

## **MIT Portugal Program**

The MIT Portugal Program, launched in October 2006, is a strategic investment in people, knowledge, and ideas by the Portuguese government to strengthen the country's knowledge base and international competitiveness. This transatlantic collaboration involves MIT, together with government, academia, and industry in Portugal, in the development of education and research programs in engineering systems. The end of AY2009 marked the halfway point in the program's initial five-year funding period.

MIT Portugal is hosted by the Engineering Systems Division (ESD) and is led at the Institute by ESD's founding director, professor Daniel Roos, who serves as MIT director of the program. Numerous other departments and divisions within the Institute's five schools are also active participants in MIT Portugal.

### **Education**

The MIT Portugal Program plays a significant role in Portugal's effort to reform and internationalize its science and engineering training, an undertaking aimed at training future leaders in the knowledge-based economy, bringing about economic development, and addressing pressing social challenges.

MIT Portugal offers a portfolio of graduate degrees to which MIT quality standards are applied. During the program's first year, we established four PhD and three executive master's programs that focus on four areas of significance to systems thinkers: bioengineering, engineering design and advanced manufacturing, sustainable energy systems, and transportation systems. Courses are cotaught by faculty at Portuguese institutions and by MIT (including ESD) faculty, and students have opportunities to conduct research at MIT collaborating laboratories for a year or longer. We formed consortia of universities throughout Portugal to establish these degree programs—the first such university collaborations in Portugal and the first to grant national degrees.

This past year saw consolidation of these degree programs and increased involvement of MIT faculty, researchers, and students in them. Nearly 60 MIT faculty (including three Institute Professors) now conduct MIT Portugal-related research or coteach MIT Portugal classes. (They do the latter in Portugal or via teleconferencing from Cambridge.) MIT faculty also engage in knowledge transfer to Portuguese faculty regarding engineering systems principles and practices as well as other areas of expertise. In addition, MIT faculty conduct outreach in Portuguese secondary schools; in more than a dozen visits, they have reviewed projects and engaged in question-and-answer sessions with more than 2,000 Portuguese students.

We have incorporated MIT innovations in active learning and other teaching strategies in our PhD and master's programs. One example is MIT Portugal's Bio-Teams course, which builds on the i-Teams concept developed at the Institute's Deshpande Center for Technological Innovation. In this course, which was further refined in AY2009, students review early-stage biotechnologies emerging from universities and companies in

Portugal and then evaluate the technologies' market potential and present go-to-market strategies. We also made significant progress this year in developing collaborative design studios, in which MIT Portugal Program students are linked directly to design and industry professionals in Portugal and worldwide. These studios allow for close collaboration and project-based learning. We also have created special learning spaces in Portugal and at MIT to conduct synchronous lectures and seminars, foster faculty and student mentoring via videoconferencing, and use other advanced collaboration tools. One such site is the sustainable energy systems classroom at the Instituto Superior Técnico (IST) in Lisbon, where doctoral seminars are held for participants from MIT; the Universities of Coimbra, Lisbon, and Porto; and from other remote industry and university locations, including the Azores islands.

More than 1,000 candidates from around the world have applied to MIT Portugal's degree programs, and the program has granted 144 PhD scholarships to date. During spring 2009, 196 students from 22 countries were enrolled in the MIT Portugal Program.

## Research

The consortia created by the MIT Portugal Program connect eight Portuguese universities with 20 Portuguese research centers and national associated laboratories. These consortia, working with laboratories and departments at MIT, have developed an array of leading-edge MIT Portugal research projects that are carried out at the Institute as well as in Portugal by program faculty, students, and industry affiliates. At MIT, funding is provided for 159 individuals: 32 professors and lecturers, 14 postdoctoral fellows, 80 research assistants, 15 research staff, and 18 administrative staff.

Our research to date—built on engineering systems and systems thinking—has focused on the same four areas as the program's PhD and master's programs. We revisited our strategy in AY2009, however, to target partnerships with industry that will lead to economic development and jobs in high-priority areas. As a result, our research going forward will focus on three areas: sustainable energy and transportation systems, stem cell engineering for regenerative medicine, and materials and design-inspired products. This research will include developing renewable, sustainable energy systems; designing alternative modes of transportation that are both energy efficient and effective; and developing next-generation biomedical products and therapies.

Our energy- and transportation-related projects concern high-speed rail and related intermodal issues, biofuels and new energy systems, integrated renewables coupled with smart grids, and the overall urban metabolism. In the arena of stem cell engineering, we address the development of novel therapies for an aging society and their clinical implementation in hospitals. We also work on pioneering medical devices in the health sector and on establishing companies that will help make Portugal a European leader in this field. With regard to materials and design-inspired products, we integrate the tools of systems thinking to create new, competitive mobility solutions that can be offered by companies developing electric cars and related parts. In addition, we focus on providing the necessary scientific base to demonstrate new solutions and systems for electric vehicles worldwide.

## Selected research highlights from AY2009:

- In addition to receiving strong support from the regional president for the Azores, Carlos César, our Green Islands project on São Miguel and several other islands in the Azores solidified partnerships with the regional electric utility Electricidade dos Açores (EdA), the University of the Azores, and SGC Energia, a Portuguese energy company. Green Islands, one of MIT Portugal's cross-cutting flagship projects, focuses on increasing significantly the contribution of renewable energy sources in the Azores in the next decade and beyond, minimizing dependence on fossil fuels, reducing greenhouse gas emissions, and creating a model for similar efforts throughout the world. Green Islands, which includes the development of a detailed characterization of the dynamics and socioeconomic trends of energy demand, involves assessing the following: building stock, retrofit and replacement opportunities, transportation options (including electric transportation), industrial and agricultural opportunities for efficiency and renewable/waste fuel production, microgeneration and smart grid/energy box integration, and new transportation systems management options based on information and communication technologies. In addition to SGC, Green Islands leverages partnerships with other leading energy-sector companies in Portugal, including Galp, Efacec, and Martifer.
- We advanced our efforts to identify and create new value-added activities for the existing auto sector in Portugal and to develop space for new players who can bring novel products to the market, particularly in power supply and management and communications systems. Part of our work in this area involves the Mobi-Design Studio Network, which is providing new benchmarks for research and validation of methods for the design of advanced vehicles, with an emphasis on smart interiors and integrated systems for electric vehicles. The network is based at the Center for Excellence and Innovation in the automotive industry, in Maia, Portugal.
- As part of our work on regenerative medicine, we continued to partner on a project to expand human mesenchymal stem cell research to the clinical scale and treat patients with several hematological diseases. This new field is supported by research and development of new bioengineering techniques to improve fundamentally the treatment and prevention of disease; assess the effectiveness and outcomes of new biological materials, processes, and devices; and develop advanced engineering techniques for conducting biomedical research at multiple scales. Our partners are the Instituto de Biotecnologia e Bioengenharia at IST; Instituto Português de Oncologia Francisco Gentil, Lisbon; and Centro de Histocompatibilidade do Sul, Lusotransplante.
- Our CityMotion project successfully tested DynaMIT traffic simulation software that could make it easier for traffic managers to assess road conditions and ease congestion in real time. The software, which was developed at MIT's Intelligent Transportation Systems lab, was tested at Brisa, Portugal's largest toll-road management company and an MIT Portugal industry affiliate. CityMotion involves setting up and exploring an infrastructure that gathers data on a city from various heterogeneous sources and includes developing data fusion algorithms that transform a rich amount of data into knowledge about the city,

making that knowledge available at various levels of abstraction, and developing new computational solutions for energy-efficient and environmentally sustainable intelligent transport systems. CityMotion is one of several ongoing MIT Portugal transportation-related research projects.

### **Partnerships with Industry**

Robust partnerships with industry are a key component of the MIT Portugal Program. In fact, we draw directly on MIT's success in forging effective university–industry partnerships in our efforts to develop similarly successful collaborations in Portugal. In AY2009, we continued to establish partnerships with leading bioengineering, pharmaceutical, transportation, and manufacturing companies, from Portuguese start-ups to multinationals. Our roster of industry affiliates grew significantly and now numbers 53.

Notably, one of our aims—to accelerate innovation in biotechnology in Portugal through industry–research partnerships—was advanced in October 2008, when four major pharmaceutical and industrial companies, as well as nine start-ups, signed affiliation agreements with the program. The signing of these new affiliate companies: Bial, Cipan, Frulact, Unicer, Alfama, Altakitin Corp., Bioalvo, Biotecnol S.A., Biotempo, Biotrend, Crioestaminal, Ecbio, and Stematters, was announced at “Bioengineering: Trends and Opportunities,” a conference held in Lisbon on October 6, 2008.

Another significant development in AY2009 was the signing by SGC Energia SGPS S.A., a Portuguese energy company, of a €1 million affiliation agreement with MIT Portugal. The April 2009 signing, which took place at the 2nd Transatlantic Conference on Renewable Energies, on the Azorean island of Terceira, committed SGC funds over five years to support MIT Portugal education and establish a research collaboration. Of SGC's total contribution, €400,000 will support a professorship, the SGC Energia Invited Research Chair in Sustainable Energy Systems, as well as help several MIT Portugal PhD students to pursue leading-edge research in areas of interest to the company. The remaining €600,000 is earmarked for MIT Portugal research; SGC will propose research projects in cooperation with a new SGC invited research chair and MIT Portugal.

Also signed at the Transatlantic Conference were agreements with the Azores' electric utility, EdA, and the University of the Azores. EdA became an industrial affiliate; its annual contribution of €10,000 will support the program's general goals and objectives. The agreement with the University of the Azores is part of an agreement on advanced studies, research and development, and demonstration projects in sustainable energy systems in the Azores. It provides further human resource funding from the Azores Regional Government to the MIT Portugal Program and its collaboration with the University of the Azores in the Green Islands project.

The program's industry collaborations not only foster cutting-edge research, they also support our educational efforts, including student internships and scholarships. For example, MIT Portugal has arranged 19 internship placements for our students to date with the program's industry affiliates.

Given these developments, the program made great strides in AY2009 toward creating an entrepreneurship ecosystem in Portugal, one that will help bring groundbreaking research to market and spur economic development. (For more on the development of an entrepreneurship ecosystem, see the description of the conference below.)

## Events

Knowledge transfer was a key aim of “Experiencing Technology Transfer & Commercialization: Fostering a New Dialogue with MIT,” a Lisbon workshop organized in part by MIT Portugal on March 29–31, 2009. The event, which explored the programs, policies, and social networks that foster successful partnerships between academic researchers and industry, highlighted MIT successes in this area with talks by leaders of the Institute’s entrepreneurship ecosystem. Participants included professor Charles Cooney, a member of the MIT Portugal faculty, Haslam professor of chemical and biochemical engineering, and faculty director of the Deshpande Center; Jack Oldham, director of foundation relations; Karl Koster, executive director of the Office of Corporate Relations Industrial Liaison Program; Tony Knopp, senior industrial liaison officer at the Industrial Liaison Program; Kenneth Morse, senior lecturer and managing director at the Entrepreneurship Center; and Lita Nelsen, director of the Technology Licensing Office. Leading Portuguese entrepreneurs also took part, as did the director of the University Technology Enterprise Network (UTEN), José Manuel Mendonça; professor Daniel Roos, director of MIT Portugal at MIT; and António Cunha, dean of the University of Minho’s School of Engineering and co-lead of MIT Portugal’s engineering design and advanced manufacturing focus area. MIT Portugal’s partners for the event, which was held at IST in Lisbon, were UTEN and the Luso-American Development Foundation.

The program also played a central role at “Thinking the Future: Urban Mobility: The Great Challenge for Society,” a conference held in Lisbon on January 27, 2009, on the challenges of, and possible solutions to, urban mobility — from emissions reductions and energy efficiency to transportation systems alternatives. Joining high-level speakers from Portuguese industry and Lisbon’s municipal government were MIT Portugal faculty Carlo Ratti, director of MIT’s SENSEable City Laboratory and professor in the Department of Urban Studies and Planning and the Media Lab; professor William Mitchell, director of the Smart Cities research group and professor of architecture and media arts and sciences at MIT; and José Viegas, full professor in transportation at the Department of Civil Engineering and Architecture at the IST, Universidade Técnica de Lisboa, and Portugal lead of MIT Portugal’s transportation systems focus area.

On March 2, 2009, the program’s bioengineering focus area organized the second annual IdeaSpring Conference at Biocant Park in Cantanhede, Portugal. The event launched MIT Portugal students’ Bio-Teams and their go-to-market innovation projects (see the Bio-Teams course description above) and provided an opportunity for information sharing with participants from venture capital firms, companies, and other leaders from Portugal’s innovation ecosystem. Representatives of technology licensing offices participated, as did MIT Portugal students.

On June 2, 2009, MIT Portugal, Biocant Park (Cantanhede, Portugal), and the Centre for Neurosciences and Cell Biology (University of Coimbra, Portugal) organized the third

annual Workshop on the Business–Government Interface: Challenges on Gene and Cell Therapies. This event brought about a high-level exchange of information among MIT Portugal faculty, scientists from Portuguese universities and stem cell laboratories, and government officials.

From June 18 to 20, 2009, MIT Portugal faculty and students also took part in the fourth annual Innovation Days exhibition held in Lisbon. Innovation Days promotes the results of successful market-oriented research and development (R&D) projects as well as new partnerships among companies, researchers, and investors. The event featured several MIT Portugal R&D projects—one involving mesenchymal stem cells and others involving prototypes developed in fall 2008 by students in the program’s engineering design and advanced manufacturing product design and development module.

MIT Portugal leadership, faculty, and students played a significant role in the second International Engineering Systems Symposium, *Engineering Systems: Achievements and Challenges*, held at MIT June 15–17, 2009. The opening session included welcoming remarks from Professor Roos, the symposium cochair, and chair of the Council of Engineering Systems Universities executive committee, and the event included research sessions detailing MIT Portugal work in sustainable energy systems and MIT Portugal experience to date in engineering systems education. Professor Paulo Ferrão, the Portugal director of the MIT Portugal Program and director of the Center for Innovation, Technology and Policy Research at IST in Lisbon, contributed to a session on “New Global University Initiatives in Engineering Systems.” Dr. Robert E. Skinner, Jr., a member of MIT Portugal’s external review board and executive director of the Transportation Review Board, participated in a discussion looking ahead to engineering systems in 2020. And Christopher Magee, co-lead of MIT Portugal’s engineering design and advanced manufacturing group and professor of the practice of mechanical engineering and engineering systems at MIT, was one of the featured speakers during a session on methodologies and large-scale system applications.

The substance of our revisited strategy, a result of consultations among MIT Portugal stakeholders and the program’s governing and operating committees in AY2009, was presented before an audience of several hundred at the first annual MIT Portugal Conference, “Engineering for Better Jobs,” in Lisbon on July 7, 2009. This high-profile event, covered by major news media in Portugal, provided a forum for chief executive officers from companies affiliated with MIT Portugal to discuss their collaborations with the program and for MIT Portugal principal investigators and doctoral students to present 140 posters representing the breadth of MIT Portugal research.

### **Other Developments**

In March 2009, MIT Portugal became the inaugural sustaining public member of the MIT Energy Initiative (MITEI), giving a designated representative of the government of Portugal a seat on MITEI’s governing board. In AY2009, the program’s faculty continued involvement in MITEI, participating in a review of research proposals to the initiative. In addition, MIT Portugal research on ocean wave energy, at the Institute and in Portugal, was featured in the autumn 2008 issue of MITEI’s newsletter, *Energy Futures*.

Members of the program's faculty also will become involved in Transportation@MIT, the campus-wide initiative announced in March 2009.

On May 30, 2009, MIT and the International Iberian Nanotechnology Laboratory (INL) formalized a \$35 million collaboration aimed at enhancing efforts in nanoscience and nanotechnology research and education. The launching of MIT-INL occurred in the context of the existing relationship between MIT and Portugal forged by the MIT Portugal Program as well as by other partnerships and research projects at MIT that are being pursued on the Iberian peninsula.

## Personnel

The MIT Portugal focus areas are co-led by MIT faculty and faculty from the eight Portuguese institutions of higher learning that make up the program's research and higher education consortia. The faculty leads from MIT in AY2009 were as follows: professor Dava Newman (bioengineering), professor Christopher L. Magee and professor Joel P. Clark (engineering design and advanced manufacturing), professor David Hunter Marks and professor John Fernández (sustainable energy systems), and professor P. Christopher Zegras (transportation systems). During the spring semester, ESD professor and MIT Portugal Program faculty member Joseph Sussman served as MIT lead for transportation systems while Professor Zegras was on research leave; on his return, Professor Zegras became research director for transportation systems. Professor Fernandez was on sabbatical in Portugal during AY2009; on his return, he became research director for sustainable energy systems and Professor Marks was named educational director. In AY2010, professor Bruce Tidor, who leads two MIT Portugal research projects that involve systems biology and synthetic biology, will share bioengineering systems leadership responsibilities at MIT with Professor Newman.

Richard de Neufville, professor of Civil and Environmental Engineering and Engineering Systems and co-instructor of two MIT Portugal transportation systems master's degree courses—one in transport technologies and operations management and another in structured financing of transport projects—was named a Fulbright scholar in fall 2008.

In November 2008, Dr. Lino Ferreira, a member of the MIT Portugal faculty and a former postdoctoral fellow in Institute Professor Robert Langer's lab, was awarded the €20,000 Crioestaminal Prize for his work on stem cell therapies to regenerate cardiac muscle in heart attack survivors and to prevent heart muscle deterioration that can lead to heart attacks. Dr. Ferreira is affiliated with the Centre for Neurosciences and Cell Biology in Coimbra, Portugal; the Biocant Biotechnology Innovation Centre in Cantanhede, Portugal; and the University of Coimbra.

In January 2009, bioengineering faculty member Sangeeta Bhatia, professor of health science and technology and professor of electrical engineering and computer science, was named one of 10 "Women to Watch" in high-tech by the newspaper *Mass High Tech*, for her work on the applications of micro- and nanotechnology to tissue repair and regeneration. One MIT Portugal Program PhD student visiting MIT from IST is currently working in Professor Bhatia's lab.

## Looking Ahead

The MIT Portugal Program will announce open calls for research funding in AY2010 that will bring in new researchers, expand our research portfolio, and leverage investments made by SGC Energia and other industry affiliates of the program. In addition, we are forming a new consortium that will establish a more formal and long-lasting agreement among Portuguese universities as well as further our goal of fostering collaborative higher education in Portugal.

We are transitioning the MIT Portugal Program from a top-down, government-led initiative to a bottom-up program with support from universities, industry, and private foundations. With our new focus on sustainable energy and transportation systems, stem cell engineering for regenerative medicine, and materials and design-inspired products—and our five-fold mission to transform scientific and engineering training in Portugal, build a research and knowledge network, invest in developing human resources, cultivate the ongoing development of advanced research methods and models, and demonstrate the advantage of systems thinking in real-world applications—our aim is to contribute even more fully in coming years to the real-life development of systems, products, and solutions that give Portugal a competitive advantage and, at the same time, continue to add value to the MIT community.

**Daniel Roos**

**Director**

**Japan Steel Industry Professor of Engineering Systems and Civil and Environmental Engineering**

*More information about the MIT Portugal Program can be found at <http://www.mitportugal.org/>.*