Engineering Systems Division

Academic year 2004 was one of significant accomplishment for the Engineering Systems Division (ESD) as we continued to move forward toward our goals of defining and evolving engineering systems as a new field of study and transforming engineering education and practice.

In April, Professor Daniel Hastings was promoted from ESD codirector to director, effective July 1, 2004. Professor Hastings holds a dual appointment in the Department of Aeronautics and Astronautics and in ESD. He has taught courses and seminars in plasma physics, rocket propulsion, advanced space power and propulsion systems, aerospace policy, and space systems engineering. Professor Hastings' recent research has concentrated on issues of space systems and space policy and has also focused on issues related to spacecraft-environmental interactions, space propulsion, space systems engineering, and space policy. He served as chief scientist of the US Air Force from 1997 to 1999. He is serving as a member of the National Science Board, the Applied Physics Lab Science and Technology Advisory Panel, and as the chair of the Air Force Scientific Advisory Board. He is a member of the MIT Lincoln Laboratory Advisory Committee and is on the Board of Trustees of the Aerospace Corporation. He has served on several national committees on issues in national security space.

The ESD faculty continued to expand. We are delighted to announce that the following have joined our faculty and teaching staff:

John S. Carroll, PhD, holds a joint appointment as professor of behavioral and policy sciences and engineering systems. He is also codirector of the Lean Aerospace Initiative. Professor Carroll's research has focused on individual and group decision making, the relationship between cognition and behavior in organizational contexts, and the processes that link individual, group, and organizational learning. Recently, Professor Carroll has conducted research on the promotion of safety in high-hazard industries such as nuclear power, chemical processing, and health care. He is presently focusing on (1) self-analysis and organizational learning processes including incident reviews, root cause analysis, and corrective action programs and (2) safety culture as supported by leadership, cross-boundary communication, and systems thinking. He is also heading a research team funded by the National Science Foundation to work collaboratively with the Sustainability Consortium, a cross-industry grouping of companies working on sustainable business practices (environmental and social sustainability), linked to the Society for Organizational Learning. Professor Carroll is a fellow of the American Psychological Society.

Charles H. Fine, PhD, holds a joint appointment as Chrysler LFM professor of management and professor of engineering systems. His research focuses on technology supply chains. Dr. Fine examines how to assess the present—and especially the future—profitability and strategic leverage among the various sectors in the supply chain; how to design the supply chain (i.e., determine the boundaries and identity of the organization) based on strategic and logistical assessments; and how to assemble the

capability to realize the chosen organizational boundaries and manage within and across those boundaries. He is author of *Clockspeed: Winning Industry Control in the Age of Temporary Advantage.*

Kenneth A. Oye , PhD, holds a joint appointment as associate professor of political science and of engineering systems at MIT. He has published six books and numerous short studies in international relations, political economy, and science and technology policy. Professor Oye's teaching includes courses on science, technology and public policy, a research seminar in international relations, and a course on the international political economy of advanced industrial countries. He received the 1998 Graduate Student Council Outstanding Teaching Award in social sciences, humanities and arts and the 2003 Technology and Policy Program Faculty Appreciation Award. Together with professors Daniel Hastings, Dava Newman, and Merritt Roe Smith, he serves as co–PI under an NSF Integrated Graduate Research and Training grant called the Program on Emerging Technologies (PoET), which assesses the implications of emerging technologies. Professor Oye served two terms as director of the MIT Center for International Studies (1992–2000). He has taught on the faculties of the Kennedy School at Harvard University, the University of California, Princeton University, and Swarthmore College.

John Sterman, PhD, holds a joint appointment as Jay W. Forrester professor of management and engineering systems. He is also director of the System Dynamics Group. Professor Sterman's research includes systems thinking and organizational learning, computer simulation of corporate strategy, and the theory of nonlinear dynamics. Professor Sterman has authored many scholarly and popular articles on the challenges and opportunities facing organizations today, as well as the book *Modeling for Organizational Learning* and the award-winning textbook *Business Dynamics*. Professor Sterman's research centers on improving managerial decision making in complex systems. He pioneered the development of "management flight simulators" of corporate and economic systems. His recent research ranges from the dynamics of organizational change and the implementation of sustainable improvement programs to experimental studies assessing public understanding of global climate change. Professor Sterman has twice been awarded the Jay W. Forrester Prize for the best published work in system dynamics, has won the 2001 Accenture Award for the best paper of the year published in the *California Management Review* (with Nelson Repenning), has five times won awards for teaching excellence from the students of the Sloan School, and was named one of the Sloan School's "Outstanding Faculty" by the 2001 *Business Week Guide to the Best Business Schools.*

James M. Utterback, PhD, holds a joint appointment as David J. McGrath, Jr. professor of management and innovation and engineering systems. Professor Utterback's research has focused on the process of technological innovation in firms in the United States and in other countries. He is author of *Mastering the Dynamics of Innovation,* published by the Harvard Business School Press in 1994. Recent publications include contributions to *Management Science, Research Policy, Strategic Management Journal, Technological Forecasting and Social Change,* and *The Sloan Management Review.* Professor Utterback's teaching focus is on the dynamics of product and process development, emerging and

disruptive technologies, and understanding the varied roles of firms as predators and prey when new technologies emerge. His current research focuses on the sustained growth of newly formed technology-based firms in the United States, Sweden, Italy, and the United Kingdom. He is one of the founding faculty and recently chair of the Management of Technology Program, which is the first area of study at MIT in which a degree was awarded jointly by the Schools of Management and Engineering. He is also one of the founders of the Leaders for Manufacturing (LFM) Program and is currently developing a similar program in biomedical enterprise. Professor Utterback received an honorary DSc from Chalmers University in Gothenburg, Sweden, and was recently elected a foreign member of the Royal Swedish Academy of Engineering Sciences.

Roy E. Welsch, PhD, holds a joint appointment as professor of statistics and management science and engineering systems. Professor Welsch's current research involves robust process control and experimental design, credit scoring models and risk assessment, diagnostics for checking model and design assumptions, reliability measurement in electronic commerce, and volatility modeling in financial markets. Professor Welsch teaches data analysis and applied statistics focusing on regression modeling, experimental design, and quality control with financial and marketing applications. He is a fellow of the Institute of Mathematical Statistics, the American Statistical Association, and the American Association for the Advancement of Science.

Annalisa L. Weigel, PhD, holds a dual appointment as assistant professor of aeronautics and astronautics and engineering systems. Professor Weigel's research interests include space system architecture and design, systems engineering, systems-of-systems analysis, aerospace policy, and finance. As an engineer at Adroit Systems from 1995 to 1998, she worked in support of the Department of Defense Space Architect Office during its stand-up and initial space system architecture design studies in the areas of satellite communications, satellite operations, and launch on demand. After completing her PhD in ESD's Technology, Management, and Policy (TMP) program, Dr. Weigel worked for a year as a research associate at Lehman Brothers in New York City.

In academic year 2004, Rania Hassan was the ESD postdoctoral associate. Dr. Hassan holds a doctorate degree from the department of Aeronautics and Astronautics at Purdue University, where she specialized in developing system-level optimization frameworks and tools for the design of commercial satellites. At MIT, Dr. Hassan has been expanding her work to investigate the issue of embedding architectural flexibility at the fleet level by integrating economic models, spacecraft sizing models, and a multilevel optimization framework. Turning her attention to the manufacturing side of commercial spacecraft, Dr. Hassan has worked on product family architectures, investigating the tradeoff between platform commonality and individual performance competitiveness using optimization approaches. On the optimization approaches front, Dr. Hassan's research at the ESD incorporated benchmarking a recently developed heuristic search method—namely the Particle Swarm Optimization (PSO)—against other heuristic approaches. She lectured on PSO to ESD graduate students and to MIT professional students. Finally, Dr. Hassan has participated in the preparation of a new ESD class on space systems architecting with Professor Daniel Hastings, the ESD director.

Currently there are 43 ESD faculty, 32 in engineering, 9 in management, and 2 in humanities, arts, and social sciences. Twenty-four hold dual appointments and 19 hold joint appointments. There are 5 teaching staff and 2 research staff.

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. The division coordinates academic programs with some 300 graduate students. We are happy to announce that the Engineering Systems PhD and Engineering Systems SM programs, which were formally initiated in fall 2003, admitted the first full class of 18 students. This included 15 PhDs and 5 SMs. Thirteen students have been admitted to the ESD PhD for fall 2004 and 4 for the ESD SM. An additional 12 are in the ESD SM for LFM.

In addition to the ESD SM, master's-level programs include Leaders for Manufacturing, the Master of Engineering in Logistics, System Design and Management (SDM), and Technology and Policy (TPP). A PhD is offered in Engineering Systems. Preexisting PhD programs in Transportation and in Technology, Management, and Policy continue to be integrated into the ESD PhD program.

ESD has three affiliated research centers: the Center for Technology, Policy, and Industrial Development; the Center for Transportation Studies and Logistics; and the Center for Innovation in Product Development. These are described later in this report.

Ongoing Initiatives

Engineering Systems Learning Center

In 2004 the Engineering Systems Learning Center (ESLC) centered its efforts on the operation of its home website, the launch of a companion website for LAI EdNet, support for the ESD Symposium, partnership with the UK Knowledge Resource Network (KRN), and the promotion of engineering systems studies.

LAI EdNet brings together over a dozen universities providing education on "lean" matters to the industry and government members of MIT's Lean Aerospace Initiative (LAI). The electronic architecture developed by John Williams for the ESLC has been adapted to serve as the foundation for this initiative, with a unique feature that enables participating instructors to first approve the sharing of their learning materials, which was a core requirement in this community.

ESLC staff played a number of supporting roles in the ESD Symposium, including content presentations, editorial support for the symposium monographs, and support for the distribution of papers from the sessions.

The partnership with KRN, which is described in more detail under the Engineering Systems Knowledge Network, included cohosting a conference on electronic learning materials with Cambridge University, TU Delft University, and UK Open University.

A signature product of the ESLC, Engineering Systems Industry Studies, has been promoted through presentations at meetings of the Sloan Foundation Industry Center directors, the International Motor Vehicle Program (IMVP), the Industrial Relations Research Association, and other venues.

Engineering Systems Knowledge Network

A number of ESD faculty and staff are involved in activities of the Cambridge–MIT Institute (CMI). In particular, CMI Graduate Education, for which Renee Robins is associate program director on the MIT side, has a number of initiatives with strong links to ESD. With significant MIT input, CMI has developed at Cambridge University a portfolio of graduate degree (master of philosophy) offerings in a range of interdisciplinary areas with strong technical components. Many drew heavily from existing MIT programs, such as the CU Technology Policy MPhil Program, modeled after MIT/ESD's Technology and Policy Program.

Originating in the summer of 2000, CU Tech Policy and MIT TPP have strengthened their relationship with ongoing collaboration over curriculum development and teaching (which draws on many ESD faculty), student intern exchanges, and participation (with other universities) in the Technology, Management, and Policy Graduate Student Consortium. Four ESD doctoral students were chosen this year to present papers at Cambridge University, which hosted the 3rd annual consortium meeting.

This year, some of the CMI curriculum development efforts involved creating case studies and other educational materials for freestanding engineering electives that were newly offered to students in a variety of CMI's MPhil programs. Some of the material developed has been adopted for teaching in classes at MIT. Other ESD faculty are involved in the development of and teaching in nondegree professional education offered by CMI, including executive education programs and lifelong learning courses. For example, Dan Roos, Debbie Nightingale, and Joel Cutcher-Gershenfeld all taught in a CMI program on "Lean Thinking: Strategies and Applications."

These curriculum development activities complement the mission of the ESD Engineering Systems Learning Center, which has been instrumental in developing its sister effort for the UK, the Knowledge Resource Network, also funded by CMI and involving both Cambridge University and the UK Open University. ESLC and KRN are well situated to serve as a central repository and sharing mechanism for a wealth of case studies and curriculum materials developed by CMI–funded efforts, in addition to ongoing ESD projects. KRN will enable CMI to share course content with a range of UK universities and employers through the National Competitiveness Network, which is also an initiative under CMI. Here at MIT, the ESLC is coordinating its efforts with other related initiatives, including D-Space, OpenCourseWare (OCW), MIT World, SloanSpace, and others. It is quickly developing international recognition for its pioneering work in the development and dissemination of electronic learning materials. ESLC cohosted a workshop with KRN and Delft University in early June that drew over

35 participants to join in ESLC's effort to codify the current state of the art and to identify new frontiers for research and action.

Program on Emerging Technologies

The National Science Foundation has awarded MIT $2.9 million for a multidisciplinary program on assessing effects of emerging technologies. The five-year award is under the NSF Integrative Graduate Education and Research Training (IGERT) program. The program is being led by four principal investigators: Daniel Hastings and Dava Newman of the Technology and Policy Program in the Engineering Systems Division; Kenneth Oye of the Department of Political Science, the Engineering Systems Division, and the Center for International Studies; and Merritt Roe Smith of the Science, Technology and Society.

PoET is organized around multidisciplinary panels that will focus sequentially on nanotechnologies, ubiquitous computing, and genetic engineering, with a fourth technology to be selected. Panels will be composed of scientists and engineers with insights into directions of technological change, engineers with insights into potential applications of technologies, and social scientists and humanists with expertise on potential effects on economy, security, environment, and society. Before turning to the emerging technologies of the present, each panel will begin by critically examining past efforts to anticipate effects of technological change. Looking back on past assessment failures and successes before looking ahead will serve as a check on hubris and as an exercise in calibration.

A full-day workshop, which was also the 4th annual symposium of the Technology and Policy Program, was held at MIT on April 12, 2004. Entitled "Emerging Technologies: Recognizing Uncertainty and Assessing Implications," the workshop explored the societal implications of emerging technologies by focusing on examples from biotechnology and ubiquitous computing.

Faculty Notes

Several ESD faculty and teaching staff were coauthors of *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative* (Palgrave, 2002), which was awarded the 2003 Engineering Sciences Book Award by the International Academy of Astronautics (IAA). The coauthors were:

- Thomas J. Allen, Margaret MacVicar Faculty Fellow, Howard W. Johnson professor of management, professor of engineering systems, and codirector, LFM and SDM Programs;
- Kirkor Bozdogan, Center for Technology, Policy, and Industrial Development (CTPID) principal research associate;
- Joel Cutcher-Gershenfeld, executive director, Engineering Systems Learning Center and senior research scientist, Sloan School of Management;
- Earll M. Murman, Ford professor of engineering and professor of aeronautics, astronautics, and engineering systems;

- Deborah Nightingale, professor of the practice of aeronautics and astronautics and engineering systems;
- Eric Rebentisch, CTPID research associate;
- Tom Shields, CTPID research associate;
- Sheila Widnall, Institute Professor and professor of aeronautics, astronautics, and engineering systems.

Other coauthors formerly affiliated with MIT are Hugh McManus, Fred Stahl, Myles Walton, Joyce Warmkessel, and Stanley Weiss.

Professor Thomas Allen became codirector of the Leaders for Manufacturing and System Design and Management programs.

Professor George Apostolakis gave the keynote speech at the Organization for Economic Cooperation and Development (OECD) Workshop on Management of Uncertainty in Safety Cases in Stockholm, Sweden, on February 2, 2004. The title of his speech was "Risk in Technical and Scientific Studies: General Introduction to Uncertainty Management and the Concept of Risk." He was invited to speak at the Atoms for Peace—After 50 Years meeting in Saclay, France (July 22–24, 2003), and the Living with Risk Workshop in London, July 17–18, 2003. He gave a lecture on the "Application of Quantitative Risk Assessment Methodology to Infrastructures and the Terrorism Threat" at the ASME Critical Assets Protection Initiatives Workshop in Washington, DC (February 12, 2004). He was invited to give a seminar at the National Center for Digital Government of Harvard University (March 1, 2004). Dr. Apostolakis was appointed chairman of the NASA Independent Peer Review Panel of the Space Shuttle Probabilistic Risk Assessment. He continues as a member of the statutory Advisory Committee on Reactor Safeguards of the US Nuclear Regulatory Commission, where he chairs the subcommittee on Reliability and Probabilistic Risk Assessment. He continues as editor in chief of the journal *Reliability Engineering and System Safety.*

Professor Cynthia Barnhart received First Prize Award for best paper in transportation science and logistics/INFORMS for "Composite Variable Formulations for Express Shipment Service Network Design" (with Andrew P. Armacost and Keith Ware).

AgeLab director Dr. Joseph Coughlin addressed how technological advances can have a positive impact on the aging experience and long-term care at the National Governors Association in February 2004 and testified at the US Senate Special Committee on Aging in April. The AgeLab also contributed to a new National Academies report on technology and aging and hosted a 21-nation OECD Symposium on "Meeting the Transportation Technology Needs of an Aging Society" in September 2003; Dr. Coughlin chaired the task force. The AgeLab, in collaboration with Harvard Medical School/Partners Telemedicine, also hosted over 100 senior health policy advisors from all 50 states as well as attending governors from Michigan, Idaho, and Massachusetts to discuss how innovation can provide better quality, improved choice, and reduced costs of health care for the elderly in the states.

Dr. Joel Cutcher-Gershenfeld was awarded a Fulbright grant under their Senior Specialist Program to spend five weeks this summer at the University of Sydney helping to launch a new initiative on negotiations in the workplace. He was elected to a three-year term on the National Executive Board of the Industrial Relations Research Association. Dr. Cutcher-Gershenfeld and Thomas Kochan delivered the keynote address at the National Labor-Management Conference in June 2004.

Professor Olivier de Weck became the Robert N. Noyce career development professor, a three-year appointment retroactive to September 2002. He won the best paper award in the modeling and tools category at the 2004 INCOSE International Systems Engineering Conference in June 2004 for a paper coauthored with M. B. Jones entitled "Isoperformance: Analysis and Design of Complex Systems with Known or Desired Outcomes." With Professor Chris Magee, he won a second-best paper award at the same conference in the education and research category for a paper entitled "Complex Systems Classification."

Professor Joel P. Clark was named codirector of a new collaborative research lab at MIT, the GM–MIT Materials and Manufacturing Systems Analysis Collaborative Research Laboratory.

Professor Thomas W. Eagar, the Thomas Lord professor of materials engineering and engineering systems, received the American Welding Society's Charles H. Jennings Award for the most valuable contribution to the welding literature, along with one of his former students, Dr. Patricio Mendez. He was also selected as the College of Engineering and Technology lecturer at Brigham Young University.

The first ESD Educational Excellence Award went to Frank L. Field III, Materials Systems Laboratory senior research associate, MIT CTPID, associate director of education, TPP senior research engineer, senior lecturer in engineering systems.

Professor Richard Larson was honored with the INFORMS 2003 President's Award and was elected president for 2004. He also received the Harold Lardner Prize, which is awarded annually to an individual who has achieved international distinction in operational research. He also ran the second international symposium for the Learning International Networks Consortium, which this year had 25 countries represented. And he directed a major project for the Korean Ministry of Information and Communications, yielding a report entitled "A Sustaining Korea–MIT Research and Education Collaboration in Information Technology."

Professor Nancy Leveson received the ACM SIGSOFT Outstanding Research Award, the CRA Nico Habermann Award, and the CRA Distinguished Professor Award. She was also the Robert T. Chien lecturer, University of Illinois (Urbana-Champaign). Professor Leveson's student, Nick Dulac, won the INCOSE Best Student Paper Award at the INCOSE International Systems Engineering Conference in June 2004 for "An Approach to Design of Complex Systems," which she coauthored.

Professor Thomas Kochan and Dr. Joel Cutcher-Gershenfeld delivered the keynote address at the National Labor-Management Conference in June 2004. Professor Kochan received the Ulrich-Lake Award for the best paper published in the *Human Resource Management Journal* in 2003. *The Effects of Diversity on Business Performance: Report of the Diversity Research Network* was coauthored with Katerina Bezrukova, Robin Ely, Susan Jackson, Aparna Joshi, Karen Jehn, Jonathan Leonard, David Levine, and David Thomas.

Professor Stuart Madnick was keynote speaker at the International Conference on Conceptual Modeling (ER'03), Chicago, October 15, 2003. His presentation was entitled "Oh, So That Is What You Meant! The Interplay of Data Quality and Data Semantics."

Professor Christopher Magee, with Professor Olivier de Weck, won a best paper award at the INCOSE conference in the Education and Research category for a paper entitled "Complex Systems Classification."

A paper coauthored in 1971 by Prof. Earll Murman was one of 36 papers republished in a special July 2003 issue of the *AIAA Journal* titled "Centennial of Powered Flight: A Retrospective of Aerospace Research." The paper, entitled "Calculation of Plane Transonic Flows," was selected from amongst all the papers published between 1934 and 1982 in the *AIAA Journal* and its predecessors.

Professor Dava Newman received the Sigma Gamma Tau Society Graduate Teaching Award for "exemplifying the qualities of a Great Teacher including not only her ability to present information clearly and well, but also for her dedication to individual students in and out of class." Professor Newman was also promoted to full professor.

Professor Daniel Roos delivered the Charles L. Miller Memorial Lecture. His presentation was entitled "Engineering Systems: Past Perspectives and Future Visions."

Dr. Donald Rosenfield, senior lecturer and director of the LFM Fellows Program, was honored by LFM founders, alums, students, partner companies, and staff at a reception in January 2004.

Professor David Simchi-Levi became an LFM–SDM codirector. Professor Simchi-Levi's new book, *Managing the Supply Chain: The Definitive Guide for the Business Professional* (together with P. Kaminsky and E. Simchi-Levi), was published in October 2003 by McGraw-Hill. He also coedited the *Handbook of Quantitative Supply Chain Analysis: Modeling in the E-Business Era.* He assumed the duties of editor in chief of *Naval Research Logistics* in July 2003. The journal, which was founded in 1954, has had a distinguished history, with the publication of seminal work that has made an impact both on the theory and practice of finance, operations research, and statistics.

Professor Joseph Sussman received the Council of University Transportation Centers (CUTC) Award for Distinguished Contribution to University Transportation Education and Research at the Transportation Research Board meeting in Washington DC in January 2004. He continued in his international activities with major addresses this past year, including in Mexico City at the 7th Annual Air Quality Conference, at the Malaysia

University of Science and Technology in Kuala Lumpur, and at Cambridge University in Cambridge, UK.

Professor Yossi Sheffi received the Accenture and the Council of Logistics Management award for the best paper in the *International Journal of Logistics Management.* The title is "Supply Chain Management under the Threat of International Terrorism."

Dr. Daniel E. Whitney, an ESD senior lecturer and a senior research scientist in the Center for Technology, Policy, and Industrial Development, published *Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development* (Oxford University Press, 2004).

Institute Professor Sheila E. Widnall was among 12 women inducted into the National Women's Hall of Fame in October 2003. Professor Widnall also delivered the third annual Brunel Lecture on Complex Systems. Her topic was "The Columbia Tragedy: System-Level Issues for Engineering."

Student Honors

The winning team for the MIT 50K Entrepreneurship Competition included two ESD students, Shashi Kant SDM '04 and Mira Sahney LFM '05. The runner-up team included Vik Sahney LFM '05, and finalist teams included SDM '03s Sam Weinstein, Badari Kommandur, and Sashi Somavarapu and SDM '04s David Michaud and Sandro Catanzaro.

Nick Dulac won the INCOSE Best Student Paper Award at the INCOSE International Systems Engineering Conference in June 2004 for "An Approach to Design of Complex Systems," which Professor Nancy Leveson coauthored.

A 2003–2004 Martin Fellowship for Sustainability was awarded to Ali Mostashari, a PhD candidate in engineering systems from Tehran, Iran.

The Charles "Harrison" Smith Award was given to Aaron Raphel LFM '05.

An honorable mention in the Eric Pas Dissertation Prize Competition in Travel Behavior Research was presented to Tomer Toledo, research associate and PhD '03 in civil and environmental engineering from Bat-Yam, Israel.

An IGERT program grant was given to incoming ESD PhD candidates Spencer Lewis and Aleksandra Mozdzanowska.

Program Honors

For the third year in a row, MIT has been ranked first among graduate business programs in the area of logistics and supply chain management, according to a recent survey by *U.S. News & World Report*.

INCOSE

Several ESD faculty, teaching and research staff, and students participated in the 2004 INCOSE International Systems Engineering Conference in June 2004 in Toulouse, France. Professor Olivier de Weck won the best paper award in the modeling and tools category at the conference for a paper coauthored with M. B. Jones, entitled "Isoperformance: Analysis and Design of Complex Systems with Known or Desired Outcomes." With Professor Chris Magee, he won a second-best paper award at the same conference in the education and research category for a paper entitled "Complex Systems Classification." Professor Leveson's student, Nick Dulac, won the INCOSE Best Student Paper Award at the INCOSE International Systems Engineering Conference in June 2004 for "An Approach to Design of Complex Systems," which she coauthored.

Conference on Systems Engineering Research

Professor Earll Murman presented an overview of ESD and discussed the recent Engineering Systems Symposium. Donna Rhodes participated on a panel of systems engineering leaders who discussed "The Need for Better Systems Engineering and How to Get There." Dr. Rhodes also presented highlights of the INCOSE vision for Systems Engineering and strategic directions for the organization. Eric Rebentisch presented a paper, coauthored with Rhodes and Murman, on Lean Aerospace Initiative research related to systems engineering and the emerging ideas on the value of combining lean practices and systems engineering practices.

ESD Administrative Staff

Su Chung, CTIPD administrative officer, and Mary Gibson, CTL manager of administration and finance, were honored on April 29, 2004, with the prestigious Annual Infinite Mile Award for Sustained Excellence. The award honors those whose work is of the highest caliber, dedication, and enthusiasm. "Su demonstrates how powerful a gentle manner can be," one nominator wrote. "Indeed Su is unassuming, but a stellar administrator. Despite her unassuming manner, she is driven by integrity, ensuring that she is knowledgeable about every situation, and her patient persistence, complete engagement, and due diligence, ensure positive closure on all issues."

Gibson was specifically cited by Donna Savicki for "a strong work ethic and a diverse set of skills, including very strong interpersonal skills." She went on to quote one of the letters nominating Gibson for the award: "Mary interacts with numerous faculty, students and staff, and encounters difficult situations, often involving contentious personnel issues. She is always extremely professional, non-judgmental, patient and generous with her time. I was always impressed by Mary's ability to put herself in another person's shoes and try to provide sympathetic explanations for actions that others might quickly condemn. Her insight and skill in managing these situations were essential to resolving them."

Eda Daniel joined ESD as academic administrator and Jeff Shao as fiscal officer. Abe Dane became director of electronic learning and Lois Slavin became full-time communications director for ESD.

Major Meetings

Engineering Systems Workshop

On October 14–15, 2003, representatives from several of the most prestigious engineering programs in Europe and the United States convened at MIT for the Engineering Systems Workshop, hosted by ESD. These schools have engineering systems programs that include different combinations of operations research, industrial engineering, systems engineering, technology and policy, and engineering and management, including entrepreneurship and management of technology.

The workshop provided a forum in which attendees—many of whom are leaders in their schools' engineering programs and were meeting each other for the first time—could discuss the emerging field of engineering systems. Provost Robert Brown and dean of the School of Engineering Thomas Magnanti made a presentation to participants on engineering systems, and attendees had ample opportunity for lively, engaging discussions with ESD faculty. The purpose of the workshop was threefold:

- to ascertain whether group members would identify any commonalities in their thinking;
- to determine if the group would support and participate in the ESD Engineering Systems Symposium, scheduled for March 29–31, 2004; and
- to identify other group initiatives.

All representatives agreed to work together to support the three-day Engineering Systems Symposium scheduled to be held in spring 2004 and to help evolve the emerging field of engineering systems.

Engineering Systems Symposium

On March 29–31, 2004, the Engineering Systems Symposium brought over 360 leading academics, industry and government representatives, and students to MIT to learn from each other about the emerging field of engineering systems and to consider ways to work together. The symposium, a "call to arms" organized by MIT's Engineering Systems Division, was sponsored by the Alfred P. Sloan Foundation, the Cambridge–MIT Institute, the MIT Industrial Liaison Program, and MIT School of Engineering.

The symposium consisted of panels and presentations by industry, government, and academic leaders who gave examples of engineering systems in their arenas, stressing the imperative for a collaborative interdisciplinary approach among all three sectors. Speakers included the following:

- MIT visiting professor Thomas Hughes, MIT professor David Mindell, and ESD codirector Daniel Roos, who spoke on the evolution of engineering
- MIT School of Engineering dean Thomas Magnanti, who emphasized that developing leaders must be a key part of engineering systems because "complex systems are a complex business"
- Institute Professor Sheila Widnall, a member of the Columbia Accident Investigation Board, who described the technical cause of the shuttle disaster and the long-standing organizational and managerial context that allowed the tragedy to occur
- Professor Fred Salvucci, who shared lessons learned from the political and economic issues and their interplay with the engineering challenges of the Big Dig and the Boston Harbor Cleanup
- William Wulf, president of the National Academy of Engineering, who called for an inclusion of macroethics in engineering systems, so that engineers consider not only their own individual actions but also the resultant interactions with society, sustainability, and policy
- Dr. Joseph Bordogna, deputy director of the National Science Foundation, who emphasized the importance of including people in the engineering systems picture
- A range of engineering leaders from MIT, Cambridge University, UK, Carnegie Mellon, Delft University of Technology, George Mason University, Georgia Tech, Stanford, the University of Arkansas, the University of Michigan, the University of Virginia, the University of Southern California, and others who shared information on their academic programs and thoughts on moving forward collaboratively to define the emerging field of engineering systems
- Thought leaders and industry experts, among them best-selling authors and consultants James Champy and Michael Hammer; chief scientist of the Singapore Ministry of Defense PC Lui; inventor and former executive director of AT&T Bell Laboratories' Communications Sciences Research Division Robert Lucky
- ESD codirector Daniel Hastings, who called for focus on developing a new generation of engineering leaders through a focus on engineering systems
- Travis Engen President of Alcan, who emphasized the importance of corporations considering sustainability in developing and implementing projects that effect society

A key feature of the symposium was the release of the *Engineering Systems Monograph* by ESD faculty and staff. In addition to the paper by Roos on the history leading to ESD's creation of ED and a paper by Hastings on the future of ESD, there are six papers in the monograph on the foundations of engineering systems. A framing paper on foundational issues by Joel Moses is followed by five papers on various aspects of the field. Dan Whitney was principal author of a paper on systems architecture, Richard de Neufville played a similar role in a paper on uncertainty, Tom Allen wrote on enterprise systems, David Marks on sustainability, and Nancy Leveson on systems safety. Over 45 papers were presented at sessions involving sociotechnical aspects of engineering systems, aerospace, education, risk/uncertainty, sustainability/open systems, safety/enterprises, infrastructures, theory/philosophy, systems engineering, and design/education. These can

be viewed at http://esd.mit.edu/symposium/agenda_day3.htm. The monograph papers can be found at http://esd.mit.edu/symposium/monograph/.

Daniel Hastings
Director
Professor of Aeronautics and Astronautics and Engineering Systems

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

Leaders for Manufacturing

The Leaders for Manufacturing (LFM) program is a partnership between MIT and over 25 global manufacturing firms to discover and translate into teaching and practice principles that produce world-class manufacturing and manufacturing leaders. This partnership is motivated by our shared belief that excellence in manufacturing is critical to meeting the economic and social needs of individuals, firms, and society, and that the health of companies operating in global markets is essential to society's well-being.

Now in its 16th year of operation, LFM is a partnership between the School of Engineering, the Sloan School of Management, and leading manufacturers. Launched in 1988 with significant industry funding, the program emphasizes collaboration and knowledge sharing with its partner companies across the entire spectrum of "Big-M" manufacturing enterprise issues. LFM supports students as fellows in the program with a generous fellowship. The largest component of the educational efforts is the Fellows Program, a 24-month dual master's degree (SM in engineering and MBA or SM in management), involving a single integrative research project carried out on site in partner firms. With regard to the School of Engineering, LFM SM students can get degrees in the eight School of Engineering departments, as well as in ESD.

On the administrative level, LFM and SDM are run as a common enterprise.

Academic Program

Fifty-seven students in the class of 2004 completed the Fellows Program, and approximately 80 percent have taken positions in manufacturing/operations firms. Each of the 57 graduates completed an internship at a partner company during the summer and fall of 2003. 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 the use of modeling and critical operations data to optimize plant performance, projects focused on optimizing supply chains, and various lean manufacturing initiatives. As a one-year project funded by the Cambridge–MIT Institute, five LFM interns completed their internships at companies in the UK. Part of the funding included a follow-up six months after the projects' completion to determine what the return on investment was for these projects. Mary

Barton, senior business analyst for MIT's D-Space Project, undertook this review, which was available in late summer 2004.

Another 48 students (Class of 2005) completed their first year of on-campus studies and are starting their six-month internships. Forty-eight new students (Class of 2006) were admitted and have begun an intensive summer session. The Class of 2006 has an average work experience of 4.8 years. Don Rosenfield continues to serve as the director of the LFM Fellows Programs. Codirectors for the program were David Simchi-Levi, Bill Hanson, and Tom Allen.

Research and Knowledge Transfer Program

As part of LFM and SDM's commitment to lifelong learning, an initiative begun in FY02 was continued to encourage LFM and SDM alumni to stay connected with MIT by sharing relevant information. Paul Gallagher, research associate for LFM and SDM, continued to schedule monthly webcasts presented by MIT faculty and various LFM and SDM alumni. The content of these webcasts, also called "webinars," provides valuable information on the latest trends, cutting-edge developments, and innovative strategies, all of which pertain to manufacturing and/or systems design. The presentations are given in real time, via the internet and telephone, which allowed participants to follow along visually and audibly as well as ask questions. Alumni continue to express a high degree of interest in these virtual knowledge–sharing events, and webinars have evolved into a key tool for alumni engagement.

Also completed was Phase 1 of the LFM–SDM Virtual Community, a portal for LFM–SDM industry partners, alumni, students, faculty, and staff supported by a robust Oracle relational database. The Virtual Community allows LFM–SDM partners to log in remotely and obtain information such as community members' contact information, research, and work history. A word-searchable thesis repository allows community members to use key words to search through all 876 theses.

Outreach

LFM continues its leadership role in the National Coalition of Manufacturing Leadership (NCML), a partnership of 15 universities with joint management and engineering manufacturing programs. The NCML met at McGill University in November 2003. This year, programs in the NCML began to tackle the issue of an NCML brand and whether the schools should initiate some joint marketing efforts. The discussion, which is being led by McGill University, will continue through 2004.

Placement

LFM students, sponsored and nonsponsored, continue to be highly sought once they have completed the program. Partner companies as well as other organizations take a special interest in LFM students as proven by their commitment to speak to the class on various issues during the Pro Seminar session. About 80 percent of each class accepts

positions within the manufacturing industry, while the number of students accepting positions within partner companies has consistently remained at about 50 percent.

Tom Allen, Codirector
Bill Hanson, Codirector
David Simchi-Levi, Codirector, Professor of Civil and Environmental Engineering

More information about the Leaders for Manufacturing Program can be found on the web at http://lfm.mit.edu/lfm.

System Design and Management

The mission of the System Design and Management (SDM) program is to educate future technical leaders in the architecture, engineering, and design of complex products and systems, preparing them for careers as the technically grounded senior managers of their enterprises. SDM intends to set the standards for delivering career-compatible professional education using advanced information and communication technologies. SDM was one of MIT's early entries into the field of distance education and remains the only degree-granting program at MIT that can be earned primarily from a remote location.

The SDM program is a joint offering of the School of Engineering and the Sloan School of Management, leading to a master of science degree in engineering and management. Targeted to professional engineers with three or more years of experience, the program centers on a 13-course curriculum in systems, engineering, and management, including a project-based thesis. It offers three curriculum options: a 13-month in-residence format; a 24-month distance education for company-sponsored students, requiring one academic semester in residence at MIT; and a 24-month commuter program for locally sponsored students. The program was conceived as an alternative to the MBA for professional engineers, allowing working professionals to pursue a degree without interrupting their careers and relocating themselves and their families.

Denny Mahoney, director of the SDM Fellows Program, is completing his fifth year in that position. Codirectors for the program were David Simchi-Levi, Bill Hanson, and Tom Allen.

Student Statistics

In January 2004, SDM admitted its eighth class, enrolling 37 students. As was done in FY03, in May 2004 SDM put on an informational evening for local MIT alumni and others interested in SDM as a way to recruit prospective students for the coming year. This successful event brought in more than 40 prospective students to campus, where they heard presentations from several faculty, students, and alumni about the program. The plan is to repeat the event in July 2004.

System design and management admissions statistics

	1997	1998	1999	2000	2001	2002	2003	2004
Admitted	35	58	47	50	37	27	36	37
On-campus	8	16	6	14	8	7	18	27
Self-supported	3	1	2	5	2	1	6	25
Research assistant	3	12	2	4	3	1	10	0
Distance education	27	42	41	36	29	18	17	10
Company-sponsored	29	45	43	41	32	25	20	12

MIT–Industry Partners System Engineering Program

This past year, SDM and its partner program, Leaders for Manufacturing (LFM), along with United Technologies Corporation (UTC), continued with a third year of the MIT–Industry Partners System Engineering Program. This year the program was expanded to include another SDM partner company, ArvinMeritor, which enrolled several students in both the certificate program and the Organizational Leaders Workshop.

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 three-year pilot has been very successful, with 56 students completing the certificate program and 100 organizational leaders completing the six days of content in the Manager/Supervisor Workshop. With its active participation in all levels of the program, UTC now has over 200 employees touched by SDM. The next cohort of certificate students for FY05 is expected to reach 40, with students from UTC, ArvinMeritor, Ford, and Raytheon joining the program.

Distance Education Delivery

As MIT's premier degree program offered at a distance, SDM has recognized its leadership role at the Institute regarding the practice of distance education and continues to evaluate its delivery with the goal of increasing the quality of the remote-learning experience while reducing costs, both for MIT and for sponsoring companies. The codirectors recognize the need to bring in more distance education students in the January 2005 cohort to justify the costs of distance education for this program. SDM

champions at ArvinMeritor and Ford have volunteered to help market the program. Plans are underway in the summer 2004 to visit companies in the Detroit area with a team led by representatives from these two key SDM partners.

Tom Allen, Codirector
Bill Hanson, Codirector
David Simchi-Levi, Codirector, Professor of Civil and Environmental Engineering

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

Technology and Policy Program

The MIT Technology and Policy Program (TPP) provides an integrative education to engineers, scientists, and humanists who wish to lead technological development by implementing responsible policies for the benefit of humankind. TPP's guiding vision is the education of "Leaders Who Are Engineers and Scientists."

The TPP graduate educational program in the School of Engineering acknowledges that the development of the skills necessary for effective implementation of technology ties into the emerging engineering systems' educational thrusts and, consequently, TPP is part of the Engineering Systems Division of MIT. The program focuses on providing a high-impact, high-quality education to its students. Its goal is to make TPP the most prestigious and sought-after technology policy program in the world and to produce the technological decision makers of the future.

TPP sponsors both a Master of Science program and the Technology, Management, and Policy (TMP) doctoral program, constituted as a track within the ESD doctoral program. TPP receives most of its applications from outside MIT, but it also has several internal admits each year, with many students pursuing a masters or doctoral degree in another program concurrent with their TPP SM degree. Each entering class is around 40 students, with approximately, 35 percent of the students pursuing dual degrees, which may require an additional semester or two to complete. This year, 40 students graduated with masters degrees in technology and policy and six masters students were accepted to continue their studies at the doctoral level. This year's Best Thesis in Technology and Policy was awarded to Anup Bandivadekar, who is continuing for his PhD degree in technology, management, and policy. The TMP track within the ESD PhD program has a current enrollment of 23 students, reflecting a steady-state admission rate of about 5 students per year. No students received their technology, management, and policy PhD in this past academic year.

One-semester fellowship funding was provided to several incoming students in order to attract the top TPP candidates to MIT. In addition, the Keill Fellowship provides tuition-only funding. This fellowship funding, which includes the Rabinowitz and de Neufville funds, has been provided by TPP alumni and donors who make possible several other

student benefits, including funding for TPP women students and some of the costs associated with the TPP visiting speaker series and alumni relations. TPP maintains ties to its 800-plus alumni and works to foster a strong alumni community through the biannual publication of the *Alumni Directory* and regional gatherings in Washington and Boston. TPP alumni also receive e-newsletters several times a year, including newsletters written by current TPP students as well as faculty and staff.

The Technology and Policy Program greatly values practical experience and actively encourages students to take summer internships between their first and second years of study. In January 2004, 18 students traveled to Washington, DC, to attend meetings with prospective internship employers, including government agencies such as the Office of Management and Budget and private consulting companies and think tanks such as ICF and CSIS. Many of our students found internships in Washington this summer, while others are working elsewhere in the United States or abroad. 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, Phillip Ng, Francis Chin, and Donald Cooke, in order to make their internship experiences possible.

The Technology and Policy Student Society (TPSS) is one of the most active student groups on campus. Generous donors have made it possible for the Technology and Policy Program to recognize TPP students for leadership. In addition to recognizing the student board of TPSS, this year's leadership prizes also went to (1) Betsy Masiello and Alan Cheng, who initiated a mentoring/tutoring effort for student athletes at Cambridge Rindge and Latin high school, and to (2) Jennifer Atlee and Anup Bandivadekar for their efforts to increase employer awareness of MIT's Tech and Policy Program with a new trifold employment brochure. Very dedicated students in the program make these and many other TPP initiatives possible.

This past year, the course ESD.10 Introduction to Technology and Policy was team taught for a third year by professors Sussman, Hastings, Field, Oye, and others. Additional fine tuning will be possible for next year through the availability of curriculum development funds from the Lord Foundation, which also supports other course changes at TPP. Professors Mindell and Weigel will lead ESD.10 with additional lectures provided by Professor Sussman and Dr. Field in AY05. Professor David Marks was awarded a Faculty Appreciation Award by the TPP students. ESD's first annual Joseph Nemec Award for Outstanding Contributions to Education in the Engineering Systems Division went to TPP education director and alumnus Frank Field.

With support from the Cambridge–MIT Institute, the Technology and Policy Program has maintained its close collaboration with the Technology Policy Master of Philosophy (MPhil) program at Cambridge University (CU), which has just completed its second year. Collaborative curriculum development efforts continue, with some of the new educational material developed for CU being incorporated into TPP teaching at MIT. Over a half dozen faculty members traveled to Cambridge University this past year to participate in teaching in the the program's core curriculum and other newly developed elective modules. Over the past three summers, TPP has sent seven students to Cambridge University for summer internships to support the new curriculum there. For

the second year, TPP has welcomed three Cambridge students to MIT to pursue summer internships in research.

TPP was a key participant in the formation of the collaborative and interdisciplinary Program on Emerging Technologies (PoET), along with ESD, STS, CIS, and Political Science. Funded by a recently awarded five-year $2.97 million grant from the National Science Foundation's IGERT program and a pending grant from the Cambridge–MIT Institute, 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. TPP was instrumental in organizing the first IGERT workshop this past spring, which served as TPP's 4th Annual Technology and Policy Symposium. Proceedings will be published this summer, and planning for a fall event has begun. Seven PhD students from ESD, CIS, and STS will begin PoET IGERT traineeships this fall. Visit http://poet.mit.edu/ for more information.

We have just completed our first year in the newly renovated academic space on the 3rd floor of E40, the Muckley Building. By the beginning of the academic year, the student lounge, computer lab, study space, waiting area, and conference room were furnished, and recent installation of lockers for students without offices on campus has completed the student space. This has given the program a physical presence and center, allowing students who are conducting their research in all areas of the Institute, with supervisors in different areas of the campus, a place to hold meetings, study sessions, lunch discussions, and so on.

We are currently reorganizing TPP staff responsibilities as part of the ESD staffing changes.

Dava Newman
Director
Associate Professor of Aeronautics and Astronautics and Engineering Systems

More information about the Technology and Policy Program can be found on the web at http://tppserver.mit.edu.

Technology, Management, and Policy Program

The Technology, Management, and Policy Program (TMP) is an interdisciplinary PhD program directed at producing world-class researchers striving to improve methods used in defining and implementing policies for the intelligent use of technology. The program was established in 1992 and became a part of the Engineering Systems Division in 1998. The students within the program are motivated by their recognition of specific problems at the boundaries between technological development and social and industrial policy. The goals of the TMP program are to supply an academically rigorous

environment within which these students, under the guidance of MIT faculty, work to extend the nature and purview of the tools needed to understand and address these issues.

The common vision of the program participants is that a dual competency in a technical area and in management and policy is the basis for the effective design of large-scale systems. The research efforts within the program are leading to the development of a new paradigm for the planning and design of engineering systems—a paradigm that blends technical expertise with competence in economics, management, and policy to achieve a better adaptation of technology to societal goals.

Students are rarely directly admitted to the program; rather, they are first admitted to the Master of Technology and Policy program. After their arrival at MIT, these potential TMP students then prepare a case for admission to the TMP program, which requires that they (1) construct an appropriate research question; (2) assemble a cadre of MIT faculty committed to that effort; and (3) develop a proposed curriculum that will assure that the student will be equipped to address this question in a manner consistent with the highest academic standards of the fields represented. This admission case is then reviewed by the TMP admissions committee, composed of faculty drawn from the MIT Schools of Engineering; Management; and Humanities, Arts, and Social Sciences. As of this past year, the technology, management, and policy PhD is a specialized track of the engineering systems PhD.

Although the majority of the students in the program initially came to TPP solely for the SM in technology and policy, many of our students pursue a simultaneous second SM or doctorate in another discipline. There has also been an upsurge in applicants who have specifically targeted admission to TMP over the past several years. The program generally admits about six students each year, and this year was typical in this regard. Students take approximately five years to complete their degrees, and there currently are 23 students enrolled in the TMP program. No TMP PhDs were awarded during AY2004, and there are 30 graduates who are pursuing careers in industry, academia, and the government.

Marvin and Joanne Grossman have made funding available to help doctoral students travel to exchange ideas with doctoral students in programs with a similar mission to that of TMP. The third annual Doctoral Consortium was held at Cambridge University in June, and four TMP students traveled there to present their research. They, along with the TPP CMI interns and members of the TPP faculty and staff, were able to continue to build the relations among the burgeoning international academic community of technology and policy scholars. Previous meetings were held in the Netherlands and in Washington, DC. We look forward to hosting next year's meeting at MIT.

More information about Technology, Management, and Policy can be found on the web at http://tppserver.mit.edu/ and at http://esd.mit.edu/.

Center for Innovation in Product Development

The Center for Innovation in Product Development (CIPD) unites industry practitioners with leading academic researchers to investigate the end-to-end product development process. A joint effort between MIT's School of Engineering and Sloan School of Management, CIPD researches all aspects in the process of product development (PD), from engineering concept to management practice and from product design to market delivery and beyond.

The internet will be key to product development's future. New products will be developed by just-in-time collaborations of globally distributed teams linked seamlessly by web-based tools and processes. These collaborations will evolve through an emerging services marketplace, where lead firms will find the world's best suppliers of information, components, and support services. Focusing on web-based methods, CIPD works with engineers and managers in real-world PD environments to extend the fundamental knowledge of the PD process and provide innovative improvements to current practice.

CIPD was founded in 1996 as a National Science Foundation Engineering Research Center (ERC). Since inception, the center has executed over 200 research projects and produced nearly 150 refereed journal articles and 100 conference papers. Our faculty has received over 20 awards for outstanding research, and our work has led to the creation of a dozen spin-off companies. In AY2004, CIPD's 12 faculty and 24 graduate students pursued product development research with a budget of $1M. Under the guidance of center director Chris Magee and assistant director Nils Nordal, CIPD continues to advance the theory and practice of product development with research programs focusing on complex systems.

Research Program

CIPD investigates specific problems with immediate relevance to industry. As a research center focused on clearly defined issues, CIPD develops projects of particular interest to individual sponsoring companies—projects that provide direct benefits in terms of solutions to current challenges.

Many of our projects are related to the emerging field of engineering systems—the study of systems characterized by their especially large scale, complexity, and high or varying rates of change. Our core initiatives explore complex system design, development, and management, a concern of increasing importance to contemporary engineering.

CIPD is directed by our vision that product development will be dispersed, global, and driven by new information and communication technologies. As we probe the end-to-end PD process, we recognize the value of cross-disciplinary integration among and within research goals. Our portfolio is a versatile suite of seven research initiatives that inform and are informed by each other. The initiatives are detailed below.

1. Virtual Customer

The Virtual Customer (VC) initiative (or closing the gap between product developers and customers) seeks to increase the speed, accuracy, and usability of customer input. With our integrated suite of projects, we pursue a radically reduced lag time between customer input and PD response—and at a fraction of current cost. PD teams and customers become joint participants in a dynamic exchange that benefits customers, companies, and the market (see demos, working papers, and downloads at http://mitsloan.mit.edu/vc/).

In academic year 2004, we achieved a substantially deeper understanding of polyhedral methods for web-based preference measurement. We also made substantial progress on the application of machine learning to the analysis of large consumer databases. Lastly, we began research in a new, promising direction: web-based, incentive-compatible, customer-based ideation. During the year we completed nearly a dozen research papers, many of which have been published or are scheduled for publication in journals such as *Marketing Science,* the *Journal of Marketing,* and the *Journal of Marketing Research*. The paragraphs below highlight individual VC projects.

FastPace. The first new idea in metric conjoint analysis in 20 years, Fast Polyhedral Adaptive Conjoint Estimation applies web-based conjoint studies to larger numbers of product features. This past year we demonstrated the method's superiority to other existing methods whenever customers are heterogeneous in their preferences and/or responses can be obtained accurately. We also continued development of FastPace CBC, the first-ever adaptive questioning procedure for choice-based conjoint analysis.

Listening in. We have developed methods to "listen in" on electronic dialogues between virtual advisors and customers to determine new unmet needs and opportunities for new vehicle platforms. This past year we applied the method to the truck market and identified two new truck segments.

Ideation. Our web-based asynchronous questioning methods draw on customers as a rich source of design ideas. We are currently exploring field applications with an advertising agency and a consumer-packaged goods firm.

Configurators. Web technology can now let users configure their own virtual products, allowing custom products to be developed more quickly and at lower cost. Our current research explores how configurator methods can be linked to managerial decisions. To date, our extensive Monte Carlo experiments have yielded exciting results.

Information Pump. Establishing formal incentives for collecting relevant information from customers, the Information Pump implements those incentives through a web-based collection protocol. This past year, we solved a significant implementation issue that will now make the method more attractive to potential sponsors.

Reinforcement learning. Machine learning allows for the development of superadaptive methods—facilitating the automatic evolution of systems as participants respond to

survey questions. We are currently validating our latest method with a large-scale field test involving 60,000 customers. This study will measure the transactions made by these customers for a period of at least six months.

CARDS. Improving web-based conjoint analysis, our Conjoint Adaptive Referral Database System reduces the number of profiles presented to respondents in the full-profile format. Simulations this past year suggest that the method may dramatically reduce the number of questions asked of respondents and make the questions themselves easier.

GARDS. Our Greedoid Adaptive Reduced Decision System applies a mathematical programming construct to the process that most consumers use to screen product choices. This approach may fundamentally change how preference information is obtained from consumers. We have completed simulations, which are quite promising, and plan an empirical test in the coming months.

2. Distributed Object Modeling Environment

Distributed Object Modeling Environment (DOME), providing global access to modeling and simulation services, is a fundamentally new approach to integrated modeling and simulation. DOME can incorporate the efforts of hundreds of developers working on radically different platforms in widely dispersed locations. All designers participate simultaneously in the modeling process, using their preferred tools and methods in a user-friendly web-based environment. While maintaining information integrity, DOME models the integrated characteristics of large, complex, rapidly evolving products and systems. Its seamless infrastructure provides the management controls of a centralized system while preserving the responsiveness of a locally autonomous system. The paragraphs below detail our current projects.

Services discovery in the worldwide simulation web. DOME requires a powerful discovery mechanism to locate simulation services for large-scale distributed simulation. DOME also needs proper knowledge-based representations that promote the share/reuse of simulation information and applications. In 2003, we developed these attributes by focusing on web service ontology and P2P system lookup schema, as well as user interfaces, distributed solving, and performance tuning. In 2004 we will develop a DOME service lookup engine based on ontology and distributed-hash tables, and we will test its performance against a battery of appropriate models.

A new approach to designing a renewable energy system using DOME. In the 21st century, renewable energy systems will become essential technologies. This DOME project has been focusing on solar technologies by developing the I-deas plugin, federated and integrated solving, and math operations and units support. In the coming year we will complete a collection of solar energy models and will simulate numerous scenarios to demonstrate the advantages of our new design approach.

Pareto optimization in DOME. In 2003 this project successfully completed a Pareto optimization tool in the DOME environment and initiated a pilot study with the Ford

Motor Company. We expect to complete that study in the coming year and to publish at least one conference paper at the ASME–DTEC conference.

Incorporating preference theory in DOME. Still in its infancy, this project is studying methods that incorporate utility (or "preference") theory and probability distributions in modeling. To date we have developed and coded DOME's preference datatype, as well as an early prototype GUI for preference inputs to DOME. In addition, we are exploring opportunities to incorporate DOME in financial modeling.

3. Information Flow Modeling

The Information Flow Modeling (IFM) initiative, or effectively managing engineering design knowledge, uses design structure matrix (DSM) and other advanced tools to model and simulate the flows of information throughout an organization. MIT is at the heart of DSM research. We use DSM to capture system-level knowledge and to accurately represent complex product architectures and large development organizations. Our visual representations provide integrated maps of all development activities—a gateway to PD process improvement. Focusing on knowledge exchange in early development phases, we aim to better convert top-level specifications into component specifications, ensuring the harmonious function of systems, subsystems, and components. Projects in the past academic year are described below.

Concurrent process mapping, organizations, and project and knowledge management in complex PD projects using the design structure matrix (DSM). Complex product development requires the integration of many domains that are in themselves highly dynamic and complex. Successful PD demands that the overall process be intelligently designed and managed. This project—based on studies at PSA Peugeot-Citroën in Paris and Ford Motor Company in Dearborn, Michigan—verified DSM's value in guiding and reconciling product design, project management, organizational management, system-level knowledge generation and management, process improvement, and other domains essential for sustainable product development.

PD process design. Companies that develop new products employ product development processes (PDPs) to coherently manage development risks. Introducing PDPs as risk-management frameworks, this project focused on 10 companies in various industry sectors (Siemens-Westinghouse, ITT, Xerox, Printco, UTC, etc.). We compared traditional stage gate PDPs with newer variants such as spiral, modified waterfall, evolutionary prototyping, and evolutionary delivery. Our research showed that PDPs vary substantially more than was previously documented, and we proposed a method for improving PDP design based on risk and integration.

Scheduling multiple development projects under unique constraints. The scheduling of resource-constrained projects is a topic that has received ample attention in the scheduling literature over the past three decades. In product development processes, where the primary resource constraints are engineering skills, the problem often obtains a special structure due to the uniqueness of those skills. In an innovative departure from traditional approaches, our research takes advantage of this special structure by

proposing a graph-based approach that exploits the transitivity property of comparability graphs.

Commonality in product development. Manufacturers of complex products often find substantial benefit in increasing the commonalities among their PD processes, locations, and components. This research investigates aspects of commonality currently relevant to industry.

Commonality of production processes in pilot production. In AY2004 we analyzed various pilot production strategies for newly developed products. We determined how to manage a new product's pilot production phase and to characterize how the product's production processes can be improved during full production.

Commonality of service locations in spare parts inventory management. We have been developing effective inventory management models for spare parts suppliers. Our focus has been the management of spare parts inventories where multiple demand classes are differentiated based on different committed service levels. Expected results include improved inventory management policies.

4. Platform Architecture: Optimizing Product Families

This program develops comprehensive, dependable system architecture principles for vehicle family design. Our current focus is the automobile industry, where heterogeneous customer demands have fragmented the market, resulting in smaller per-vehicle sales volumes. In response, we are helping the industry to optimize the number and type of platforms for given product families, reducing production time and cost while maintaining product variety. This initiative seeks to (1) match customer needs with function, (2) match function with technology, (3) transform complex technologies into a set of integrated design modules, and (4) optimize these modules against rigorous portfolio architecture principles.

A market-driven design process for flexible product platforms. This project focuses on the strategic placement of flexibility in product platforms to respond quickly to changing market needs with minimum increase in platform complexity. Through observations of customer reactions to products, we seek to determine sensitivities to critical product attributes and then establish a basic set of components for a given product platform. In collaboration with General Motors, we have thus far defined a basic framework for the process and are currently working on a simple design process case to demonstrate the framework's validity.

Commonality of components in automobile manufacturing. Many auto manufacturers seek to improve component commonality levels across different brands and platforms. The improvements are greatly affected by communication among PD teams. This new field study investigates the evolution of communication among PD teams that pursue component commonality strategies. We aim to develop effective negotiation models to increase the speed and degree of commonality improvement.

5. System Dynamics

This involves extending the system dynamics method for sustainable process improvement. The history of management practice is filled with innovations that failed to live up to their early promise, even when compelling evidence suggests that appropriate adoption would have provided substantial benefits. We use the system dynamics method to understand the sources of success and failure in large-scale design and development projects. Our research broadens the method's typical application, applying it to cases when multiple projects compete for a common resource pool. Our ultimate goal is to develop management "flight simulators" and other decision-support tools to help managers accurately model scenarios before making resource allocation decisions.

Applying system dynamics to large-scale complex development. This research seeks to understand the organizational mechanisms that contribute to performance in complex oil industry projects. Key research activities in AY2004 included interviews with senior managers at British Petroleum (BP), the development of an "alpha" version management flight simulator in support of the BP Academy initiative with MIT, and the development of system dynamics models necessary to test the systems under investigation. In AY2005 we will conduct interviews and data collection at a specific BP deepwater offshore development site, and we will pursue refinement of the management flight simulator.

6. PD–Enabling Factors

PD–enabling factors increase robust decision making in large organizations. "Should we adjust the sale prices of our products?" "Should we buy back shares of our stock?" "Should we invest in quality improvement?" Executives in large companies often face questions like these, and the resulting decisions can profoundly impact the organization. This CIPD initiative seeks to understand how large organizations approach crucial decisions. To make their approach more effective, we are developing a method to help them make decisions that are more *robust*—insensitive to variation in uncontrollable factors.

Because rigorously testing the consequences of crucial decisions in a large organization is quite difficult, we have chosen to begin by testing them on a simulation model of a large company. Results thus far suggest that we can set up a decision process as a design of experiments (DoE), and rely on DoE literature for guidance about options to consider in detail. If we can show that our decision process can be conducted with a reasonable level of resources and that the resulting decisions are good, we can then fully develop a method for our industry collaborators.

To date we have had some success running our simulated company with the DoE protocol. Our next step is to work with a collaborating company to make a decision in a manner dictated by a chosen protocol. We intend to complete two case studies of our decision process by the end of 2004. From these we expect to understand our method's limitations and expect to know more clearly its cost/benefit tradeoffs.

7. Effective Enterprise Learning

This initiative seeks to negotiate boundaries to knowledge transfer. Firms that manage knowledge across functional boundaries often face obstacles to knowledge transfer. Especially in PD settings, knowledge tends to become localized, embedded, and invested in particular practices. We propose that knowledge is not so much *transferred* across boundaries as it is *transformed*. Using boundary objects and other technologies, we develop cross-boundary practices that render knowledge transfer more negotiable.

Building the capacity to resolve novelty in product development. Novelty is essential to product design, but it can present significant opportunities for both success and failure. Begun in 2003, this project identifies two basic types of novelty—known and emergent—that occur in PD settings. We investigate how teams manage the emergence of novelty in the product design process. We propose that organizations can effectively build capacity into their PD processes to resolve novelty and so achieve competitive advantage through improved quality, reduced time to market, and lowered resource consumption.

We began collaboration with Hewlett-Packard (HP) in 2003, collecting data on development teams past and present. We are now examining their development processes to determine how teams can most effectively leverage both types of novelty. Analysis will be complete by June 2004 with the dissemination of our results to HP.

Education Programs

CIPD is an interdisciplinary program between MIT's School of Engineering and School of Management. We believe that students' course experiences should address the interplay between the technical, social, and system elements of product development and should prepare them for work in a globally distributed services marketplace. Our PD education programs target three communities: working professionals, graduate students, and undergrads.

For Working Professionals

The SDM product development track was created in collaboration with MIT's System Design and Management (SDM) program. This 24-month distance learning degree program (or 13-month on-campus program) targets mid-career engineering professionals who are potential leaders in product development settings. At graduation, students receive an MIT degree in engineering and management.

Since the program's inception in 1997, 23 CIPD faculty have participated in SDM's product development track. Nearly 300 students from 55 organizations have enrolled, with over 200 students graduating. In AY2004, participating organizations included Ford, IBM, Raytheon, ArvinMeritor, UTC, and many others. Thirty-six students began the program in January 2004, and a like number graduated between September 2003 and June 2004.

Systems engineering course. CIPD director Chris Magee coteaches ESD.33J Systems Engineering with CIPD researcher Dan Frey. The course examines the sources of complexity that can adversely affect new product design and development and formulates a systems engineering process that can mitigate the effects of complexity. Subject materials and exercises are complemented by special event seminars showcasing speakers from industry and government. Class size averages about 40 students, most enrolled in the SDM PD track.

Executive education courses. CIPD faculty created and have taught a full suite of short courses as nondegree programs. These industrial minicourses have been offered during the year through MIT's office of summer professional programs and through Sloan's office of special executive programs. Since the center's inception, well over 2,000 students have attended. In AY2004, students attended courses that included Marketing for the Non-Marketing Executive and Understanding and Solving Complex Business Problems.

For Graduate and Undergraduate Students

Graduate course in product design. Professor Thomas Roemer of the IFM initiative teaches a semester-long class 15.783J, 2.739J, and ESD.32J Product Design and Development. The class focuses on integrating the design, manufacturing, and marketing functions in a new product development firm. The course's associated website (its construction was supported by CIPD) provides extensive resources for students, as well as support materials for faculty who are teaching comparable courses at other institutions. The site is organized around the book *Product Design and Development* as taught at MIT, and can be found at http://www.ulrich-eppinger.net/.

Graduate course in systems design. Professor de Weck, leader of the Platform Architecture initiative, coteaches the semester-long class 16.888J and ESD.77 Multidisciplinary System Design Optimization. The course considers engineering systems modeling for design and optimization and provides an overview of principles, methods, and tools. Topics include subsystem identification, heuristic search methods, multiobjective optimization, and system design for value. The class applies general principals to specific examples in the aerospace, mechanical, civil engineering, and system architecture fields.

Doctoral seminar. CIPD director Chris Magee, in collaboration with other faculty, taught the ESD doctoral seminar ESD.934 Engineering Systems in the fall of 2003. Designed to codify current thinking about the emerging field of engineering systems and to give direction for its future development, this seminar is helping to shape the structure and operation of the ESD PhD curriculum at MIT.

Freshman course. The 2.009 Product Engineering Process course helps undergraduates understand the phases of product development. Taught by CIPD director Chris Magee and senior lecturer Sandy Campbell, students form into teams that design and construct high-quality product prototypes. Students learn to reason about design alternatives and apply modeling techniques appropriate to different development phases.

Noon seminars. In AY2004, CIPD hosted nearly 28 lunchtime seminars—informal talks from researchers at CIPD and throughout the Institute. Guest speakers also included researchers and industrial product developers from the Ford Motor Company, Synopia, Inc., the Wharton School of Management, the Technical University of Denmark, the Helsinki University of Technology, and the UK's Cranfield University.

During the past academic year, CIPD funded 10 PhD and 14 masters candidates. Of those, one PhD and six masters students graduated in June 2004.

Outreach

The center's outreach activities introduce organizations to our research and open new venues for a vigorous exchange of ideas between academic investigators and industry practitioners.

PLM Conference. In October 2003, CIPD hosted a daylong conference devoted to product lifecycle management (PLM), a topic of increasing importance among product developers. The conference provided a venue for leaders in industry and academic research to formulate the framework for a potent PLM–grounded research agenda. The first part of the conference focused on the perspectives of senior managers and executives from CAD– and PLM–reliant industries. Presenters included senior technical representatives from Boeing, Daimler-Chrysler, D. H. Brown Associates, EDS, IBM, IDe Enterprises, PTC, and Rockwell Collins. Following their presentations, breakout sessions provided a forum for participants to discuss the key drivers to create value for PLM in product development and the key issues that limit successful PLM implementation.

The second part of the conference concentrated on the PLM–related findings of CIPD researchers and the potential directions for their initiatives. In the breakout sessions that followed, participants began to define the research programs that could enhance the value of PLM in product development settings and resolve the implementation issues. In the months since the conference, this conversation has continued as CIPD has engaged with numerous potential partners in further discussions about how center research could meet industry needs in advancing PLM.

Department of Homeland Security (DHS). In December of 2003, CIPD participated in a best-practices conference that considered several topics of current interest to the DHS Advanced Research Projects Agency. These included presentations on the status of DHS–University collaboration, program management, and solicitation and procurement vehicles.

Naval-Industry R&D Partnership Conference. In August 2003, CIPD attended this annual conference, taking part in panels and workshops that focused on optimizing the deployment of emerging technologies to the US Navy.

Visiting scholars. This past academic year, CIPD continued its tradition of hosting visiting scholars from technical universities around the world. These included Christian Engau from the Technical University of Darmstadt, Katja Holtta from Helsinki University of

Technology, Ellen Kugelberg from the Swedish Royal Institute of Technology, and Karsten Zakarias from the Technical University of Denmark.

Personnel

CIPD underwent no personnel changes in AY2004, reflecting its assurance and stability as a focused research center.

Director Chris Magee continues to guide the center's product development investigations with a concentration on complex systems; Professor Magee's extensive background in product development is the result of many years in R&D for the Ford Motor Company.

Nils Nordal continues to serve as the center's assistant director, with Michael Mack as communications coordinator, Kathleen Sullivan as office and finance manager, and Susan MacPhee as media design and production specialist.

Nils Nordal
Assistant Director

More information about the Center for Innovation in Product Development can be found on the web at http://cipd.mit.edu/.

Center for Technology, Policy, and Industrial Development

The programs of the Center for Technology, Policy, and Industrial Development (CTPID), a multi-industry, interdisciplinary research facility, are united by their commitment to develop sustainable solutions to industry problems and policy perspectives that deliver economic and social benefits. Programs examine the global impact of emerging technologies on business and on people. Knowledge and support from 75 industry and government partnerships are key to CTPID's efforts.

Founded in 1985, CTPID engages more than 80 faculty, researchers, and staff working in these programs: the Cooperative Mobility Program (CMP); the Ford–MIT Alliance (administered by CTPID); the International Motor Vehicle Program (IMVP); the Labor Aerospace Research Agenda (LARA); the Lean Aerospace Initiative (LAI); the Lean Sustainment Initiative (LSI); the Materials Systems Laboratory (MSL); the MIT Information Quality program (MIT IQ); the Program on Internet and Telecom Convergence (ITC); and the Technology and Law program (T&L).

Priorities

CTPID is committed to the intellectual and academic success of the Engineering Systems Division. As ESD develops its core competencies and translates them into academic and

research activities, CTPID is increasingly involved both with strengthening the intellectual core and serving as a major research arm of ESD.

CTPID programs fall firmly within the defined scope of ESD activities. Our research involves interdisciplinary teams, large-scale systems behavior, interactions between government and industry, and the impact of emerging technology on societal issues. As a research arm of ESD, CTPID programs explore broad issues such as transportation by examining topics from aerospace and automotive production to global mobility.

In a winter 2004 *Impact* article entitled "How Research Fuels ESD—and Vice Versa," ESD director Dan Hastings was cited on CTPID's contributions to ESD: "ESD, like all units at MIT, has both a research mission and an academic mission. ESD manifests this mission, in part, by having a set of associated research centers, with CTPID as the largest. . . . The research centers have a footprint larger than ESD because they bring together joint projects with faculty outside of ESD. So the research centers act as focal nodes for faculty and research staff."

An equal priority is seeking broader funding for CTPID programs through joint proposals as well as individual program efforts.

Accomplishments

CTPID's research impact includes two major books this year:

- *Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development*, by CTPID senior research scientist Daniel E. Whitney, was published by Oxford University Press.
- *The Second Century: Reconnecting Customer and Value Chain through Build-to-Order*, by Matthias Holweg and Frits Pil, International Motor Vehicle Program (IMVP) principal investigators, was published by MIT Press.

CTPID and the Industrial Liaison Program cosponsored the Industry Leaders in Technology and Management lecture, "Pharmaceuticals: Just a Cost Factor?" by Novartis AG chairman and CEO Daniel Vasella. CTPID's article on the talk, outlining the real versus perceived value of health care costs and possible curbs, was shared with the MIT community in *Tech Talk*.

Program Highlights

The Lean Aerospace Initiative (LAI) has formed a strategic partnership with the Ogden Air Logistics Center (ALC) at Hill Air Force Base in Utah, which has committed to applying the lean approach at the total enterprise level. LAI has also begun initial contacts with the US Air Force's Oklahoma City ALC.

The success of the LAI Educational Network's inaugural Lean Academy at Rolls-Royce Corporation in Indianapolis in June 2003 resulted in four new workshops in June 2004. These workshops and a June 14–17 short course on campus used a new strategic

component—the Lean Enterprise Value Training Simulation that demonstrates enterprise-level lean. Another new tool, the LAI Supplier Networks Transformation Toolset, offered to the public at no cost, provides a guide to plan, practice, and assess this mutually beneficial transformation.

New IMVP leadership is focused on strengthening the MIT connections of the virtual program and sponsor relations. Sloan professor Michael A. Cusumano, an International Motor Vehicle Program principal investigator in the 1990s, was named codirector, working with Codirector John Paul MacDuffie, Wharton associate professor. Sponsor relations is the focus of new executive director John B. Moavenzadeh, a World Economic Forum director who worked with transportation companies. Stoyan Sgourev, who recently completed a PhD in sociology at Stanford University, arrived at MIT May 1 as an IMVP Sloan Industry Centers fellow.

IMVP welcomed a new sponsor. The Hyundai Motor Company, Korea's leading independent automaker and the world's eighth-largest automaker, signed a three-year IMVP sponsorship agreement on December 1, 2003. The Honda Motor Company renewed its sponsorship for a three-year term. Delphi Inc., a major auto supplier, joined IMVP as the first company involved with a new Lean Locational Logic project.

The ITC program has agreed to join an Institute-wide coalition of research programs investigating the communications value chain, the Communications Futures Program. ITC director David Clark, senior research scientist at the Computer Science and Artificial Intelligence Lab, is one of four directors.

ITC won new support with a National Science Foundation grant that provided seed funding to develop case studies and an econometric analysis of the growing number of US municipal electric utilities offering communications services. A Cambridge–MIT Institute grant to the Communications Innovation Institute funded ITC case studies on convergence of voice over internet protocols and municipal electrical systems' provision of broadband internet.

MIT IQ, led by Director Richard Wang, hosted the 8th International Conference on Information Quality, a forum for researchers and practitioners to exchange IQ knowledge and ideas in November at MIT. In a new initiative, MIT IQ and German Rail (Die Bahn) cosponsored the First German Information Quality Management Conference and Workshop October 19–21 in Frankfurt.

Acxiom Corporation and MIT IQ announced a new research project focusing on customer-centric information quality management in March. The team will explore data quality issues related to customer-centric information architectures, particularly knowledge-driven customer recognition systems used in customer relationship management applications.

Joseph Saleh, who earned an MIT PhD in aeronautics and astronautics in 2002, returned in January as the new Ford–MIT Alliance executive director.

Joel Cutcher-Gershenfeld, codirector of LARA, won a Fulbright grant under the Senior Specialist Program to spend five weeks at the University of Sydney helping launch a new initiative on negotiations in the workplace.

Cutcher-Gershenfeld and research scientist Betty Barrett, leaders of both LARA and the Engineering Systems Learning Center (ESLC), hosted an international conference on learning objects at Endicott House in June. ESLC also launched i2i, a web site that offers case studies and online learning objects to educators, industry, and government groups in September.

Professor Wesley L. Harris, LSI director, became head of the Department of Aeronautics and Astronautics July 1.

MSL initiated a new Markets and Electronics Recycling project that applies ideas from auto recycling to the electronics industry.

Program status changes. Several programs are in a quiet phase, including the Cooperative Mobility Program and the Lean Sustainment Initiative. The Program on Science, Technology, and Environmental Policy is inactive.

Administrative Initiatives

Communications Highlights

CTPID's newsletter, *Impact* (published three times a year), offered these new features:

- Special focus issues documenting IMVP's Japan study trip/symposium and LAI's plenary that reported on successful new enterprise work.
- Interviews with John Heywood, Donna Rhodes, and Mari Sako.
- Big picture article: "What Do Academics Learn from Industry Partnerships?"
- Initiated Staff Snapshot series, short profiles of staff who contribute to CTPID's success.

The communications director began the process of redesigning the newsletter to be more cost effective and revamping the web site home page to be more strategic. We also initiated and implemented a web maintenance plan.

Finances and Funding

CTPID engages some 80 faculty, staff, and students working on projects based on a research volume of about $8 million, funded by 50 industry sponsors and 15 government agencies. Major grants and sponsorships are reported in each program's report.

Future Plans

ESD has completed an initial five-year period with a particular focus on developing academic strengths. This fall, ESD will begin the review process, meeting with the Visiting Committee to consider the first five years and plan for the future. CTPID looks forward to contributing to discussions that will clarify ESD's research agenda and the intellectual core competencies of the division's research centers. We believe the review will provide a useful guide for ESD's research potential and reflections on how CTPID's capabilities can be best organized to carry out ESD's research mission. We look forward to applying the center's strengths in multidisciplinary research, policy expertise, and industry and government partnerships to advancing ESD.

Personnel Information

Awards and Honors

The work of CTPID researchers and staff won acclaim both from professional societies and within MIT, as reflected in the following notes:

- Daniel Whitney, CTPID senior research scientist, was named an Institute of Electrical and Electronics Engineers (IEEE) fellow in 2003 "for contributions to robot control, robot assembly, and fundamentals of mechanical assembly."
- LSI director Wesley L. Harris, head of the Department of Aeronautics and Astronautics, was named to the Air Force Science and Technology Board of the National Academies.
- Joel Cutcher-Gershenfeld, LARA codirector, won a Fulbright grant under the Senior Specialist Program to spend five weeks this summer at the University of Sydney helping launch a new initiative on negotiations in the workplace.
- LAI research engineer Alexis Stanke received a Lean Subject Matter Expert Award from General Gregory Martin, USAF, at a December ceremony in Washington, DC. Stanke, who earned a SM in aeronautics and astronautics from MIT in 2001, has been accepted into the ESD PhD program.
- IMVP's Frits Pil, University of Pittsburgh associate professor and research scientist, accepted the Young Scholar Award from the Industrial Relations Research Association at their annual meeting in San Diego in January 2004.
- IMVP's Ki-Chan Kim accepted the Grand Award of the Korean Automobile Parts Industry from the minister of commerce, industry, and energy at December ceremonies in Seoul for his work as chairman of the Parts Industry Commission, Korea Auto Forum.
- CTPID administrative officer Su Chung received a School of Engineering Infinite Mile Award for sustained excellence on April 29, a tribute to her many contributions to MIT during 17 years of service.

Personnel Changes

Ford–MIT Alliance. Joseph Saleh, who earned an MIT PhD in aeronautics and astronautics in 2002, became MIT executive director. Rita Adom, a longtime ITC administrative assistant, now works part-time for Ford.

MIT IQ. Dr. Nalaka Edirisinghe contributed to the development of a next-generation information quality system as an MIT IQ postdoctoral associate.

LAI. John S. Carroll, professor of behavioral and policy sciences, joined LAI as the Sloan School of Management codirector. Geoffrey Groesbeck became communications manager this year, replacing longtime communications director Deneen Silviano. Communications specialist Allie Lopez also left the program.

IMVP. Sloan professor Michael Cusumano became codirector. IMVP appointed a new executive director, John Moavenzadeh, who was a World Economic Forum director working with automotive companies. Sloan Industry Centers fellow Matthias Holweg became a research affiliate after joining the University of Cambridge UK faculty as a university lecturer. Stoyan Sgourev, the new Sloan fellow, arrived in May to study industry peer groups.

ITC. Executive director Sharon Eisner Gillett was promoted to principal research associate.

CMP. Andreas Schafer was named research affiliate when he left MIT to work at the University of Cambridge, UK.

Norwegian scholar and former international energy executive Oddmund Granli was a CTPID visiting student this year working with CTPID director Fred Moavenzadeh on a project titled "Uncertainty Management: the Sustainable Competitive Advantage in Project Management and Development in Capital Investment Projects."

Ford–MIT Alliance

Since 1997, the Ford Motor Company has engaged the Institute in addressing an array of 21st-century challenges confronting the automotive manufacturer. The initial multimillion-dollar, five-year alliance focused on three research areas: product development process technology, virtual education, and the environment. With the alliance renewed through 2007, research spans two original areas—product development process technology and the environment—as well as active safety and powertrain.

Current projects supported by the alliance include the following:

- Oxygen Reduction Mechanisms in SOFC (Y. Shao-Horn)
- Variability Strategies for Robust Design (D. Frey)
- Decouple Control and Vibration (M. Culpepper)

- Homogeneous Charge Compression Ignition Research (Cheng/Green)
- Advanced Natural Language Interface (J. Glass)

Will Boddie, Ford vice president of North American Engineering, recently commented on the alliance's substantial progress: "We are light-years ahead of where we were. The progress is stunning." Particular progress has been made (1) in devising venues for a frequent and in-depth dialogue between Ford and MIT; (2) in projects, research definition, and selection; and (3) in executive committee meetings.

The alliance's Operating Committee members are committed to ensuring a brilliant success for the alliance and making it a model and a benchmark for long-term industry-university partnerships. The Operating Committee recognizes that success rests on two pillars: first that everyone at Ford involved with the alliance, from the senior executives to the technical specialists, finds significant value in its work; and second, that the alliance provides appealing collaboration opportunities for MIT's current and future PIs and students.

Joseph Saleh, who earned an MIT PhD in aeronautics and astronautics in 2002, joined the alliance as the MIT executive director in January. His focus includes building the value of the alliance to both partners and increasing the productive exchanges between MIT and Ford.

Current meeting venues are as follows:

- Executive Committee meetings (3 times a year).
- Alliance Technology Day at Ford: This year, eight MIT faculty presented their alliance results May 25–26. The annual event is widely advertised within Ford, open to all, and draws from 30 to 50 people.
- Special topic-focused meetings, such as the sustainable mobility meeting at Ford with senior executives and MIT faculty.
- Ford–MIT Alliance research seminar (4–6 times a year): Faculty not involved with the alliance are invited to travel to Ford and discuss their work with the Ford technical community.

Proposed meeting venues are as follows:

- VP forum on critical issues and challenges at Ford, with the alliance Operating Committee and alliance program area managers.
- "Inverse" Technology Day at MIT, where Ford technical specialists come to MIT and discuss their work.

As a partner in this Institute-wide initiative, CTPID supports 10–15 researchers working on Ford–MIT projects. Alliance leadership includes MIT chancellor Phillip L. Clay as director; codirector is John B. Heywood, Sun Jae professor of mechanical engineering.

More information can be found on the web at http://web.mit.edu/ctpid/www/ford.html.

International Motor Vehicle Program

The International Motor Vehicle Program (IMVP), the largest international research group studying the automobile industry and its global milieu, cosponsored a major Tokyo conference, hosted a weeklong Japan study trip, and added significant new leadership and sponsors this year. In addition, researchers published a major new book and won accolades from universities, professional associations, and industry.

More than 250 scholars and decision makers from industry and government attended the Auto Industry Symposium, cosponsored by IMVP, Hosei University, and the Japanese government's Research Institute for Economy, Trade, and Industry in Tokyo on September 12. The conference probed how the auto industry has remained the most dynamic sector in Japan's industry and examined current global challenges. An IMVP team spent four days visiting six plants, including Toyota, Honda, Nissan, Subaru, and colocated supplier sites.

Planning began for a new executive short course led by faculty from Wharton, MIT, and other universities. The intensive four-day course plus daylong seminar will be offered at the University of Pennsylvania–Philadelphia, February 7–11, 2005.

New Leadership

Sloan professor Michael A. Cusumano, an IMVP principal investigator in the 1990s, joined the IMVP leadership team as codirector, sharing the leadership role with John Paul MacDuffie, Wharton associate professor. Cusumano's IMVP work focused on suppliers and product development—specifically, platform development. CTPID director Fred Moavenzadeh, who served as acting codirector, stepped down with thanks from the program.

John B. Moavenzadeh, a World Economic Forum director working with transportation companies, joined the IMVP team in November as executive director. Moavenzadeh is based at IMVP's Wharton School offices at the University of Pennsylvania in Philadelphia. Moavenzadeh has focused on strengthening IMVP sponsor relations. He has worked with the program manager and communications director to augment identity materials and begun an aggressive campaign to expand IMVP sponsor activities and engage new original equipment manufacturers (OEMs) and suppliers.

IMVP inaugurated an Advisory Committee headed by Professor Daniel Roos, formerly head of IMVP and CTPID. Roos introduced the first industry member, Paul Anderson, at the spring researchers meeting held at MIT May 6–7. More than 25 researchers presented new research and learned of initiatives such as the Lean Locational Logic project.

New Funding

The Hyundai Motor Company, Korea's leading independent automaker and the world's 8th-largest automaker, signed a three-year IMVP sponsorship agreement on December

1, 2003. Hyundai operates eight research centers in Korea and four international centers, including the Hyundai America Technical Center, Inc., near Ann Arbor, Michigan. The Honda Motor Car Company renewed its three-year sponsorship this spring. Delphi Inc., a major automotive supplier, is the founding company involved in the new Lean Locational Logic project, which is working to rationalize plant location choices through a series of case studies and analyses.

Books

PIs Matthias Holweg, University of Cambridge university lecturer, and Frits Pil, University of Pittsburgh associate professor, published *The Second Century: Reconnecting Customer and Value Chain through Build-to-Order.* The MIT Press book builds on new results from the IMVP assembly plant study, the basis for *The Machine That Changed the World,* plus build-to-order data and other research.

Codirector Michael A. Cusumano's new book, *The Business of Software: What Every Manager, Programmer, and Entrepreneur Must Know to Thrive and Survive in Good Times and Bad,* was published in hardcover and e-book in March by the Free Press.

Honors

Frits Pil, University of Pittsburgh associate professor and research scientist, accepted the Young Scholar Award from the Industrial Relations Research Association at their annual meeting in San Diego on January 4, 2004. Pil, who was also promoted to associate professor with tenure, was honored for work on assembly plants, industrial relations, social capital research, and product design.

Ki-Chan Kim, an IMVP affiliate, accepted the Grand Award of the Korean Automobile Parts Industry from the minister of commerce, industry, and energy in December at ceremonies in Seoul for his work as chairman of the Parts Industry Commission, Korea Auto Forum.

Stoyan Sgourev, who recently completed a PhD in sociology at Stanford University, arrived at MIT May 1 as an IMVP Sloan Industry Centers fellow. During the one-year appointment, Sgourev will work with IMVP principal investigator Ezra Zuckerman, Sloan School associate professor, on peer group support among auto dealers. IMVP affiliate Matthias Holweg, who was awarded two IMVP Sloan Industry Fellowships, left MIT for an appointment as university lecturer at the Judge Institute of Management, University of Cambridge.

University of Venice professor of management Arnaldo Camuffo, an IMVP principal investigator, was appointed to a one-year sabbatical working with the MIT Industrial Performance Center to begin September 2004.

IMVP researcher Chunli Lee, recently promoted to full professor at Aichi University, Japan, began a one-year sabbatical at the Fairbanks Center for East Asian Research at Harvard University in April.

IMVP Research Impact

IMVP, founded in 1979, examines critical developments in auto industry production paradigms, management systems, and technological innovation. The program engaged 13 faculty and 6 graduate students in research projects this year. Worldwide, they visited 30 industry enterprises and gathered data from 12 companies. IMVP hosted two workshops and researchers made more than 15 presentations to academic conferences, industry, trade groups, and government agencies. IMVP researchers published 5 industry trade journal articles and more than 20 working papers online.

Key Findings from Select Projects

- Round Three of the International Assembly Plant Study reports a convergence in labor efficiency worldwide but persistent gaps on quality and capacity for handling product variety among US, European, and Japanese producers.
- Extended Enterprise supply chain research finds that tensions are rising between megasuppliers and OEMs as cost containment pressures collide with a new division of labor that shifts design responsibility to suppliers.
- Survey data from second-tier suppliers shows them to be struggling to avoid losing money, yet often turning to each other for technical information in a survival strategy. Over one-third reported getting needed technical assistance from competitors, a higher percentage than from customers or consultants.
- Build-to-Order (BTO) project finds that interest in BTO continues to grow but is inhibited by information barriers and delays throughout the supply chain, continued large inventories in distribution, and the need for stronger supplier capabilities.
- Supplier park study traces the growing trend to colocate suppliers and assembly plants during retrofits in the United States and Europe and evaluates its staying power.
- Ongoing study of business-to-business marketplaces for the auto industry shows continued problems for the major public exchange, Covisint, which is driving OEMs and suppliers toward private exchanges.
- International product development study reports on trends in China's motorcycle industry as a possible leading indicator for autos, as grass-roots experiments by Chinese firms imitating Japanese designs promote more modular product architecture.
- The Gains from Alliance project found that savings and efficiencies from OEM strategic alliances may be overrated, but gains in styling and market appeal can be seen, most dramatically in the Renault-Nissan alliance/merger.

More information about IMVP can be found on the web at http://imvp.mit.edu/.

Labor Aerospace Research Agenda

LARA is committed to advancing theory, practice, and policy relating to the 21st-century aerospace workforce. The program focuses on the impact of instability on employment and new work systems. We also consider factors such as intellectual capital investments, effective institutional infrastructure, and global employment dynamics in the industry.

Accomplishments

Codirector Joel Cutcher-Gershenfeld won a Fulbright grant under the Senior Specialist Program to spend five weeks this summer at the University of Sydney helping launch a new initiative on negotiations in the workplace.

Cutcher-Gershenfeld and Codirector Thomas Kochan delivered concluding keynote speeches at the National Labor-Management Conference in Chicago, June 2–4. They addressed the current status and future prospects of collective bargaining and the transformation of American industrial relations.

Research scientist Betty Barrett completed a case study available on the LARA website: "Rockwell Collins & IBEW Locals 1362 and 1634: Investing in Knowledge, Skills, and Future Capability in an Uncertain Business Environment" (Cedar Rapids, IO, 2003).

Kevin Long and Betty Barrett completed a case study available on the LARA website entitled "International Association of Machinists and Boeing Joint Quality through Training Programs" (2004).

Betty Barrett, Lydia Fraile, Joel Cutcher-Gershenfeld, and Adam Litwin completed a study of the Boeing St. Louis facility funded by the Department of Labor that is available on the LARA website: "Strategies for Workforce Flexibility and Capability: IAM/Boeing St. Louis."

Betty Barrett and Lydia Fraile presented a paper entitled "Negotiating Functional Flexibility in Aerospace: The Case of Boeing St. Louis" at the International Industrial Relations Association World Congress, Berlin, Germany, in September 2003.

Cutcher-Gershenfeld and Barrett, leaders of both LARA and the Engineering Systems Learning Center, hosted an international conference on learning objects at Endicott House in June. ESLC also launched i2i, a web site that offers case studies and online learning objects to educators, industry, and government groups in September.

About LARA

LARA began in June 1998 with the belief that people are at the heart of new work systems—establishing stability and then driving continuous improvement. LARA was designed to further the understanding of this critical social dimension of lean principles in the aerospace industry.

In its early phases, LARA administered a national aerospace survey to further the understanding of the impact of instability on employment and work practices in the aerospace industry. Working with the Lean Aerospace Initiative, several case studies and other reports have been developed to increase the understanding at the facility and individual levels. LARA has also published a guide, *Collective Bargaining in the Face of Instability: A Resource for Workers and Employers in the U.S. Aerospace Industry.*

In recent years, LARA presented testimony twice based on its white paper, "Developing a 21st-Century Aerospace Workforce." Kochan testified before the US Commission on the Future of the Aerospace Industry. Cutcher-Gershenfeld, sponsored by ASME and other professional associations, testified before a special session for congressional staff. The LARA team is continuing to work with the US Department of Labor on the implementation of recommendations from this commission. LARA also contributed to the book *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative* (Palgrave, 2002), a LAI capstone product.

LARA is an MIT–based team conducting research with funding provided via the Manufacturing Technology initiative of the US Air Force and other sources. LARA's coprincipal investigators/codirectors are senior research scientist Joel Cutcher-Gershenfeld and Professor Thomas A. Kochan.

More information about LARA can be found on the web at http://web.mit.edu/ctpid/lara/.

Lean Aerospace Initiative

Current Goals, Objectives, and Priorities

The Lean Aerospace Initiative (LAI), now well into a third phase of operations, has shifted its research focus to provide a better understanding of the interactions *between and across* core enterprise functions. The main organizing principles of the Enterprise Value Phase (September 1, 2002–August 31, 2005) reflect key insights set forth in *Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative,* winner of the 2003 Engineering Sciences Book Award from the International Academy of Astronautics. A chief finding is that lean is not merely the goal of eliminating waste—it must also create value for enterprise stakeholders.

With the knowledge and tools now being researched, developed, and deployed in LAI's Enterprise Value Phase, the US aerospace enterprise can substantially improve its capability and agility in delivering best life-cycle value. Additionally, enterprise-level research will provide the foundation for emerging systems-thinking approaches to enterprise architecting and enterprise transformation.

This year, LAI has upheld and significantly expanded its primary mission to research, develop, and promulgate relevant knowledge, principles, and practices whose purpose is to efficiently enable and accelerate the transformation of the national aerospace

enterprise. In particular, the following six goals provide the framework for the consortium's efforts:

1. Support the ongoing lean transformation of the aerospace industry;
2. Enable a lean value-creating supplier base;
3. Support lean transformation of the government;
4. Educate and train stakeholders in value-creating lean principles and practices;
5. Improve effectiveness of organizations and all the employees across the total enterprise;
6. Support member lean implementation efforts by sustaining tools and knowledge base and by sponsoring outreach events.

In the Enterprise Value Phase, the main objective is to extend lean practices to the total enterprise. To do so, our intellectual orientation has shifted from functional areas to broader enterprise areas. Accordingly, LAI has chosen three *knowledge areas* and two *focus areas* for group activities. The three knowledge areas perform research and develop products: enterprise change, enterprise architecting, and product life cycle. These knowledge areas conduct research and make contributions to curriculum and knowledge deployment products. The two focus areas develop their own products or gather information from the other knowledge areas to develop products: curriculum development and knowledge deployment.

Transforming the US Aerospace Enterprise

Industry members of the consortium have, with the support of the LAI, made significant progress in implementing lean principles and practices in production operations. As a consortium, there have been an increasing number of *islands of success,* but the expectation going forward is to continue recognizing opportunities for the *enterprise*—the greatest value. As examples of recent successes, we offer the following enterprise-level achievements:

- The C-17 unit price decreased from $260M to $178M for the final 80 units of a 120-aircraft purchase.
- The JDAM unit price came in at $15K, compared to an initial estimate of $68K.
- Northrop Grumman's ISS lean enterprise implementation reduced throughput times for major systems by 21–42 percent.
- Both JSF competitors aggressively adopted lean principles and practices in their designs.

To further catalyze enterprise transformation, particularly among government stakeholders, LAI rolled out Lean Now in 2002. This government-conceived initiative focused on interface processes between industry and government that could be improved and then diffused more broadly. There have been two waves of activities. Adding to its initial successes, Lean Now assists organizations to transform at the enterprise level. This total consortium team facilitated through LAI targets these actions:

- Leverage collective, consortium-wide knowledge
- Eliminate barriers that impede progress
- Capitalize on government and industry teamwork

Lean Now taps industry expertise by creating a group of coaches and trainers known as LAI subject matter experts (SMEs); 14 have joined the ranks this year. Lean Now takes a spiral approach as it engages program prototypes. Spiral One included the F/A-22, F-16, and Global Hawk system program offices. Spiral Two includes turbine engine testing at the Arnold Engineering Development Center, procurement requests at the Ogden Air Logistics Center, and the Information Technology Services Program at the Electronics System Center.

Accomplishments, Research Results, and Knowledge Deployment

This year, LAI also stepped up its efforts to help transform the US aerospace enterprise by developing and deploying education programs as well as leadership and transformational tools steeped in ongoing research. In particular, the Educational Network (EdNet™) and its core offering, the LAI Lean Academy™, have been very successful. This year alone, six academies have been convened across the nation.

The LAI EdNet advances lean thinking through education and advocates enterprise level lean practices. The network also significantly broadens the reach of lean curriculum. It provides an opportunity for other universities to collaborate in the LAI community by providing a forum for communication between schools, as well as linkages to LAI stakeholders. The objective is to create a maximum leverage but low overhead engagement for all universities involved. The network's goal is not to develop and deploy curriculum but to facilitate the execution of curriculum development and its deployment in a distributed environment.

First and most important, EdNet exists to stimulate ad hoc collaboration between network members. There are several opportunities for participation in the EdNet. Meetings of this community are held regularly, hosted by various universities across the country. Ongoing EdNet activities include the two listed below.

LAI Lean Academy. An opportunity for undergraduate students to participate in a one-week, intensive, hands-on learning experience that introduces lean principles in conjunction with an opportunity for real world applications, such as an internship or co-op experience, the LAI Lean Academy pilot course was launched successfully in summer 2003 at the Rolls-Royce Corporation in Indianapolis.

Lean Systems Engineering Working Group. This is a special interest group formed to discuss the intellectual convergence of lean principles and systems engineering and how lean can be integrated best into graduate level systems engineering courses.

LAI Research

The following key questions drive ongoing and future LAI research efforts:

- How to architect/design future lean enterprises
  - Lifecycle value creation perspective
  - Organizing principles
  - Integration strategies
- How to accelerate lean enterprise transformation
  - Workforce and cultural change
  - Metrics for motivating desired behavior
  - Information technologies
- How to build evolving and adapting lean enterprises
  - Evolutionary acquisition and spiral development
  - Knowledge management
  - Fostering innovation across acquisition value stream

LAI has continued a long-standing policy of publishing the best and most relevant research available in lean practices. Recently published reports, conference papers, and student theses include observations and recommendations in the following areas: "The Application of Value Stream Management Principles in a Batch Production Environment"; "IT Management in the Aerospace Industry"; "Modularity as an Enabler for Evolutionary Acquisition"; "The Dell Operating Model"; "ACE *v*. Six Sigma"; "Developing aCircumstance-Based Innovation Strategy for a Midsized Aerospace Manufacturer: Fostering Intrapreneurship, Opening Boundaries, and Seeding Disruption"; "Enterprise Design for Dynamic Complexity: Architecting and Engineering Organizations Using System and Structural Dynamics"; and "An Assessment of the Degree of Implementation of the Lean Aerospace Initiative Principles and Practices within the US Aerospace and Defense Industry."

LAI Products

Lean Enterprise Value: Insights from MIT's Lean Aerospace Initiative. This work redefines lean production as a framework for enterprise transformation. Extending the prevailing view of lean to one of eliminating waste with the goal of creating value, the authors explore the core challenge for technically complex industries in the new century. The eight-year LAI study has provided a living experiment for the principles and the value creation framework developed and explored in this book.

Lean Enterprise Model (LEM). This is a systematic framework for organizing and disseminating MIT research and external data source results of LAI. The framework, which encompasses lean enterprise principles and practices, is populated by MIT and external data derived from surveys, case studies, and other research activities. LEM is available to all LAI consortium members as a reference to help them better understand the leanness of their own organizations and processes. It is intended to provide insights on future lean efforts.

Transitioning to a Lean Enterprise (TTL). This guide is made up of three volumes that provide a set of materials allowing the user to understand and navigate through the *Transition-to-Lean Roadmap* at increasingly deeper levels of detail. Volume 1, *Executive Overview,* invites the enterprise's leaders and lean change agents to understand the compelling "whats and whys" of lean. Volume 2, the *Transition-to-Lean Roadmap,* provides the next level of description and details in understanding the nature and scope of the tasks required to complete each of the primary activities that make up the dynamic roadmap. Finally, Volume 3, *Roadmap Explorations,* provides an in-depth exposition—using a common template—of each of the 22 tasks identified within the roadmap.

Lean Enterprise Self-Assessment Tool (LESAT). This is a tool for self-assessing the state of an organization's leanness and readiness to change. It is presented in three sections: enterprise leadership, life-cycle processes, and enabling processes.
Government Lean Enterprise Self-Assessment Tool (GLESAT). The alpha version of this product is complete and ready for testing in a government setting. This tool was built off the foundation provided by the LESAT and reconstructed relative to System Program Office operations.

Enterprise Value Stream Mapping and Analysis (EVSMA). This product presents a coherent method for analyzing and improving enterprise performance, integrating strategic objectives, stakeholder interests, and process performance. This decision aid for enterprise executives can help identify barriers to the creation/delivery of value to each stakeholder, specify a vision of their future lean enterprise, determine significant gaps between current and future states, and prioritize opportunities.

Product Development Value Stream Analysis and Mapping Manual (PDVSM). Now released in alpha form, this is a practical guide tackling the application of lean to product development. It is focused at the tactical level—engineering process improvement—and is a summary of and reference to more than five years of product development group experience facilitated through LAI.

Supplier Networks Transformation Toolset. Recently released in beta format, this integrated set of products includes the *Supplier Management Assessment Tool* for self-assessment of internal progress in creating lean supply chain management capabilities; the *Roadmap;* a *How-to Guide* for building lean supplier networks; and a *Reference Guide* with lean principles for supply chain management. The *Supplier Networks Transformation Toolset* is designed to address questions such as what are lean supply chain management concepts, practices, and metrics; how one develops lean supplier networks; and how one assesses where an organization is in evolving lean supply chain management capabilities.

LAI Knowledge Deployment

Annual plenary conference: "Making It Happen." This annual stakeholder event brought more than 220 lean learners together from across the aerospace sector to help shape the future of the industry by examining past and present accomplishments and the risk

takers behind them, as well as potential future strategies. LAI codirector, Professor Deborah Nightingale, book-ended the conference with a pair of well-received presentations, while more than 30 individuals from academia, government, industry, and labor offered facts and opinions on enterprise transformation.

Other keynote leadership perspectives were provided by Major General N. Ross Thompson III, US Army; Dr. Thaddeus H. Sandford of Boeing; Rear Admiral Michael C. Bachman, US Navy; Dr. J. Daniel Stewart, US Air Force; Major General Kevin J. Sullivan, US Air Force; Lisa V. Kohl of Northrop Grumman; Thomas A. Pinski, IAMAW District 837; Christopher B. Cool, also of Northrop Grumman; and Colonel William A. Guinn, US Army. Each shared his or her thoughts and experiences on what it takes to transform government and industry perspectives.

In addition to the annual plenary conference, LAI also convened a number of executive board and executive committee meetings to formulate strategy and fine-tune direction, as well as numerous small group sessions and workshops relative to the consortium's main knowledge areas.

Moving Forward

LAI has grown and flourished as an innovative model of industry, government, labor, and university partnership. The consortium also represents a true learning community with the ability to leverage multiple perspectives for longer-term solutions. Through this community, LAI is able to open and sustain knowledge sharing, create a common vocabulary, infuse new ideas into the industry, and enhance communication among all stakeholders. This accelerates lean transformation efforts by bridging sectors and cultures as well as organizational functions, layers, and competing interests. It also creates a system to rapidly diffuse best practices throughout the enterprise. LAI is no longer merely poised to do for the rest of the enterprise what it did for manufacturing, but it is in fact now proactively engaged in doing exactly this.

LAI's membership has grown to include 38 organizations from aerospace companies, US government offices and programs, organized labor, MIT, and affiliated universities in Sweden and the United Kingdom. This consortium-guided research program continues to be led by the MIT Engineering Systems Division in close collaboration with the Sloan School of Management and managed under the auspices of CTPID.

LAI Leadership

This year LAI was managed by a trio of codirectors representing stakeholder interests. This group includes Professor Deborah Nightingale, Department of Aeronautics and Astronautics; Professor John Carroll, MIT Sloan School of Management; and a third codirector from industry, Frederick "Terry" Bryan of Raytheon.

More information about the Lean Aerospace Initiative can be found on the web at http://web.mit.edu/lean/.

Lean Sustainment Initiative

The mission of LSI, founded in 1997, is to enable a fundamental transformation of the US commercial and military maintenance, repair, and overhaul (MRO) industries into cost-effective, quality-driven, timely, and responsive support enterprises. As a joint academic-military-industry consortium, LSI develops research-based recommendations for systemic change and military-industry pilot projects to demonstrate the impact of the recommendations on MRO effectiveness.

Professor Wesley L. Harris is LSI director and head of the Department of Aeronautics and Astronautics. He serves as cochair of the American Institute of Aeronautics and Astronautics Product Support and Logistics Technical Committee.

This year Harris was named to the Air Force Science and Technology Board of the National Academies. The board works closely with air force senior scientific and technical managers to develop specific study tasks requested by the air force, assists in the establishment of study committees to perform the studies, monitors the progress of studies underway, and assures that quality standards are met.

Harris was a featured speaker at a joint Institute for Defense and Government Advancement and International Quality and Productivity Center conference June 27–30 in Miami. He shared the podium at the Maintenance, Repair, and Overall for Aerospace main conference with government and airline leaders.

More information about LSI can be found on the web at http://web.mit.edu/ctpid/www/lsi.html.

Materials Systems Laboratory

MSL is internationally recognized for innovative work analyzing the competitive position of materials and the strategic implications of material choice. For nearly two decades, MSL has addressed issues arising from materials choice in a range of applications in the automotive, electronic, and aerospace industries, but with a recent emphasis on automotive applications.

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, particularly focusing on issues of strategic position of new automotive technologies both from economic and environmental standpoints. MSL used two National Science Foundation grants to support work on a study of the application of environmental life-cycle analysis to the automotive industry and a study of resource use implications of emerging materials.

MSL is also taking a new look at recycling. Historically, MSL has examined automotive industry recycling practices and material selection and substitution in the electronics industry, particularly in packaging. The new Markets and Electronics Recycling project applies ideas from auto recycling to the electronics industry. MSL researchers Randy Kirchain, materials science and engineering assistant professor, and Frank Field, CTPID senior research associate, have visited half a dozen electronic recyclers in the past year to gather data on current practices and to develop an economic model for improving product design and recycling technology. This research responds to pressures from new European regulations and laws passed or pending in Massachusetts and 22 other states on electronics firms to create environmentally friendly products.

The lab's work builds upon a unique combination of materials processing knowledge, engineering design practice, manufacturing process analysis, and environmental information to construct analytical tools for decision support and competitive analysis. To develop these tools, MSL has refined its extensions to classic engineering process modeling for the past two decades. Modeling elements have been married to elements of product design, material properties, and manufacturing assumptions to yield tools that can estimate the costs of product manufacture under a wide range of conditions. These tools analyze primary materials production, primary materials processing, component and subassembly manufacture, and end-of-life vehicle processing. In each case, these tools estimate the costs of production as a function of processing technology, material flows, operating conditions, and energy and capital requirements.

MSL has also developed techniques for understanding how markets respond to the different combinations of engineering and economic performance available by using different materials. Further, MSL researchers analyze the environmental consequences of materials and process choice, incorporating the emerging life-cycle analysis paradigm. These tools make it possible, when used with economic and engineering assessments, to develop robust, credible, and defendable product strategies that take life-cycle information into account.

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

More information about MSL can be found on the web at http://web.mit.edu/ctpid/www/msl.html.

MIT Information Quality Program

The MIT IQ program develops new knowledge in the information quality field and information quality benchmarking standards. MIT IQ, launched in 2002, equips professionals with the understanding and skills to significantly improve their organization's information and to use that information as a strategic tool. MIT IQ is an outgrowth of MIT's Total Data Quality Management Program founded in 1989 by Wang and the Sloan School of Management's J. N. Maguire information technology professor Stuart Madnick.

Accomplishments

MIT IQ hosted the 8th International Conference on Information Quality, a forum for researchers and practitioners to exchange IQ knowledge and ideas in November at MIT.

In a new initiative, MIT IQ and German Rail (Die Bahn) cosponsored the First German Information Quality Management Conference and Workshop, October 19–21, in Frankfurt. Dr. Wang and speakers from Daimler-Chrysler AG, IBM Business Systems, and German, Swiss, and Irish universities addressed 130 European participants.

MIT IQ offered a three-day executive IQ course at MIT titled "Information Quality: Principles and Implementation" through the MIT Professional Education Program. MIT IQ also offered initial short courses leading to an IQ certification program for information quality professionals.

Dr. Wang was the keynote speaker at the Environmental Protection Agency annual conference held in Tampa, FL, in April.

Dr. Nalaka Edirisinghe, a R&D colead at MIT IQ, worked this year as a postdoctoral fellow on the development of a next-generation information quality system.

Funding

Acxiom Corporation and MIT IQ announced in March that they will collaborate on a research project focusing on customer-centric information quality management. The team will explore data quality issues related to customer-centric information architectures, particularly knowledge-driven customer recognition systems used in customer relationship management applications.

Acxiom Corporation, which integrates data, services, and technology to deliver customer and information management solutions, is the founding corporation in the consortium.

Internet and Telecom Convergence and Communications Futures Program

CTPID's Internet and Telecoms Convergence (ITC) research program is merging into an Institute-wide coalition of research programs investigating the communications value chain, effective August 1, 2004. ITC's director, David Clark, senior research scientist at the Computer Science and Artificial Intelligence Lab, is leading the new Communications Futures Program (CFP), along with Sloan School of Management professor Charles Fine, Media Laboratory senior research scientist Andrew Lippman, and Media Lab adjunct professor David P. Reed.

CFP promotes growth and innovation across the communications value chain by conducting research and facilitating cross-industry interactions. This multidisciplinary program provides insight by combining research on emerging and breakthrough

communications technologies and architectures with development of industry roadmaps and models.

CFP continues ITC's partnership with the Center for eBusiness (CeB) at MIT. CeB sponsor companies can participate in CFP by targeting a portion of their research funds toward this program as a special interest group of the CeB.

Key Accomplishments

CFP established the Communications Innovation Institute (CII) effective December 2003, sponsored by the Cambridge–MIT Institute, to engage Cambridge University and British industry in cross-industry interactions. CFP held a launch workshop for industrial partners at MIT in October 2003 and a UK launch event with CII in June 2004, leading to several industrial sponsorship commitments, including France Telecom. CFP and CII are jointly convening the following industry and academic working groups: Security and Privacy, Edge-Core Dynamics, Viral Networks, and Broadband. Sharon Gillett, ITC executive director, leads the CII/CFP Broadband Working Group.

A National Science Foundation grant provided seed funding to develop an econometric analysis and case studies of the growing number of US municipal electric utilities offering communications services. Gillett and ITC associate director William Lehr are leading the project titled "Local Government Stimulation of Broadband: Effectiveness, E-Government, and Economic Development," in collaboration with Carnegie-Mellon University professor Marvin Sirbu. The first publication from this research, "Local Government Broadband Initiatives," is forthcoming in the premiere academic journal *Telecommunications Policy*. Dr. Lehr presented related papers focused on wireless at several academic and policy conferences.

Separate Cambridge–MIT Institute funding enabled the development of a new communications policy course, first taught at Cambridge University in Michaelmas term 2003, entitled "Telecommunications: Technologies and Policies in the Networked Digital World." Gillett and Lehr joined with CTPID senior research associate Frank Field and Cambridge engineering lecturer Tim Wilkinson to coteach the course, which was offered in the MPhil in Technology Policy Program.

Personnel

Sharon Gillett was promoted to principal research associate at CTPID.

Carlos A. Osorio Urzúa, who earned a technology and policy master's degree working with ITC this spring, was accepted into the ESD PhD program.

Recent Publications

Lehr, William, Marvin Sirbu, and Sharon Gillett. (2004). "Municipal Wireless Broadband: Policy and Business Implications of Emerging Access Technologies," presented at London Business School Conference on Competition in Wireless and Wireline Services, May 14, 2004.

Lehr, William. (2004). "The Economic Case for Dedicated Unlicensed Spectrum below 3 GHz," presented at a conference on unlicensed hosted by New America Foundation, April 16, 2004.

Best, M.L. (2003). *The Wireless Revolution and Universal Access: Trends in Telecommunication Reform 2003* (Geneva: International Telecommunication Union, 2003).

McKnight, Lee W. William Lehr, and James Howison. "Coordinating User and Device Behavior in Wireless Grids," October 2003.

Gabel, David and Guang-Lih Huang, "Promoting Innovation: Impact of Local Competition and Regulation on Deployment of Advanced Telecommunications Services for Businesses,"

Dutton, William H., Sharon Eisner Gillett, Lee McKnight, and Malcolm Peltu. "Bridging Broadband Internet Divides: Reconfiguring Access to Enhance Communicative Power," *Journal of Information Technology* 19 (March 2004).

Madnick, Stuart, Vincent Maugis, Nazli Choucri, Michael Siegel, Sharon Gillett, Farnaz Haghseta, Harry Zhu, and Michael Best, "Global e-Readiness for What? Readiness for e-Banking," forthcoming in *Journal of Information Technology for Development* (special issue on banking) 2004.

ITC affiliates presented the following seven papers at the 2003 Telecommunications Policy Research Conference in Alexandria, VA, September 28–29, 2003: Sharon Gillett, William Lehr, and Carlos Osorio, "Local Government Broadband Initiatives"; William Lehr and Glenn Hubbard, "Economic Case for Voluntary Structural Separation"; Anupam Banerjee and Marvin Sirbu, "Towards Technologically and Competitively Neutral Fiber to the Home (FTTH) Infrastructure"; Martha Garcia-Murillo and David Gabel, "International Broadband Deployment: The Impact of Unbundling"; Jean Camp and Allan Friedman, "Making Security Manifest Security and Autonomy for End Users"; David Gabel and Eugene Floyd, "An Econometric Analysis of the Factors that Influence the Deployment of Advanced Telecommunications Services"; and Benjamin Compaine, "Revisiting Cost and Affordability Assumptions for High Speed Data Services in Low Population Density Locations."

Student Theses

Carlos A. Osorio Urzúa, "Bits of Power: The Involvement of Municipal Electric Utilities in Broadband Services," SM, technology and policy, Massachusetts Institute of Technology, June 2004.

Maria Isabel A. S. Neto, "Wireless Networks for the Developing World: The Regulation and Use of License-Exempt Radio Bands in Africa," SM, technology and policy, Massachusetts Institute of Technology, June 2004.

Rintaro Kurebayashi. "A System Dynamics Model for Analyzing Bubble Effects in Long Distance Telecom Industry," SM, management of technology, Massachusetts Institute of Technology, June 2004.

Technology and Law Program

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

T&L offers a two-semester sequence in environmental law and policy colisted with Urban Studies: Law, Technology, and Public Policy, a core subject in the Technology and Policy Program; and Sustainability, Trade, and Environment. Both are listed jointly with Engineering and Sloan. The latter course continues to be offered at Cambridge, England, as part of the Cambridge–MIT Institute. Two course books related to these offerings are in preparation: *Environmental Law, Policy, and Economics* by Nicholas Ashford and Charles Caldart and *Globalization, Technology, and Sustainability* by Nicholas Ashford.

Recent Publications

- N. A. Ashford: "Sustainable Development and Globalization: New Challenges and Opportunities for Work Organization," Proceedings of the European Union Conference on Promoting New Forms of Work Organization and Other Cooperative Arrangements for Competitiveness and Employability, Athens, Greece, January 23–25, 2004; "Implementing the Precautionary Principle: Incorporating Science, Technology, Fairness, and Accountability in Environmental, Health, and Safety Decisions," Proceedings of the Collegium Ranazzini, forthcoming 2004; "Technology-Focused Regulatory Approaches for Encouraging Sustainable Industrial Transformations: Beyond Green, beyond the Dinosaurs, and beyond Evolutionary Theory," Proceedings of the 3rd Blueprint Workshop on Instruments for Integrating Environmental and Innovation Policy, September 26–27 2002, Brussels; "Major Challenges to Engineering Education for Sustainable Development: What Has to Change to Make It Creative, Effective,

and Acceptable to the Established Disciplines," Contributed Paper to the MIT Engineering Systems Symposium 2004.
- N. A. Ashford and C. C. Caldart, "Regulation, Implementation, and Compliance in the United States," in Edoardo Croci (ed.), *The Handbook of Voluntary Environmental Agreements* (Kluwer, 2004).
- Now available in PDF: "Public Participation in Contaminated Communities" at http://web.mit.edu/ctpid/www/tl/TL-pub-PPCC.html.

Technology and Policy professor Nicholas Ashford is director. Charles Caldart participates as a lecturer in the course offerings.

More information about T&L can be found on the web at http://web.mit.edu/afs/athena/org/c/ctpid/www/tl/.

MIT Center for Transportation and Logistics

Established in 1973 to develop and coordinate the wide range of transportation-related activity at MIT, the center provides a focal point for transportation education, facilitates transportation research, conducts an outreach program to the transportation industry, and encourages a sense of common purpose among the many departments, centers, and laboratories involved in transportation and logistics at MIT.

On our web site there is a wealth of information about the center and its programs, including descriptions of current research projects and a listing of MIT theses in transportation since 1980. Transportation faculty and research staff are also listed with their areas of interest, along with connections to other interesting resources on the web.

Education

Thirty-eight new students arrived on campus this past fall to enter the center's Master of Engineering in Logistics (MLOG) program, an intensive nine-month degree track preparing graduates for logistics management careers in manufacturing, distribution, retail, transportation, and logistics organizations.

This year, 159 applications were received for graduate studies in logistics and supply chain management in the MLOG.

MIT ranked first in logistics and supply chain management. For the third year in a row, MIT was ranked first among graduate business programs in the area of logistics and supply chain management, according to a survey by *U.S. News & World Report*. As part of a comprehensive evaluation of US colleges and universities, the magazine regularly asks deans and senior faculty of business schools to nominate up to 10 of the best programs in several specialties. This year's other top programs for logistics and supply chain management were Michigan State, Carnegie Mellon, and Stanford University. The survey also ranked MIT first among graduate engineering schools, as it did for the past

two years. The other top graduate engineering schools were, again this year, Stanford and Berkeley.

New graduate course in radio frequency ID. A new graduate course was offered this spring in MIT's Engineering Systems Division, focused on the ways in which radio frequency ID (RFID) systems are transforming the business landscape—especially the supply chain. In the course of the semester, students gained a hands-on understanding of RFID system components and how such systems interact with other aspects of business. This may be the first graduate course ever to focus entirely on RFID and Auto-ID (automatic object identification technology. The comprehensive list of topics in the syllabus reflected the interdisciplinary strengths on the MIT campus: science (the physics of radio waves), engineering (the mechanical appliances and their software systems), and business (policy implications and process design). A key component of the course was The RFID Value Competition, a practical, hands-on project that called for teams of students to build physical RFID appliances. Designed to help students understand exactly how the technology works, the assignment was graded not only by the course professors, but also by executives from the retail industry, most notably two leaders of Staples, Inc.—their president of US stores and their vice president of strategy.

MLOG Alumni Reunion. The first-ever MLOG Alumni Reunion was held in May. The three-day event celebrating the five-year anniversary of the Master of Engineering in Logistics program drew more than 60 MLOG alumni to MIT's campus from May 23 to May 25. During those three days, alumni from six different graduating classes gathered to not only reminisce about their time in MLOG but also to build a network with other MLOG graduates in hopes of developing an even stronger program in the future.

New Supply Chain Management Club. Students from the Master of Engineering in Logistics program (MLOG) and from the Sloan School of Management banded together to initiate an Institute-wide Supply Chain Management Club, open to both graduate and undergraduate students of all disciplines. Supported by the center and advised by center director Yossi Sheffi, the club will sponsor a guest speaker series, a series of visits to local industry sites, knowledge exchanges with other universities, and alumni outreach.

Supply Chain Education Partners Program. One of New England's biggest supermarket chains turned to students from MIT's MLOG program to help solve its transportation and supply chain challenges. This cooperative project between Shaw's Supermarkets and MIT students was made possible through the Supply Chain Education Partners Program, established in 2002. The Partners Program promotes supply chain knowledge sharing among leading executives and students in MIT's MLOG program. Shaw's was a charter member of the program.

Research

During the past academic year, 30 new research projects were posted on our website, along with scores of continuing projects carried over from previous years—a total of more than 100 efforts listed in various categories and cross-indexed with their principal

researchers. Many of those entries were research programs that included within them still more individual projects.

Major New Projects

The MIT–Zaragoza International Logistics Program. Last fall, the center signed a multiyear agreement with the government of Aragón, Spain, to help create an international education and research program in logistics and supply chain management. The MIT–Zaragoza International Logistics Program is part of a massive initiative to develop the Aragón region of Spain, around its capital city of Zaragoza, into a significant logistics center in Europe. The government of Aragón is investing over 2 billion Euros in a state-of-the-art logistics park near Zaragoza to be run by a dedicated firm called Plataforma Logística de Zaragoza (PLAZA). In the midst of the logistics park, the government is also creating the Zaragoza Logistics Center (ZLC), an international center for education and research in logistics and supply chain management. The MIT–Zaragoza International Logistics Program is the center's flagship effort. In addition to conducting cutting-edge research, using PLAZA as a working laboratory for international logistics practice, the ZLC will also offer graduate and executive education in logistics to students from around the world. The offerings will include a master's degree modeled on MIT's Master of Engineering in Logistics, a doctorate degree, and a set of executive education courses leading to certificates in various logistics-related disciplines. The curricula will be taught by professors in the new center; the first courses will be offered in the fall of 2004. The MIT MLOG and the ZLC students will participate in student and research exchange and collaboration.

Supply Chain 2020. Supply Chain 2020 is a pioneering project mapping innovations to successful supply chains as far into the future as the year 2020. Initiated by the MIT–Zaragoza International Logistics Program, the global research project involves dozens of faculty, research staff, and students at MIT and at other institutions around the world. An advisory council made up of leading companies will play a crucial role in helping to shape the work and generate new ideas. The research is broad and far reaching and designed to meet a series of objectives in two phases. Phase I will develop a better understanding of future successes in supply chain management; Phase II will determine what actions organizations should take to make sure they are not left behind.

Major Events

International Logistics Summit. An international symposium held in Zaragoza, Spain, in March brought together thought leaders from around the world to share their strategic insights on the future of supply chain management. The meeting was sponsored by the center in cooperation with the Zaragoza Logistics Center and the government of Aragón. Keynote speakers included Dr. Gabriel Bitran, chair professor at the Sloan School; Dr. Martin Christopher of the Cranfield School of Management; Dr. Morris Cohen, Matsushita professor of manufacturing and logistics at the Wharton School; Dr. Marshall Fisher, Stephen J. Heyman professor of operations and information management at the Wharton School; Dr. Hermann Krog, executive director for logistics at Audi; Dr. Hau Lee, Thoma professor of operations, information, and technology at the Graduate School

of Business at Stanford; Dr. H. Donald Ratliff, UPS and regents' professor of industrial and systems engineering at Georgia Tech; and Dr. Yossi Sheffi, director of the center. In addition to the keynote speakers, seminar sessions offered the opportunity for researchers, practitioners, and policymakers to interact.

New Transportation Technology for Older People. An international symposium was held at MIT in September focused on New Transportation Technology for Older People. The two-day meeting was hosted by the center and the AgeLab in collaboration with the Organization for Economic Cooperation and Development (OECD). Sponsored by The Hartford Financial Services Group and the New England University Transportation Center, the symposium engaged transportation and aging researchers, policy makers, transportation planners, the automobile and insurance industries, and other stakeholders interested in the nexus between transportation technology, mobility, and aging. Drawing upon participants from over a dozen nations, the symposium examined the mobility demands of older people, the promise of in-vehicle telematics, cutting-edge vehicle systems, and innovations in public transportation to improve the safe mobility of older people. Presenters included strategists and researchers from Ford, Motorola, several departments of transportation, and transit operators from across North America and Europe. They also included representatives of the AAA, the AARP, The Hartford, and leading consulting firms and universities.

Smaller Functions

CTL researchers featured at Technology Day. CTL researchers were featured at this year's Technology Day on June 5. This year's program, "Shifting Gears," brought together some of the best minds at MIT and in the corporate world in a daylong program delving into the car, the problems associated with its success, and visions for meeting the challenges its success has brought. The meeting featured Ralph Gakenheimer, professor of urban studies and of civil and environmental engineering, and Joseph Coughlin, director of the AgeLab. Other speakers at "Shifting Gears" included Daniel Roos, associate dean for engineering systems and codirector of the Engineering Systems Division, and John Heywood, director of the center for 21st Century Energy and the Sloan Automotive Laboratory.

Visits from governors. Idaho governor Dirk Kempthorne, newly elected chairman of the National Governors Association, paid an official visit to MIT's AgeLab in November as part of his high-priority Chairman's Initiative on long-term care issues. Governor Kempthorne's visit followed on the heels of another visit from the National Governors' Association in September, when former governor John Engler of Michigan took a tour of the lab with nearly 100 health policy advisors from almost all 50 states. The policy makers came to the AgeLab to meet with its researchers and to see for themselves the technologies and ideas developed to improve the health of our aging society. They found the AgeLab's ongoing telemedicine work with Harvard Medical School and Partners Telemedicine of particular interest.

Joseph Coughlin testifies before US Senate. Dr. Joseph F. Coughlin, director of MIT's AgeLab and of the MIT New England University Transportation System Center, testified

before the US Senate Special Committee on Aging in April on technology-enabled innovations to support an aging society. His testimony, "Assistive Technologies for Independent Aging: Opportunities and Challenges," highlighted the work being done at MIT. Projects include transportation, telemedicine, technology development around retail health services, and research on the policy and market barriers to market innovation in support of an aging society.

Affiliates Program in Logistics

Annual meeting at Lucent Technologies. Over 60 people convened at Lucent Technologies in New Jersey last fall for the 2003 Affiliates Day, an annual event of the center's Affiliates Program in Logistics (APL). Designed to be a showcase of leading supply chain and logistics practices at member companies, the annual meeting this year was sponsored by Lucent Technologies at their Murray Hill headquarters in New Jersey. The event, "Evolving the Supply Chain Organization of the Future," featured presentations by senior executives at Lucent describing the massive change in their supply chain (called Supply Chain Network) that Lucent's CEO Pat Russo has credited with helping the company achieve its first profits in three years. The Affiliates Program in Logistics was established in 1981 to develop relationships between MIT and the private sector transportation and logistics industries. The program helps support research that is of particular interest to private sector organizations and that contributes significantly to improved educational programs for private sector management. The Affiliates Program serves its members through a series of symposiums that cover a broad expanse of critical leading edge topics and issues for companies that ship and carry products and materials.

Integrated Supply Chain Management Program

Since its inception in FY1995, the Integrated Supply Chain Management Program has maintained a small but solid set of sponsors, now including Avaya, Helix Technology, Intel Corporation, Leica Microsystems, Lucent Technologies, Monsanto, Procter & Gamble, and Texas Instruments. The consortium has been productive in funding research over the course of its eight years of operation, with most recent seed funding supporting the Supply Chain Response Project under Professor Y. Sheffi. The consortium has recently included events that brought sponsors together to understand the importance of managing uncertainty, as well as how supply chains respond to disruption.

Professional Education

Supply Chain Management: Thought Leadership, our annual weeklong summer program, was offered June 22–25.

Personnel Changes

Ken Cottrill appointed director of Global Communications. Ken Cottrill, formerly an editor with Traffic World, was appointed director of Global Communications at the center,

responsible for expanding the center's reach within the industry. As associate editor for *Logistics & Special Projects,* Cottrill was responsible for covering logistics and supply chain management for Traffic World. While there, he created a weekly column called "E-Strategies" about the development of e-commerce in logistics and supply chain management and played a key role in developing a series of supply chain roundtables for high-level executives in collaboration with *Business Week.*

Dr. Jarrod Goentzel named director of MIT's effort in the MIT–Zaragoza Program. Jarrod Goentzel has joined the staff of the center as a research associate and as executive director of MIT's effort in the MIT–Zaragoza International Logistics Program. Goentzel's primary charge is the management of MIT's participation in the newly formed international program, a research and education partnership with the Government of Aragón, Spain, the University of Zaragoza, and the logistics companies of PLAZA, a state-of-the-art logistics park now being constructed in Aragón's capital city of Zaragoza. A joint effort between the MIT center and the new Zaragoza Logistics Center, the MIT-Zaragoza program is headquartered in the park. The program's education offerings include a master's degree, ZLOG (modeled on MIT's Master of Engineering in Logistics, MLOG); a doctorate degree; and a set of executive education courses leading to certificates in various logistics-related disciplines. The research program will use the logistics park as a working laboratory to experiment with new logistics processes, concepts and technologies, in active collaboration with leading academic institutions and companies from around the world.

Dr. Lawrence ("Larry") Lapide named director of Supply Chain 2020. Dr. Lawrence ("Larry") Lapide joined the staff of the center as director of Supply Chain 2020, a multimillion-dollar research effort looking into the future of logistics and supply chain management. The research will explore such areas as future technologies, business practices, corporate structure, regulations, culture, and customer expectations, resulting in a series of publications and a book. It will involve dozens of MIT faculty members, research staff, and students, as well as the participation of leaders in industry and faculty at other universities. A recognized leader in supply chain technology, Dr. Lapide has more than 12 years of experience in supply chain and marketing consulting, 10 years of management experience in the high tech sector, and 7 years as a supply chain technology market analyst, as well as 10 years' experience in college teaching on a part-time basis.

David Riquier appointed director of Corporate Outreach. David Riquier was appointed to the staff of the center as director of Corporate Outreach as of June 7. A resident of Needham, MA, he is responsible for building the center's outreach relationships and programs, working with Jim Rice and Ken Cottrill to serve and increase the center's connections with industry. From 1995 to 2002, Riquier was associate director of Communications and Sponsor Relations at the MIT Media Lab. In that capacity, he planned and executed launches of new research groups, recruited targeted sponsors (such as Dupont, Time, and the US Department of Defense), and maintained key sponsor relations with such firms as MasterCard, Merrill Lynch, and Hewlett-Packard.

New research and support staff. The center's research staff was enhanced this year with several new hires: Clint Plummer, Rozanne Puleo, Jennifer Gilbert, and Bryan Reimer; the support staff was also expanded with the addition of Nicole Blizek, Lisa Emmerich, and Rebecca Schneck. Postdoc Kai Jiang also joined the staff.

Recognition

Mary Gibson Wins Infinite Mile Award for Sustained Excellence. At a reception in April, Mary Gibson, the center's manager of administration and finance, was presented with the prestigious Infinite Mile Award for Sustained Excellence. Gibson first joined the School of Engineering in 1988 as the administrative officer for Project Athena, MIT's campuswide computer network system. She left for a brief stint in central administration but returned to the School in 1993 as manager of administration and finance at the Center for Transportation and Logistics.

Sussman honored for contribution to education and research. Joseph Sussman, J. R. East professor of civil and environmental engineering and of engineering systems, was named the winner of the 2003 CUTC Award for Distinguished Contribution to University Transportation Education and Research. Awarded annually by the Council of University Transportation Centers (CUTC), the honor recognizes individuals with a long history of outstanding contributions to university education and research resulting in a lasting impact on the transportation field. Sussman was chosen by the CUTC executive committee from a list of nominees submitted by council members. A previous director of the center (1986–1991), Sussman is the author of *Introduction to Transportation Systems,* a graduate text in use at a number of universities. His research in railroad service reliability, operations, and risk assessment has had a major impact on the railroad industry in the United States and Japan, and his work in intelligent transportation systems helped to build the US national program.

AgeLab gets national press attention. The AgeLab received a number of visits from the national press corps. On November 17, *USA Today* devoted the lion's share of its front page, in both its national and international editions, as well as most of the second page, to a feature on the AgeLab. The first of the AgeLab-Hartford studies on the role of age and health in driving was a lead story in the *AARP Bulletin,* the largest circulation publication in the United States, with distribution to over 30 million people. And the *Ladies Home Journal* also ran a significant feature on the AgeLab's older driver research earlier in November, as have several local media: the *Boston Globe,* Boston's Channel 7, the BBC, *Metropolis,* and the *Toronto Star*.

Yossi Sheffi
Director
Professor of Civil and Environmental Engineering and Engineering Systems

More information about the Center for Transportation and Logistics can be found on the web at http://web.mit.edu/ctl/.