MIT Portugal Program

The MIT Portugal Program (MPP), 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 and academia in Portugal and global and Portuguese companies, in the development of education and research programs in engineering systems.

MPP is hosted by the Engineering Systems Division (ESD) and is led at the Institute by its 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 MPP.

Research

The consortia created by MPP 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 MPP research projects that are carried out at the Institute as well as in Portugal by program faculty, students, and industry affiliates. The initial round of research was conducted within the same four focus areas as those in which the educational programs are offered; the projects funded in this phase largely drew to a close during AY2011. Research now focuses on three application 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.

Portuguese Science Foundation (FCT)–funded research projects targeting the program's three application areas completed the first year of their two-year grants in June 2011. Projects are being carried out by joint teams that include MIT faculty and staff and researchers from various Portuguese institutions and companies.

Awarded Projects and MIT Principal Investigators

MIT Principal Investigator	Project Title
Professor Richard de Neufville (ESD/Civil Engineering)	Forest Fire Protection: Risk Management
Professor Randy Kirchain (ESD/Materials Science)	Capturing Uncertainty in Bio-derived Fuels for Transportation: Resolving Environmental Performance and Enabling Improved Use
Professor Randy Kirchain (ESD/Materials Science)	Economic and Environmental Sustainability of Electric Vehicle Systems
Professor Robert Langer (Chemical Engineering)	Micro/Nano Design of Functional Stem Cell-Instructive Materials for Bone Tissue Regeneration

Professor Richard Larson (ESD/Civil Engineering)	A Learning, Adaptive, Communicating Energy Box
Professor Joseph Sussman (ESD/Civil Engineering)	Strategy for High Speed—Supporting a Multimodal, Multisectoral Deployment Strategy for HSR in Portugal

AY2011 also saw the continued development of three international research networks (launched during president Susan Hockfield's visit to Portugal in late 2009) that seek to expand and make sustainable MPP's research in key areas:

- The Sustainable Cities Forum and Research Network brings together the MIT Energy Initiative (MITEI) and city officials and urban experts from around the world to benchmark sustainability and help design, test, and implement new policies for greener cities. This network leverages the emerging field of urban metabolism, in which MPP is a leader, and aims to contribute directly to the real-world needs of Portuguese cities while also advancing global efforts toward a humane and sustainable urban future.
- The Sustainable Energy Systems and Electric Mobility Research Platform and Network (E2 Research Net) aims to make Portugal a center for new research and advanced training. Bringing together industry, academia, and governmental agencies, E2 Research Net builds on recent initiatives in Portugal to implement various forms of electric mobility and renewable sources of energy generation and integrates research developed by more than 80 MPP PhD researchers at Portuguese universities.
- The Stem Cell Engineering and Clinical Research Network (StemCellnet) seeks to develop the emerging field of stem cells for regenerative medicine, with a focus on the treatment of cancer, hematological and genetic disorders, and autoimmune diseases. StemCellnet addresses both development and implementation.

Academic research initiatives take time to establish and demonstrate results, and during AY2011—MPP's fourth year—there was significant progress and output from the many examples of collaborative research involving MIT and Portuguese researchers. The highlights below illustrate a few of the exciting directions that have emerged from these MPP research efforts.

"Smart" Drug Carrier Targeted for Tumor Cells

Professors Langer and Lino Ferreira (University of Coimbra) demonstrated the feasibility of a "smart" drug carrier targeted for tumor cells that over-express epidermal growth factor. They also developed quantitative mathematical models for critical rate processes (including drug leakage from drug-encapsulating liposomes and distribution of liposomes in blood vessels).

Green Islands Research Collaborations in the Azores

Twelve research projects were designed and implemented in cooperation with the University of Azores and were funded by the Azores government. Ranging from renewable resource assessment to social studies on mobility and energy efficiency

or house stock characterization, the projects are producing valuable results, such as the characterization of electricity demand on the residential sector. In one project, Sustainable Energy Systems (SES) PhD student Patrícia Baptista developed energy and CO_2 emissions scenarios related to the introduction of new vehicle technologies in the Portuguese fleet, both on the mainland and in the Azores.

Energy-efficient Building Technology

Previous studies suggest potential for energy savings through cool and green roofs but do not always consider the many factors that affect potential savings or the relative advantages of different technologies. In this project, a general model for green roofs was developed. Simulations show that a one-story building in Boston with a modified-bitumen roof and 2.7 m2K/W roof insulation can save 13% in cooling and heating energy by doubling the insulation but only 12% if a green roof is installed. However, in Lisbon the same additional amount of roof insulation to the same building results in –0.010% savings, while the installation of a green roof results in a 26% reduction.

CityMotion Research on Real-time Information Systems in Transportation

CityMotion, a project investigating data fusion for mobility consumers, providers, and planners, is already beginning to influence operational approaches in industry partners. A foremost example is the project's collaboration with Jorge Lopez, head of research for Brisa Innovation, which has introduced concepts for new data-based techniques to that company's management. This has led to the capability to handle incidents and incident-related traffic forecasts which underpin the implementation of a system to support traffic operations and route guidance services, on the Brisa network, for real-world evaluation tests.

AirNets

In August 2010, the AirNets project, which studies the implications of congestion for the configuration of airport networks and airline networks, was the subject of an article in *Executive Digest*, one of Portugal's leading business magazines. Written by AirNets principal investigator António Pais Antunes, University of Coimbra, the article describes how AirNets has developed models to help fight congestion in major airports and air networks and how these models are already are being used by the airline TAP Portugal and other major transportation companies and organizations.

Lean Design in Product Development

The main goal of this research is to develop a systematic method to analyze the development of complex products in order to identify inefficiencies in the development process and opportunities for improvements. The systematic method was applied to a Rolls-Royce high-pressure turbine blade detailed design process. The results show the benefits of the preliminary proposed framework in promoting communication among the people involved in the design process, in discovering process inefficiencies, and in finding opportunities for possible improvements.

Education

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

MPP offers a portfolio of graduate degrees to which MIT standards are applied. The program's four PhD and three executive master's programs focus on four areas of significance to engineering systems thinkers: bioengineering, engineering design and advanced manufacturing, sustainable energy systems, and transportation systems. Courses are co-taught by faculty at Portuguese institutions and by MIT faculty, and students have opportunities to conduct research at MIT collaborating laboratories during their doctoral programs. Consortia of universities throughout Portugal have been formed to establish these degree programs—the first such university collaborations in Portugal and the first to grant national degrees.

The MPP Education Innovation Awards were established in 2010 as part of a continuous effort to recognize and reward excellence in the design and delivery of educational programs in Portugal, and thereby give greater incentive to outstanding teaching as part of its aim to ensure the quality of its degree programs. The second set of award winners (six faculty members, from three Portuguese universities) were selected in November 2010.

In addition, MIT faculty members conduct outreach in Portuguese secondary schools; in more than 15 visits, they have reviewed projects and engaged in question-and-answer sessions with more than 2,500 Portuguese students.

More than 2,000 candidates worldwide have applied to MPP's degree programs, and the program has granted 204 PhD scholarships to date. By spring 2011, over 400 students from 44 countries had enrolled in or graduated from MPP degree programs. The admitted doctoral students in the 2011–2012 cohort include graduates of MIT; University of California, Berkeley; Northwestern University; University of Edinburgh; University of Munich; University of Sidney; and other distinguished international institutions. This is the third consecutive year in which more than 30% of admitted MPP PhD students have come from outside Portugal.

There were several other examples in AY2011 of the growing effectiveness and expanding impact of MPP's education programs.

Benchmarking Study

As a highly innovative and unprecedented program in Portugal, MPP has a strong interest in performance benchmarking. The system of real-time program assessment, implemented in 2008, focuses on program performance with respect to the declared MPP objectives: (1) creating strong, international graduate programs geared towards innovation, industry needs, and entrepreneurship; (2) attracting excellent students; (3) strengthening networking and the critical mass in research power; (4) improving university-industry linkages; (5) facilitating positive spillovers from MPP into the overall Portuguese university system; and (6) supporting ongoing reform processes in Portugal.

The assessment provided a key opportunity for organizational learning with respect to these issues, and has yielded a number of policy recommendations on how to improve the program in terms of design and implementation.

The study drew mainly from three sources of data: (1) an annual comparative student survey that covers major issues related to education, student research, networking, industry linkages, and program administration, carried out with approximately 100 MPP students and a reference cohort of over 200 non-MPP students enrolled in Portuguese graduate programs in engineering; (2) a series of over 20 semi-structured faculty interviews, including faculty inside as well as outside MPP; and (3) a variety of program statistics obtained from the program coordination office. The analysis was partly quantitative, using statistical tools, and partly qualitative, using a grounded theory approach. The study found that MPP represents a highly apposite, effective, and comprehensive policy response to Portugal's imminent innovation and higher education challenges, including pan-European reform pressures.

Portuguese Faculty and Student Visitors to MIT

The MPP collaborative venture provides unique opportunities for students and scholars in Portugal to visit MIT for extended periods of learning, research, and interaction on campus. Some 62 doctoral students and 24 visiting scholars have spent a month or more at MIT during the last two academic years, and 43 executive master's students have enjoyed intensive one-week visits to MIT.

Student Participation in Ciência 2010 Conference

A new research partnership proposed between MIT Portugal and Continental Mabor and the presentation of 96 doctoral students' posters were two highlights of MPP's strong presence at this year annual Ciência conference, , which offers an "encounter with science and technology." Held July 4–7, 2010, at the Lisbon Centro de Congressos, the conference and was organized by FCT and the Council of Associated Laboratories, in association with Ciência Viva.

In addition to the 96 MPP PhD student posters, several sessions featured MPP moderators and speakers, including students. Among the PhD students who presented their work at the conference, SES students Leonardo Rosado and André Pina were also presenters in a session that featured João Nuno Mendes, the director of innovation for GALP Energia Group, and that focused on a proposed research project with MPP in the area of smart metering of home energy consumption. João Pita, PhD student in transportation systems, moderated a session dedicated to postgraduate programs in Portugal; the session included panelists Marco Leite and Hrvoje Keko, PhD students from the Leaders for Technical Industry and SES programs, and featured a debate among students about what enhancements are needed for postgraduate studies in Portugal. As in previous editions of this event, there were bio-teams sessions given by MPP PhD students in bioengineering, who had the chance to show their latest innovations derived from research collaborations with Portuguese universities, companies, and research labs.

Industry and Entrepreneurship

MPP research and education activities continue to stress entrepreneurship and university-industry interactions. Two examples of these interactions are:

MIT Portugal Program Venture Competition

In 2010, MPP launched the Innovation and Entrepreneurship Initiative (IEI) as a collaboration among the Instituto Superior de Ciências do Trabalho e da Empresa/ Instituto Universitário de Lisboa, the Deshpande Center for Technological Innovation, the MIT Entrepreneurship Center (E-Center), and the School of Engineering. IEI adapts elements of MIT's entrepreneurial ecosystem to MPP to expose participants to challenges and opportunities associated with technology commercialization, complementing MPP's education initiatives. IEI has three broad aims: to create new business ventures from emerging technologies, to support the expansion of the Deshpande and E-Centers' innovation teams (i-Teams) approach across MPP from its current implementation in bioengineering, and to design and implement a series of meetings and events to showcase technological innovations in Portugal.

MPP's Venture Competition aims to foster the innovative and entrepreneurial spirit in Portugal. Open to anyone willing to register their company in Portugal, the high-visibility Venture Competition is designed to help identify and reward global projects that are at an embryonic stage—projects with high-level technological content, or products or services that are able to demonstrate a highly innovative approach. To highlight growing areas of entrepreneurial activity, the Venture Competition began with four tracks:

- Sustainable energy and transportation systems
- Life sciences
- Information technology and the web
- Products and services.

Each of the four track finalists is awarded up to €100,000, and the finalists then compete during a televised event for an additional €100,000 award. During the venture phase, track finalist and grand finale awardees benefit from the direction of "catalysts," with an opportunity to double their award, for a total of up to €1,000,000 in track finals, grand finale, and venture phase awards. Awardees also benefit from an interactive "go-to-market" workshop designed by professor Fiona Murray (associate director, E- Center) and research scientist Luis Perez-Breva, co-faculty directors of i-Teams.

The inaugural Venture Competition received a total of 95 applications and enrolled over 360 participants. The application period ran from March–June 2010, and was open to the community of students, researchers, and technologists from polytechnics, universities, and other institutions, public or private. Early stage companies (no more than five years past incorporation) that are dedicated to developing technology-based products or services and are international in scope were encouraged to participate. The final winner, announced in October 2010, was Around Knowledge, a company that has developed an indoor shopper positioning system (titled BIPS) that records shopping patterns in real time.

As a follow-up event, in April 2011, winners and participants of the Venture Competition spent a week participating in eTeams III @MIT, an excursion into the MIT innovation ecosystem. This was the third educational boot camp of the inaugural Venture Competition and included the founders of participating companies Around Knowledge, Waydip, Plux, weADAPT, Acellera Therapeutics, and Cell2B. Tangible outcomes from the visit included connections to potential partners (clinical and industrial) in the U.S., Cambridge Innovation Center's offer to host the teams for up to a month, a large number of potential business contacts and peer advisors developed by the teams, and invitations to move forward on joint proposals with MIT faculty and/or entrepreneurs.

The eTeams III @MIT curriculum was delivered via interactive sessions led by founders/officers of startups and thought leaders from E-Center. The interactive sessions provided practical advice on marketing and sales, as well as contributions from thought and practice leaders. The sessions were complimented by networking events designed to hone pitching skills and expand the network of entrepreneurs and potential US partners for the visiting teams. The week culminated with participation and networking at Deshpande Center's annual symposium, IdeaStream 2011, where the teams pitched their companies and networked with over 200 venture capitalists, angel investors, strategic investors, and founders.

IdeaSpring

IdeaSpring, an annual event now in its fourth year, was held at Biocant Park in Cantanhede, Portugal in February 2011. The event is held within the context of the bioengineering focus area's bio-innovation teams module (integrated in the advanced course on bioengineering systems). IdeaSpring aims to make public several biotechnologies with promising economic value developed in Portuguese national research centers and companies, and aims to promote interaction between inventors, students, potential investors, and other entities interested in bioentrepreneurship. Each year, IdeaSpring brings together MPP's bio-teams—groups of first-year bioengineering systems students and their faculty advisors. The teams devise "go-to-market" strategies for emerging technologies that are in development at Portuguese research labs—strategies that could help launch each innovation in the marketplace. A competition for the best strategy follows the event, normally in July. IdeaSpring 2011 included a workshop on intellectual property and a site visit to Critical Software, a company that is partnering with MPP and others on the Critical Challenge—a competition for the design and construction of an autonomous electric vehicle for use in cities.

Events

A number of high-profile public events to promote science and technology education and help foster MPP student and researcher interactions with industry and the public were held in AY2011.

The Second Annual MPP Conference was held on September 28, 2010, at the Faculty of Engineering of the University of Porto (FEUP). The conference was attended by more than 300 participants, including students, researchers, and business leaders, and approximately 150 scientific posters were prepared by MPP PhD students. Three publications were produced in conjunction with the conference: MPP Highlighting

Collaborative Research; Proceedings of the Second Annual MPP Conference; and MPP Doctoral Students 2010. With over 300 delegates from all sectors of Portugal's research and industry community, the second annual symposium emphasized the progress of the program's initiatives in three main targeted application areas for research. The minister of science, technology, and higher education, Mariano Gago, and several business leaders from established and startup Portuguese engineering companies, such as Galp, Energias de Portugal, TMG Automotive, Novabase, Mota-Engil, and Plux, presented examples of applied research projects being developed in collaborations between companies, Portuguese universities, and MIT. The conference was also the subject of extensive media coverage in Portugal; highlights included an interview with professor Edward Crawley (keynote speaker) and an overview of how MPP has attracted international attention to Portugal's academic-industry collaboration programs.

Challenged to fulfill the promise of their extraordinary achievements, over 200 new and senior MPP students from all seven educational programs began AY2011 together in Porto just prior to the annual conference. Following a keynote address by professor Dava Newman, who urged the students to "learn, act, discover, and innovate," the students used the courtyards and open spaces of the FEUP campus to engage in such teamwork challenges as "find the tree," in which teammates guide their blindfolded companions using nonverbal commands.

During fall 2010, the MPP Visiting Scholar Lecture Series was inaugurated. Featuring Portuguese faculty members spending time at MIT, the lecture series has focused on a variety of MPP research areas, from malaria to transportation to neurodegenerative disease. The series provides an opportunity to introduce MPP researchers to a broader section of the MIT community, and each lecture is followed by a reception, allowing further time for interactions and discussions. The lectures have been videotaped and are available on the MPP website for viewing.

The Fifth Annual Workshop on the Business-Government Interface in BioEngineering was dedicated to the theme of systems and synthetic biology and was organized by MPP's bioengineering focus area and the University of Minho. The workshop took place on June 6, 2011, and focused on issues such as innovation, benefits, and business strategies within systems and synthetic biology.

The Education, Employment, and Entrepreneurship (E3) Forum, organized by MPP students, was held on June 30, 2011, at the Faculty of Science and Technology of New University of Lisbon. The main objective of the E3 Forum was to fill the gap between research and current practice, academic paths and "real world" problems, and to provide an opportunity to raise awareness about ongoing research projects. Students had the opportunity to present their work, build a contact network, and learn more about possible career paths in academia and industry, as well as the opportunity to hear success stories related to the creation of technology-based companies.

Other Developments

Daniel Livengood, a PhD student who has worked on MPP's energy box project as a research assistant over the past four years, successfully defended his doctoral thesis,

"The Energy Box: Comparing Locally Automated Control Strategies of Residential Electricity Consumption under Uncertainty." His defense was held on May 16, 2011, and committee members were MPP professors Richard Larson (chair) and James Kirtley, and MIT Sloan School of Management professor Steven Graves. Livengood's work had already been distinguished with the Best Poster Award at the first MPP annual conference in 2009.

The first MIT Portugal Program MITEI postdoctoral fellow, Dr. Christos Ioakemidis of IST–Technical University of Lisbon, spent most of 2010 at MIT, thus solidifying Portugal's status as the sole sustaining public member of MITEI through FCT.

Personnel

MPP focus areas are co-led by MIT faculty and faculty from the eight Portuguese institutions of higher learning that comprise the program's research and higher education consortia. The AY2011 MIT faculty leaders were: bioengineering systems, professor Dava Newman (aeronautical and astronautical engineering and engineering systems) and professor Bruce Tidor (biological engineering and computer science); engineering design and advanced manufacturing, professor Joel P. Clark (materials systems and engineering systems); sustainable energy systems, professor John Fernández (architecture and engineering systems); and transportation systems, professor P. Christopher Zegras (urban studies and planning and engineering systems).

Professor Daniel Roos, national director of MPP at MIT, was honored at the Charles L. Miller Symposium titled, The Evolution of Engineering Systems: A Rich Past, an Exciting Future, held on campus on April 20, 2011. Speakers who worked with Professor Roos during his 55 years at MIT discussed his contributions to research, education, and developing relationships with industry. Professor Paulo Ferrao, national director of MPP in Portugal, and Professor Zegras, spoke of Professor Roos's contributions to building the partnership between MIT and Portuguese universities and industry.

Daniel Roos
Director
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