauri Sergi, international visiting scholars; Marios Bisilkas, Samuel Demont, Gandolf Finke, Jorge Barnett Lawton, Florian Naegele, Bodgan Popescu, Lijie Song, Chuanzhong "Zach" Tan, and Michele Vitagliano, international visiting students.

Departures from the center include Priscilla Bennett, Timothy Griffin, Tracy Nash, and Dr. Larry Lapide, who retired.

**Recognition**

In March 2009, MIT was granted the Aragón International Prize for its contribution to innovation and economic growth. The complete news release is at <http://esd.mit.edu/HeadLine/sheffi042309.html>.

Prashant Saran and Clay Siegert, students in CTL's MLOG program working with Dr. Jarrod Goentzel as their advisor, won the MLOG 2009 Outstanding Thesis Award for their research "Using SCM to Make Wind Plant and Energy Storage Operation More Profitable."

**Yossi Sheffi**

**Director, Center for Transportation & Logistics**

**Director, Engineering Systems Division**

**Professor of Civil and Environmental Engineering and Engineering Systems**

*More information about the Center for Transportation & Logistics can be found at <http://ctl.mit.edu/>.*