

MIT-Portugal Program

The Portuguese government, through the Ministry of Science, Technology and Higher Education, entered into a long-term (five-year) collaboration with MIT focusing on basic research and education in October 2006. The objectives, framework, and structure of the collaboration were developed during a five-month assessment conducted by MIT between February and July 2006, which recommended that MIT foster collaborations with Portuguese institutions based on the excellence of the research identified in Portuguese research centers throughout the assessment exercise. The study also acknowledged that the commitment of the Portuguese government to strengthen science and technology and promote international collaborations in higher education and in science and technology makes Portugal an interesting place for doing research and a relevant partner for future collaborations in the emerging knowledge-based, globalized economy.

The Portuguese government intends to strengthen the country's knowledge base at an international level through a strategic investment in people, knowledge, and ideas and the MIT-Portugal Program (MPP) was designed, together with other renowned research and education institutions worldwide, to contribute to the development of basic research and education and to foster a set of new and diversified institutional partnerships. The goals of the overall operation include launching and promoting new research-based consortia at a national level. The MPP contributes to this effort by involving 10 schools of higher education and seven different universities, together with a large number of research centers and associated laboratories as well as state laboratories.

Collaborative Agreement

There are two main foci for collaborative agreements. The first involves a formal, ongoing cooperative arrangement in the area of management sciences, which will be explored in a program design and planning process concerning a possible multiyear collaboration around management education and technology-based entrepreneurship.

The second is a five-year agreement about research and education with an engineering systems focus, responding to the increasing size, scope, and complexity of systems in today's global competitive environment. This report focuses on the second portion of the agreement.

This engineering systems collaboration emphasizes large-scale systems that not only have critical technological components but also have significant enterprise and sociotechnical level interactions that call for engineers in leadership positions to have training in engineering systems that goes beyond traditionally defined engineering disciplines.

Four Focus Areas

The MPP program is coordinated at MIT by the Engineering Systems Division and includes collaborations with various other departments, divisions, and schools at MIT. The following specific fields represent the four focus areas for the MIT Portugal collaboration, on top of which an integrative anchor program (in engineering systems) is being developed: engineering design and advanced manufacturing, transportation systems, energy systems, and bio-engineering systems.

A number of joint research and educational projects will be undertaken in each focus area involving participants from both Portugal and MIT. Educational programs will vary for each focus area and will consist of a mix of doctoral programs, professionally oriented master degrees, and short courses. Faculty are encouraged to make new educational material publicly available—namely, making use of Creative Commons licensing. At MIT, OpenCourseWare will be used.

In all program focus areas, there are several common elements including the following:

- An engineering systems framework
- A coupling of education and research initiatives
- Collaboration with a consortium of Portuguese universities
- Development of educational programs at three levels: PhD, professional, and short courses
- Interactions with industry
- Developing research projects and educational programs among Portuguese universities
- Developing joint projects between focus areas with cross-cutting flagship projects

Since January 2007, each focus area has undertaken a major workshop in Portugal, prepared a progress report for the first meeting of the External Review Committee, and prepared this second-year annual plan; they are working hard to get new educational programs in place by September and recruit students for those programs. This period has been extremely busy for all involved in the leadership of the MPP.

Following are summaries of the progress of each focus area to date.

Engineering Design and Advanced Manufacturing

This focus area emphasizes the development of design as a key academic field. It is aimed at enabling the development of a cadre of innovative leaders who not only are educated in the fundamental elements of technology management and design but also are trained in the practical exploitation of those core skills in the formation and leadership of knowledge-based creative enterprises. There will be particular emphasis in the automotive and aeronautic sectors as well as in medical devices.

The mission of the engineering design and advanced manufacturing (EDAM) focus area is to develop a paradigm for engineering education that closely links high-quality research to novel curricular programs and to promote an entrepreneurial approach to knowledge-based manufacturing and competitive product development.

Year One was essentially devoted to the establishment of working teams to support educational, research, and management activities, with the strongest emphasis on the educational program. The first year also saw the launch of the key target initiatives of the EDAM area, namely:

Educational programs: Leadership Training Institute PhD Program and Technology Management Enterprise Advanced Course Program

- Design of the programs
- Identification and recruitment of the lecturing teams
- Joint curricula development (under way)
- Registration of the programs at the Ministry of Science, Technology and Higher Education (concluded)
- Promotion of the planned activities (under way)
- Establishment of support infrastructure of the education programs (lecturing rooms with videoconferences and other hardware facilities)
- Review of the education programs with industrial partners and potential partners
- Outreach initiatives to secondary school and university students

Educationally Coupled Research

- Development of a joint research project (the pilot project) with industry involvement and clear links to the educational courses
- Definition and launching of broader research projects, involving MIT, Portuguese universities, and industrial companies

Industrial Affiliates Program

- Initiation of the program and establishment of the joint programs with 10 industrial affiliates in the automotive sector. Expansion of this to other sectors is planned for late in Year One or during Year Two.

Year Two activities will represent a transition from planning education and research programs to implementation.

Transportation Systems

The overarching focus of the MPP Transportation Systems Program is the design of complex, large-scale systems that have major societal impact and provide opportunities for sustainable economic development. The mission of the transportation area of the MPP is the development of a cadre of transportation researchers and professionals

in Portugal who are trained in the design of a technology-intensive intermodal transportation system, considering it as an integrated whole. The centrality of transportation to social goals and economic and industrial development makes it a vital area to pursue in MPP.

Since September 2006, faculty at MIT and in Portugal have undertaken the initial work on refining research and education objectives and beginning the planning and implementation for the new programs.

The seminal event for the transportation systems focus area was a January 29–31, 2007, workshop held in Lisbon. This three-day workshop included a larger one-day public session followed by two days of working sessions on a smaller scale—about 15 people—where participants worked on designing the education programs, laying out research thrusts, and developing research partnerships between Portuguese and MIT colleagues.

The major achievements during Year One in the education programs are as follows:

- Design of the basic structure for two new education programs, including three themes (transportation systems, international context for transportation, and business models: innovative procurement and operations of transportation infrastructure)
- Initial assessment of competing programs
- Identification of administrative needs and timing (admissions, marketing, student logistics)
- Identification of existing classes and teaching materials at MIT and in Portugal that may be incorporated into these programs and new subjects needed
- Initial development of new subjects to be offered as part of these programs

The research programs we have embarked on are designed to relate closely to the themes of the educational enterprise. We have developed and initiated a set of projects at MIT and a proposed set of subdomains in Portugal in four thrust areas. Research progress to date in these areas includes the following:

- Integrated systems: Development of an overarching regional strategic transportation planning framework, which will consider the integration of urban and regional transportation systems from an intermodal perspective.
- Intelligent transportation systems (ITS): Upgrading the MIT modeling frameworks to treat various pricing concepts and to develop methods, such as real options analysis, that can help evaluate such strategies (for example, in considering the value of flexibility in the ways we manage lane use). On the Portuguese side, work has involved add-on developments for a commercial traffic microsimulation tool (AIMSUN) for support of the intermittent bus lane system (already in live demonstration), development of information systems to guide drivers after traffic incidents, development or improvement of transportation concepts that depend on ITS tools for full performance (clubs of carpooling, market segmentation in public transport based on small vehicles,

operational improvements in traditional public transport), and innovative pricing strategies for urban mobility.

- Airports: Definition of an appropriate planning process, including appropriate means for valuing flexible design concepts, for the development of aviation infrastructure of Portugal, given the vast uncertainty surrounding the air transportation environment.
- Railways: Structuring the overarching framework for a generalized global risk assessment, gathering information about how the Decision Aids for Tunneling model might be tailored in such a way as to be effective in the Portuguese context and, in the natural hazards area, reviewing sources in the literature and ascertaining the availability of databases for natural hazards germane to the Portuguese situation. Additional work on the application of real options analysis to value flexibility in design options is ongoing.

Sustainable Energy Systems

Extending far beyond traditional energy research, this area will focus on the dynamics among energy services and supplies, including opportunities for developing combined heat and power and incorporating renewables in the distribution network.

The sustainable energy systems focus area of the MPP will work to improve research, education, and outreach in developing cost-effective robust and implementable energy strategies to address climate change, energy security, and other sustainability criteria.

The primary task for Year One (September 2006 to August 2007) has been building the team of Portuguese and MIT faculty, staff, and students to launch sustainable energy systems activities. Workshops in Portugal in October 2006 (program launch) and November 2006 (energy industry workshop) introduced energy systems topics and goals to prospective partners, including the Portuguese energy industry, and allowed for more focused discussions among research and educational leaders on the details of the program, research topics, students, and resources.

Through a series of meetings on each of the research and educational elements, in January 2007 in Lisbon and Porto, participants further refined the near- and medium-term research and educational topics the sustainable energy systems team is pursuing. Fundamental to the January visits was the identification of graduate student research topics to be pursued in each of the research projects as well as the university, research lab, and departmental groups collaborating within and across these topics.

The first four research topics in the integrated energy systems theme focus on energy systems design and analysis, beginning with local, short time-step power network research (microgrids), followed by projects that broaden the scope of energy systems planning geographically, temporally, and with respect to the range of energy services and policies under consideration. These four projects are “book ended” by two projects that focus on specific energy technologies (e.g., wave/marine energy), and energy-environmental policies and regulations at Portuguese and European Union levels. MIT students are conducting preliminary work in three of these projects.

In the area of education, Instituto Superior Técnico, Technical University of Lisbon; Instituto Superior de Economia e Gestão, Technical University of Lisbon; Faculdade de Engenharia da Universidade do Porto; and the University of Lisbon have received approval to launch an integrated sustainable energy systems doctoral program (PhD), a diploma of advanced studies (DEA), the curricular step toward the PhD in sustainable energy systems, and a diploma of advanced education (DFA), beginning in fall 2007. The Portuguese universities are in the process of refining their collective offerings, especially for fall 2007. Key next steps are for MIT faculty to comment on the scope and timing of the course offerings, and volunteer curriculum and lectures to the effort, to aid the successful launch of the sustainable energy systems educational programs.

Bio-Engineering Systems

Efforts in this focus area will build on the research capacity existing in Portugal and develop emerging aspects of bioengineering, cell and tissue engineering, and bioprocess and computational biology.

The mission of the bioengineering systems focus area of the MPP includes excellence in education, research, impact on university–industry–government relations, and benefit to humanity.

In education, the goal is the highest quality graduate education programs offered jointly by three Portuguese universities with collaboration from MIT to prepare students to:

- Master fundamental understanding of physical, chemical, and biological engineering; computational systems; and medical technologies
- Understand the innovation path to translate academic research to practice
- Creatively solve complex problems and demonstrate innovative systems thinking
- Provide leadership in academia, industry, and government

In research the goal is an exciting and rigorous international research program that:

- Attracts the best students in Portugal, the European Union, and worldwide
- Offers opportunities in the areas of innovation, bioprocesses, tissue engineering, computational systems, biomedical devices and technologies, biomaterials and nanobiotechnology, drug development, and neuroscience
- Significantly affects human capital development, society, and the economy

The specific objectives of the bioengineering systems program are to:

- Promote new interinstitutional postgraduation training and opportunities aimed at educating a new generation of leaders in bioengineering technical innovation in Portugal
- Create new knowledge through research and development
- Promote industrial, health care, and environmental biotechnology education and research that makes it possible for new start-ups, which implement new models of interaction between universities and enterprises, government, and society

The measures of success of the program include the following:

- The level of new interinstitutional cooperation among Portuguese institutions
- The quality and type of the MIT participation in the implementation of new post graduation training and opportunities (participants, papers, presentations)
- The number and quality of the students in the postgraduate opportunities

During Year One, the bio-engineering area's progress was achieved in four main areas of activity: curriculum development, communications, student recruitment, and symposia and workshops.

- Significant progress has been made on all of our planned educational curricular modules. Syllabi and learning objectives for nine bio-engineering systems courses was completed.
- The bio-engineering systems educational program currently consists of four core modules and four elective modules. The three lead universities (Instituto Superior Técnico, Technical University of Lisbon; Universidade Nova de Lisboa; and University of Minho) and Coimbra have selected Portuguese faculty to participate in the spring 2007 offering of the Innovation i-Teams course at MIT to learn and then adapt innovation practices to the Portuguese culture. The innovation in bio-engineering systems course follows the very successful teach-the-teacher model in which MIT faculty will initially teach and work with the Portuguese faculty at MIT and then the Portuguese faculty will teach additional Portuguese faculty colleagues at their home institutions.
- All lead MIT and Portuguese faculty are in frequent and excellent communications. There have been five visits (four in Portugal and one at MIT) between MIT and Portuguese faculty to work on establishing collaborations, curriculum development, and finalizing education and research plans. All meetings have had significant faculty interaction.
- Student recruitment and announcements were completed in December and were finally approved by the Portuguese universities and the Faculdade de Ciências e Tecnologia on January 22, 2007. Recruiting students is a top priority and is proving difficult in the first year because of the late recruiting start and the lack of program awareness and marketing.
- Numerous workshops and curriculum meetings have been held on innovation, biomedical devices and biomaterials, and all the educational course modules.

Anchor Program

An integrative anchor program is also being developed and will feature research and curriculum development led by MIT's Engineering Systems Division. Research addressing fundamental issues in engineering systems such as complexity, uncertainty, large-scale system architecture, security, and sustainability will cut across the focus areas, providing coherence around emerging themes. Related curriculum development efforts on methodologies and fundamental system concepts will provide materials

that could be used in education programs in different focus areas. A video-conference seminar series will help sustain a cross-Atlantic research community of interested scholars and educators.

The program will involve MIT and Portuguese faculty, graduate students, postdoctoral associates, and research staff. Visiting appointments of faculty at MIT and in Portuguese institutions will enrich the collaboration. Portuguese graduate students will spend time at MIT as visiting students and Portuguese students will be encouraged to apply to MIT for graduate degrees. The collaboration will involve opportunities for a significant number of professionals.

To develop the program in Portuguese institutions it is expected, besides the involvement of their faculty, that new contracts with invited professors and postdoctoral researchers with recognized merit on an international basis will be established to reinforce their education and research capability. This will involve about 14 new professorships and 18 postdocs annually in the program. The program will also involve about 35 new graduate students and 80 new professional master students annually in Portuguese institutions.

The program envisages the collaboration of students, researchers, and professors of Portuguese institutions with research teams at MIT, where the “Portugal Program at MIT” will be developed, involving around 38 professors, 15 postdocs, and 46 graduate students at MIT annually. MIT will also be available to receive up to 33 graduate students and 15 researchers/professors from Portuguese institutions visiting MIT each year. All MIT professors, researchers, and PhD students will have a coaffiliation with a Portuguese institution.

Faculty at the Engineering Systems Division were invited to submit brief proposals for funding in engineering systems. Fourteen proposals were received and were discussed and evaluated by the MIT focus area leaders. The most promising proposals were identified and in several cases it was suggested that proposals should be combined and the faculty should work together. The proposals under consideration were sent to MPP Portugal director Paulo Ferrão for his review and comment.

In spring 2007, commitments were made to nine separate proposals. The program continues to work with these faculty to refine budgets, work plans, and deliverables for these projects, including research, curriculum development, and textbook development.

On the Portugal side, a national request for proposals is being prepared. It will constitute the process by which potential Portuguese collaborators on these projects are identified.

Green Car Project

A flagship project on green cars is under consideration. The green car would develop the vision of a new niche car with the potential to be manufactured in Portugal. The green car, a new-generation, light-duty vehicle designed for sustainable urban environments, would be the basis for a new mobility concept that would be tested locally in a real urban environment. The proposal for Year Two is to develop the concept for the project

and the potential for the MPP to make a strong contribution in this area. Future activities will depend on the preliminary evaluation of the concept and potential.

Educational Innovation and Excellence Project

This project is in the very preliminary stages of development. The overarching goal is to have a project that is cross-cutting and visible with a clear educational benefit to Portugal, with the specific objectives of demonstrating and implementing improved facilities and procedures for quality teaching and enhanced learning. The effort would be devoted to building or redesigning one classroom at each university with accompanying high-visibility workshops directed at enhanced teaching methods.

A flagship project must have the active support of Portuguese industry. A principle reason the green car project is under serious consideration is that several companies have expressed interest in participating and possibly funding the effort.

Anchor Program Outreach Project

The program is considering holding two workshops in conjunction with Portuguese leadership in the second semester in the European Union. The first would be on engineering design and the second would be on effective interdisciplinary cooperation.

The program is also planning to hold the Second Engineering Systems Symposium in Lisbon sometime in 2008. The first symposium, held at MIT, was an important event that attracted several hundred participants. It was the first major conference to introduce engineering systems concepts.

Program Budget

The anticipated total public budget for the first five years of the MIT-Portugal partnership in engineering systems amounts to around 65 million euros (US \$82 million), from which 33 million euros are to fund activities at MIT (US \$41 million) and 32 million euros are public funding to Portuguese institutions. In addition, private funding will be used to support activities in industrial affiliates and to support advanced professional education programs.

Annual Plans

The specific activities to be undertaken by MIT and the Portuguese consortia are specified in the annual plans. Since the projects involve both MIT and Portuguese institutions, the successful execution of joint activities requires each side to carry out its contractual responsibilities. The MIT annual plan will focus on those activities MIT will undertake, and the Portuguese annual plan will focus on the activities by all the Portuguese institutions involved in each focus area. The Portuguese organizations involved in the MIT-Portugal collaboration explicitly acknowledge their institutional commitment to the overall program and the specific activities in the annual plan by means of a written commitment, on which MIT may rely, to participate in the MIT-Portugal collaboration through collaborations with MIT in the focus areas. These commitments specify how each institution will contribute to the overall program in general and to specified projects in particular.

Governance

The program governance structure includes a Program Governing Committee responsible for policy oversight with respect to overall objectives of the relationship as well as approval of the annual plan and budget allocation for the proposed activities in the annual plan; a Program Operating Committee responsible for developing and initially approving annual plans in the focus areas; and an External Review Committee, which will review and comment on the annual plan and evaluate the program based on the specified program objectives.

The Program Governing Committee and Program Operating Committee, simultaneously with their respective review and approval of MIT's annual plan, apply the same review and approval process to the annual plan of the Portuguese institutions that are committing to collaborate with MIT on a project or program.

The External Review Committee, which meets at least twice each year, consists of distinguished external advisors with expertise in the focus areas and has an important role in the development of the program. Its independent review includes recommendations about alterations in the annual plan and budget to support achievement of the overall objectives of the MIT-Portugal collaboration.

Industrial Affiliates

Each of the thematic focus areas will involve a new companion effort, MIT-Portugal industrial "affiliates" with the goal of fostering new research consortia in collaboration with MIT, leading to new frontiers of trans-Atlantic collaboration in science and technology. EDAM will launch the first affiliates program with a set of leading companies in the automotive sector, including VW AutoEuropa, the largest car assembler in Portugal, and major automobile-parts manufacturers.

Leadership

The MIT program director is Daniel Roos, professor and founding director of the Engineering Systems Division. The Portuguese program director is Paulo Ferrão, professor at the Instituto Superior Técnico, Technical University of Lisbon. Both will be assisted by a team of joint coordinators for each focus area, as follows:

EDAM:

- Joel Clark and Chris Magee, professors at MIT, Engineering Systems Division
- António Cunha, professor in the School of Engineering, University of Minho

Energy Systems:

- David Marks and Steve Connors, professors at MIT, Engineering Systems Division
- Paulo Ferrão, professor in the Instituto Superior Técnico, Technical University of Lisbon

Transportation Systems:

- Christopher Zegras, assistant professor of transportation and urban planning, Department of Urban Studies and Planning (replacing Joe Sussman, professor at MIT, Engineering Systems Division, now on sabbatical)
- José M. Viegas, professor in the Instituto Superior Técnico, Technical University of Lisbon

Bio-Engineering Systems:

- Dava Newman, professor at MIT, Engineering Systems Division
- Manuel Nunes da Ponte, professor in the School of Sciences and Technology, Universidade Nova de Lisboa

Personnel

In October 2007, Joshua Jacobs joined the program as director of education and Renee Robins became director of program integration. In January 2007, MIT-Portugal hired Robin Lemp as assistant director of the program. In June 2007, MIT-Portugal hired Michelle Gaseau as director of communications for the program. Other personnel that joined the program in the last year include Beverly Kozol-Tattlebaum as administrative assistant II, Susan MacPhee as administrative assistant–visitor services, Flavia Cardarelli as administrative assistant to the bio-engineering systems focus area, Edward Acworth and Richard Roth as research associates for the EDAM focus area, Jeremy Gregory as research scientist for the EDAM focus area, Ken Zolot as senior lecturer in the bio-engineering focus area, and Stan Finkelstein as senior research scientist.

Dan 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/>.