

MIT Portugal

Sharpening Portugal's Competitive Edge



May 2012

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Industrial Affiliates

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Massachusetts Institute of Technology

Introduction

Letter from the Directors

Economic prosperity and societal progress depend increasingly on nations' ability to mobilize their "knowledge triangle": education, research, and innovation. Technological change and the global circulation of ideas, talents, and goods have led to the rapid advancement of emerging economies. The same factors have challenged those economies to maintain and increase their competitiveness.

Portugal has identified scientific and technological development as a national priority, and in 2006, joined with the Massachusetts Institute of Technology (MIT) to launch the MIT Portugal Program to expand the country's opportunities for long-term success in the globalized knowledge economy. This initiative was designed to strengthen Portugal's universities in four key areas: transportation, bioengineering, sustainable energy, and engineering design and advanced manufacturing.

During the first five years, the MIT Portugal Program's primary objectives have been to:

1. Develop world-class educational programs to train the next generation of Portuguese leaders in areas vital to Portugal's future.
2. Undertake cutting-edge research that contributes to the development of new knowledge-based industries and enables Portugal to move up the value chain in established industries.
3. Create a strong network among Portugal's universities to build excellence, achieve critical mass in research and innovation, and disseminate the benefits of collaboration.
4. Establish and foster university-industry ties that enable joint projects producing high-impact applied research.

5. Promote an innovation-and-entrepreneurship ecosystem that inspires an entrepreneurial attitude among students, drives technology transfer, and stimulates the establishment of new enterprises.
6. Enable Portuguese faculty and students to work and study at MIT, and benefit from MIT's integrated approach to learning and research.

Portugal recognized that international collaboration and mobility are essential ingredients of today's research. Portugal could benefit from the participation of a strong outside partner, such as MIT, which has specific expertise in innovation-driven education and research.

The MIT Portugal Program represents a unique opportunity to internationalize Portuguese higher education, research, and industry by:

- Attracting the best international students to Portuguese universities and companies.

Enabling students and faculty to work and study at MIT.

- Providing an international academic and business network that gives students, faculty, and executives access to global perspectives and opportunities.

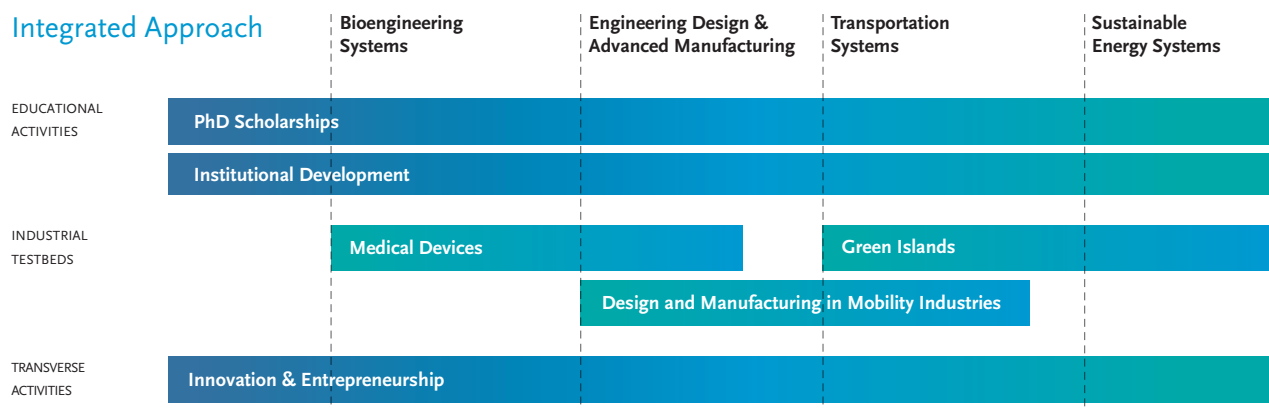
The program joins Portugal's institutions in a unique platform integrating education, research, and innovation, and serves to enhance Portugal's capacity for competing in today's global marketplace.

Professor Paulo Cadete Ferrão

Professor Dava Newman

Directors, MIT Portugal Program

Integrated Approach



EDUCATION



Raising the Bar for Portugal

At the heart of MIT Portugal's educational vision are seven graduate programs designed to provide world-class learning opportunities to the best Portuguese and international students. These programs combine exploration of cutting-edge scientific problems with real-world preparation for future employment.

Four PhD programs:

- Bioengineering Systems
- Leaders for Technical Industries
- Sustainable Energy Systems
- Transportation Systems

Two professional master's programs:

- Technology Management Enterprise
- Sustainable Energy Systems

One Master of Science (MSc):

- Transportation Systems

The MIT Portugal student body, selected from more than 2000 total applications since 2007, includes more than 30 percent internationals from 28 countries. Many are graduates of the most prestigious universities around the world. This program serves as a lighthouse of internationalization and competitiveness in Europe. It also incorporates a connection with the USA, as many students do research at MIT, benefiting from the fully-English educational program.

Innovation in Education

From the beginning, MIT Portugal's custom-tailored educational strategy has introduced many educational innovations to Portugal and the world. Seventy-one new courses were developed jointly by MIT and Portuguese faculty specifically for the program, combining Portugal's rich university tradition with MIT's best

practices. MIT Portugal courses venture boldly into new territory, such as Bio-innovation Teams, a course that trains students to assess the market potential of real examples of emerging biotech research. Going forward, the bio-innovation module will be transversal to all areas.

Courses are frequently led by multiple faculty and supplemented through video lecturing, combining expertise and research cases from different Portuguese institutions and MIT.

Some of the program's education tracks created curricula based on intensive 2-week modules. Students relocate among the country's institutions, experiencing the best schools, teachers, researchers, and labs for a unique learning experience.

Educating for Innovation

MIT Portugal has taken seriously the challenge of connecting engineering education to innovation, entrepreneurship, and industrial needs. All seven education tracks include economic and business aspects of engineering, as well as training in policy, innovation management, and leadership.

Designed with input from industry, the curricula have attracted a markedly different student body with more background and interest in industry work than those in comparable programs. Industry-based theses and internships provide a competitive advantage to more than 50 companies that partner with the MIT Portugal Program.

Globally Competitive

The MIT Portugal Program's advanced studies network is dedicated to creating a new generation of leaders with unique knowledge of engineering systems and innovation for technological systems, as well as a global perspective—leaders who can make a critical contribution to Portugal's economic growth.

This approach was developed by bringing together Portugal's universities, engineering schools, and research institutions in a dynamic national consortium for education and research. This high-profile network grants students access to the best teachers and research labs in the country, and brings together

the critical mass necessary for advancing Portuguese education and research, and making a global impact.

MIT Portugal has developed unique academic programs with shared curricula where students rotate among Portuguese universities for different courses of their curriculum. This design offers a globally competitive education and research experience with immediate access to the strong scientific network of Portugal's universities, further enriched by the best of MIT's expertise.

MIT Portugal in Numbers

CURRENT STUDENTS	349
PHD STUDENTS	307
AWARDED SCHOLARSHIPS	202
STUDENT COUNTRIES OF ORIGIN	28
FACULTY & POST-DOC CONTRACTS	23
STUDENT VISITORS AT MIT	162
MIT FACULTY INVOLVED	70
PORTUGUESE FACULTY INVOLVED	270
TOTAL PHD GRADUATES	31
TOTAL MASTER'S GRADUATES	134

INNOVATION

The goal of the MIT Portugal Program is to establish a lasting channel for innovation and communication across disciplines and with society.

The first phase of the MIT Portugal Program developed and refined innovation activities, adapting lessons from the MIT ecosystem and MIT's international alliances. These activities grew organically as experiments in the separate areas of the program. This pilot program has successfully engaged faculty and students, and attracted Portuguese industry and innovators.

Such an increase in interaction can diminish barriers between higher education and society, increase entrepreneurship, and produce economic development. Innovation activities have already resulted in the creation of new companies and new collaborations. The graphic below highlights some measures of the early impact of these activities.

During the next five years, the program will grow a higher-education ecosystem that embraces technology innovation and invites continuous exchange of talent, knowledge, and expertise with industry.

A trans-disciplinary curriculum of technology innovation courses and activities (theory, process, and practice) will strengthen communication across programmatic areas and will promote a "can-do" attitude among students, researchers and industry.

Successful innovation ecosystems maximize knowledge transfer and help translate technology-based ideas into economic value by a combination of individual drive, basic research, technology innovation, entrepreneurship, industry-academia collaborations, and the successful integration of highly educated innovators into the workforce.

Education-Innovation Pathways

Students will master and appreciate systems thinking through courses, research in test beds, and industry-sponsored projects structured according the program's areas of focus.

The MIT Portugal Program experience will be structured as two parallel pathways that all students will follow: systems education complemented by education, training, and experience in innovation (see diagram on page 4).

In the innovation pathway, students acquire trans-disciplinary skills to enhance their disciplinary expertise. Students will own their education, developing collaboration and communication skills through action-oriented courses, practice, and development of their own networks.

INNOVATION IN EDUCATION *Surveyed from 2008 to 2010*

- 60% of Bio-Teams projects bridged the gap**
- 6+ startups founded, two by students during their PhDs**
- 100+ students
- 4 startups, 3 new patents, 6 new academic-industry partnerships
- 2 commercialization projects
- 14 faculty trained on pedagogy



PARTICIPATION *Surveyed from 2008 to 2010*

- 1000+ people participated in the MIT Portugal Program's innovation ecosystem**
- Innovators, Industry experts, mentors, judges, catalysts, interviewees, audience, sponsors, speakers, etc.
- Many more learned about MIT Portugal Program's commitment to innovation through the media

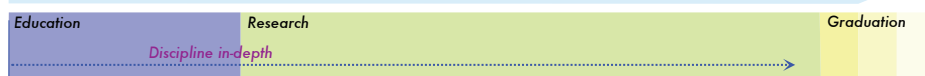


VENTURE FORMATION

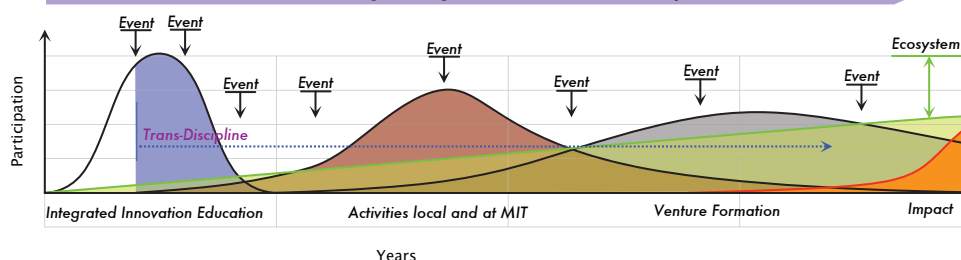
- More than €3B pitched**
- First-year alumni reported raising over €4M**
- As of August 2011, the Bio-Teams and the Innovation Entrepreneurship Initiative have raised €4.6M in prizes and investments combined.



MIT Portugal Program Academic Pathway



MIT Portugal Program Innovation Pathway



The parallel academic and innovation pathways as experienced by a PhD student. Top: The academic pathway: education—research—graduation, with deep concentration in a single discipline. Bottom: The innovation pathway showing how students navigate through innovation by participation in innovation courses and activities. For example, a student may try venture formation before participating in other innovation activities, locally or at MIT.

Designing, Coordinating, and Monitoring for Success

The proposed integrated approach to innovation and entrepreneurship includes:

- ▶ Transverse educational modules
- ▶ Venture formation activities, such as competitions
- ▶ A network of coaches to mentor innovators in training throughout their projects

A new center will coordinate the activities along the innovation pathway and across program areas. In addition, the center will monitor the emerging innovation ecosystem, maintain the community of coaches, coordinate with ecosystem and alumni, and develop new activities to further the connection between industry and innovation.

We built I&E capacity with four kinds of “interlocking” activities piloted from 2007-2011

COURSES

Innovation modules
MIT Portugal Innovation teams
Curriculum for IEI action-based go-to-market analysis
Cross-discipline Innovation BootCamp
Spin-off courses based on i-Teams pedagogy
Introduction to innovation lectures for pre-module

EVENTS

Idea-Spring
· After i-Teams and IdeaStream
Bio-Teams midterm and finals
IEI competition events, mixers, networking visits to MIT
Student/community initiated events

INNOVATION COORDINATION CENTER

VENTURE FORMATION

Innovation and Entrepreneurship Initiative (IEI) venture competition
· Designed to attract Portuguese and global entrepreneurs
· Increasing the visibility of the competition through award system
IEI catalyst and team formation programs
IEI US-based venture catalyst program

Ecosystem
Industry

Alumni
Measuring

BEST PRACTICES & TEACH-THE-TEACHER MODEL

Independent activities and events
Hosting scholars in innovation
Adapted innovation practices
· PI and catalyst guidelines
· Community outreach and engagement in courses and events
Coordination with University Technology Enterprise Network

INDUSTRY

Joint R&D Projects with Industry

AUTO CLASS PROJECT - Automatic classification and quality control for car tires

In 2009 the tire industry was in a crisis. The CEO of Mabor Lousado, the Portuguese subsidiary of Continental AG, identified a challenge: automatic classification and quality control for car tires. Such technology would help maintain Lousado's position among the best of Continental's twelve passenger tire plants.

Continental has connections with many universities and hosts many interns. However, it favored MIT Portugal's unique, holistic approach to academic-industry relationships. The partnership has resulted in three PhD research projects, and the company expects to leverage the research findings at other plants, as well.



SMARTGALP

The MIT Portugal Program has partnered with Portuguese utility company GALP Energia to develop a web portal to help consumers to monitor their energy consumption. The portal will also provide carbon footprint, personalized energy efficiency tips, and other information. The project started in 2011 with the installation of energy monitoring equipment in the homes and cars of 60 Lisbon-area residents.

By the end of 2012 the project will reach 120 households. Data will show whether consumers informed about their consumption will improve their energy efficiency and maintain the change as an enduring behavioral pattern.



EXTENDING LIFE THROUGH FASTER STEM-CELL DEVELOPMENT

This project with the Portuguese Institute for Oncology - IPO Lisbon develops expedited isolation and ex vivo expansion of mesenchymal stem cells (MSCs). It focuses on using MSCs in the treatment of graft-versus-host disease (GVHD). A common complication of bone marrow transplantation, GVHD is a severe and fatal disease: the functional immune cells in the transplanted marrow recognize the recipient as "foreign" and attack immunologically.

Eight patients have already benefited from this work, three with acute GVHD, one with extensive chronic GVHD, and four with other diseases treatable with MSCs.

SCUSSE - Smart Combination of passenger transport modes and services in Urban areas for maximum System Sustainability and Efficiency

This project with industry partner Geotaxis analyzes how new urban transport solutions interact with traditional transport modes and fit with current travel patterns and lifestyles.

One result, a shared taxi solution, presents a high implementation potential, showing an average 20 percent cost reduction for shared taxi riders, a potential win-win-win for passengers, operators, and society. The project's models significantly expand the ability to characterize transport supply and demand with detailed spatial-temporal resolution that allows for the space and time matching required for shared transport.

MIT Portugal Startup Companies

CELL2B is an early-stage biotech company that develops life-saving cell therapies for immune inflammatory diseases that affect more than 20 million people and lead to 3 million deaths per year. Effective treatments had not previously existed for these diseases.

Cell2B's ImmuneSafe® can treat millions of patients suffering from graft-versus-host disease, organ rejection, ulcerative colitis, rheumatoid arthritis, acute liver failure, and fulminant sepsis.

Cell2B has developed and applied ImmuneSafe to patients for three years. The core team includes four MIT Portugal Program PhD graduates from Instituto Superior Técnico, Lisbon, and MIT.



www.cell2b.com

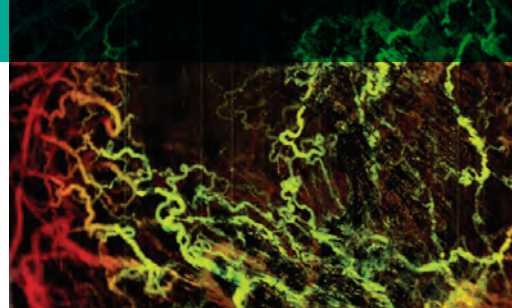
SILICOLIFE is a spin-off from the MIT Portugal Program in bioengineering that creates computational biology solutions for the life sciences based on bioinformatics and systems biology. Its main focus is the development and commercialization of optimized microbial strains for the production of specific target compounds such as bio-fuels, food ingredients, or bio-polymers.

Two of SilicoLife's founders participated in the MIT Portugal Program Bio-Teams, where they explored how to market mathematical and computational tools developed at the bioinformatics and systems biology group at the University of Minho.



www.silicolife.com

BIOENGINEERING SYSTEMS



Stem Cell-based Therapies

The “Mesenchymal Stem Cell-based Therapies” project applies cross-disciplinary approaches to establish safer and more efficient methods to isolate and grow stem cells through optimization of culture conditions, reduction or elimination of animal-derived components, and controlling microenvironmental factors affecting cell growth.

The team is evaluating the importance of three-dimensional scaffolds to sustain cell adhesion and proliferation. These scaffolds could ultimately be the basis for bioreactor design for clinical-scale culture of human mesenchymal stem cells.

Participants include MIT Portugal principal investigators Cláudia Lobato da Silva and Joaquim Cabral, both from Instituto Superior Técnico (IST), and Sangeeta Bhatia (MIT).

Tissue Regeneration

The “Regeneration of Ischemic Tissues by Transplantation of Human Stem Cells and Biomaterials” project is developing approaches for the regeneration of cardiac muscle after myocardial infarction (heart attack). Cardiovascular disease remains the number one cause of death in the western world, accounting for an estimated 960,000 deaths per year in the USA.

Many patients who survive a heart attack develop a chronic, progressive deterioration of the heart muscle and restricted blood supply called ischemia. About 2.4 million patients suffer from this pathology in the USA.

Recent clinical data indicate that cardiac function may be improved with the application of stem cell therapies. This project is testing several strategies. One involves the transplantation of progenitor cells isolated from human cord blood, bone marrow, or human embryonic stem cells in three-dimensional scaffolds. Another uses cardiac patches to deliver biomolecules.

A related goal of this cross-disciplinary project is to use stem cells and biomaterials for the regeneration of chronic wounds in diabetic patients.

Key participants include MIT Portugal principal investigators Lino Ferreira and Eugénia Carvalho, both of Centro de Neurociências e Biologia Celular (CNC) in Coimbra, and Robert Langer (MIT).

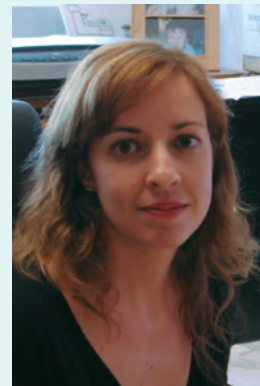
Bioengineering Affiliates

In the Bioengineering Systems research area, thirteen companies have become industrial affiliates of the program. These companies work in fields such as industrial biotechnology, the food and beverage industry, drug development and regenerative medicine. These companies support the program's educational goals in several ways:

- ▶ Industrial laboratory rotations: the bioengineering PhD program includes laboratory rotation modules. For the last two years, the call for research topics was opened to MIT Portugal industrial affiliates. In each year, students selected two of the rotations with affiliate companies, Frulact and Bioalvo, gaining direct exposure to industrial environments.
- ▶ PhD in an industrial environment: last year one bioengineering PhD student applied for and secured a doctoral grant from FCT that allowed co-financing of her PhD at Bioalvo.
- ▶ Bio-innovation teams (Bio-Teams): these groups of first-year bioengineering systems students and their advisors devise go-to-market strategies for emerging technologies being developed in Portuguese research labs.

FACULTY PROFILE

Isabel Rocha is an assistant professor in the biological engineering department, University of Minho, Portugal. She has a PhD in chemical and biological engineering and a post-doc in systems biology. She has established a research group in metabolic engineering, systems and computational biology at the Institute for Biotechnology and Bioengineering, and has published books, 47 papers in international journals, and 31 papers in international conferences. She has been responsible for the supervision of fourteen PhD students. Isabel also launched and now leads a new master's program in bioinformatics. During 2007 she was a visiting scholar at MIT.



As leader of the Bio-Teams program in Portugal she received the first Innovation in Education Award from the MIT Portugal Program and the Luso-American Development Foundation. She is also one of the founders and the chief scientific officer of the spin-off companies Biotempo and SilicoLife.

BIOENGINEERING SYSTEMS

The industrial affiliates program provides students with a network of industrial contacts and experience with entrepreneurship. Several industrial affiliates (Alfama, Bioalvo, Biotrend, Biotempo, Biotecnol, and Stematters) have participated in educational modules and in Bio-Teams events, such as IdeaSpring, the Cantanhede conference, and midterm and final presentations at Minho and Lisbon. Several other actions were taken in response to new realities emerging in the business environment:

- ▶ Additional companies initially not affiliated with MIT Portugal have collaborated on MIT Portugal projects (e.g., PLUX Wireless Biosignals and Hovione).
- ▶ MIT Portugal faculty and students have launched start-ups Matera and Cell2B.
- ▶ BioMode S.A. and SilicoLife researchers have recently submitted projects to Bio-Teams.

Most Portuguese companies in the field of bioengineering are small- or medium-sized. They are nonetheless drivers for technology transfer between academia and the marketplace, high-tech job creation, and economic growth. Best practices, taken from the “MIT Innovation/Entrepreneurship (I/E) Ecosystem” in Cambridge, USA, and MIT structures such as the MIT Industrial Liaison Program, could be adapted to the Portuguese case, providing an international network for access to funding, customers, and potential exit strategies for investors. In bioengineering, young companies focused on taking specific technologies to market are often acquired by and integrated into larger corporations.

STUDENT PROFILE

Federico Cismondi Bioengineering Program PhD candidate Federico Cismondi is conducting research on modeling clinical data in order to optimize the use of resources in patients' health care. Within the MIT Portugal Program, Federico has been able to work with a wide range of professionals with different scientific and operational backgrounds: medical doctors, nurses, epidemiologists, statisticians, information technologists, and people from business and management.



Collaborations with research groups in Portugal, the United States, and the Netherlands resulted in several publications in journals and international conferences, which could lead to needed changes in health care delivery. In addition to his own research, Federico is currently working on a private enterprise project with scientists from Portugal and other European countries.



Medical Devices

Portugal currently spends about ten percent of its gross domestic product on health care. This percentage is expected to increase with an increasing proportion of aged population, which will likely double by 2050.

The creation of the Health Cluster Portugal (HCP) [www.healthportugal.com] reflects the growing importance of medical devices in Portugal. HCP is a private initiative bringing together more than one hundred members: universities, R&D institutions, hospitals, public agencies, and companies in the sectors of medical devices, pharmaceuticals, biotechnology, and others. It aims to “turn Portugal into a competitive player in the research, design, development, manufacturing and commercialization of health-related products and services, in selected market and technological niches,

targeting the most demanding and relevant international markets...”

The medical device sector receives a great deal of attention within HCP, and the MIT Portugal Program has already made significant contributions in this area. These include the development of a smart stent graft implanted by minimally invasive therapy and a novel ankle-foot orthosis to help patients recover lost mobility or to master movements they were previously unable to make.

The smart stent SenseCardioHealth project has progressed from concept selection to material characterization to fabricating a flexible sensor that also provides telemetry. The collaboration includes Hospital S. João (Angiology and Vascular Surgery Division) and two industry partners: stent-graft

EDAM

Competitive strategies for Portuguese companies require the integrated development of innovative products and manufacturing processes that offer new and value-added solutions, reduced production costs, and provide efficient access to markets.

The mission of **Engineering Design and Advanced Manufacturing** (EDAM) is to develop a new paradigm in Europe for engineering research and education based on an application-driven approach, knowledge-based manufacturing, and competitive product development.

EDAM's strategy is based on an engineering systems approach that integrates engineering, management, design, and manufacturing, providing knowledge vital to the industries that are fundamental to Portugal's future. EDAM has developed a research program built upon strong industry interactions with firms that have experience in product development, design and R&D.

PhD students in the Leaders for Technical Industries (LTI) specialty occupy the core of EDAM research activities. Their theses are based on EDAM research topics and they work with the whole range of EDAM participants: industrial partners, Portuguese faculty, MIT faculty, and MIT students.

FACULTY PROFILE

Lia Patrício, assistant professor in the Industrial Management Division at Faculdade de Engenharia da Universidade do Porto (FEUP) has conducted research in the services, interaction, and experience-design fields for a number of years.

In the EDAM focus area Lia has been teaching the engineering systems research methods course. She also has led the EDAM project Designing the Travel Experience, a project that emphasizes the social and human aspects of product design and development within the tour bus production industry. The project is unique because it brings together several members of a value chain that do not normally interact, in order to develop methodologies for incorporating customer experience factors into product and service design. Lia has made important contributions to this project by implementing multidisciplinary engineering systems research methods not commonly used in traditional engineering research.



manufacturer Cook Medical and textile manufacturer Falcão Fibras, as well as technical advice from the Malmö Vascular Center, Skånes University Hospital, Lund, Sweden.

The innovative powered ankle-foot orthosis will aid individuals who have reduced mobility and neuromuscular disabilities. It will improve locomotion and enhance muscular rehabilitation, providing wearable sensing and incorporating features with power, size and weight benefits. Participating in the research effort are three current MIT Portugal Program PhD students, other graduate students, postdoctoral associates, and faculty from multiple Portuguese universities and MIT, as well as a Portugal biomedical start-up (PLUX Wireless Biosignals).

New-generation medical devices, biosensors, and assisted-living solutions include devices and systems for diagnostic and/or therapeutic purposes, based on built-in "intelligent" functionalities at the physical or biological level.

Potential applications include:

- Hybrid human-machine systems: prostheses and orthoses, algorithms and sensors
- Musculoskeletal loading and exercise systems, exoskeletons, and human modeling
- Cardiovascular systems and components
- Micro and nanotechnologies for medical devices

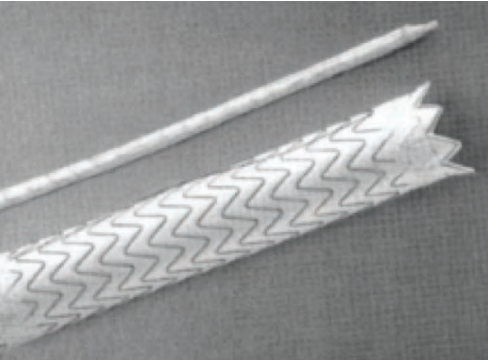
- Nanobiosensors and biochips
- Targeted drug delivery biosystems

The MIT Portugal Program and the HCP are motivated to launch this research network bringing together the major national hospitals, industrial players, and national scientific and technological institutions, and promoting the development of new high-added-value products based on innovation in the health-care sector.

The research application areas, selected after discussions with major Portuguese industrial leaders and associations (e.g. AEP—Associação Empresarial de Portugal), are (1) the mobility industries (e.g., automotive and aeronautics) and (2) the health sector (medical devices). Other opportunities associated with the efforts of entrepreneurs and graduates involved in the Partnership will also be considered.

Design for New Functions

The research areas and specific products described above all have the potential to become important growth sectors for the Portuguese economy. However, there are certainly other technological products that may also be well-suited for Portugal. An extensive effort will be made to find other opportunities for developing research capabilities in the area of materials and design-inspired products. This effort will involve working with industry leaders in Portugal and Europe, and will include an assessment of key areas of existing research capabilities in Portugal that will benefit from the support of MIT Portugal and its industrial partners. The ultimate selection of a technology sector as a focus for the materials and design-inspired products research area of MIT Portugal will be a balance between industrial demand and the capabilities of MIT Portugal to supply the research.



Advanced stent graft for smart cardiovascular device

STUDENT PROFILE

Rui Carreira joined the Leaders for Technical Industries doctoral program in 2007, bringing eight years of experience working in industry and an MSc in industrial engineering from FEUP. Rui worked with Lia Patrício on the EDAM project Designing the Travel Experience for his thesis work in the LTI program. In particular, Rui developed methods for eliciting and incorporating customer experience requirements into product design and applied them to bus interior design. Under the scope of this project, the improvement of the integration of product and service components into the design of the overall offering was also addressed.



Rui Carreira completed his thesis in April 2012 with the title “Designing the travel experience—identification and incorporation of passengers’ experience requirements in new bus body development.”

Design and Manufacturing in Mobility Industries

New mobility concepts and paradigms, including those associated with sustainable transportation, challenge the research and engineering communities to develop novel design and manufacturing solutions, particularly in the area of in-vehicle power systems, such as propulsion systems, power train, and energy storage, conversion, and management.

For most of its century of widespread use, the automobile has been characterized by the mobility and driving experience it supplies, not by the means for achieving that mobility. The electric vehicle, however,

is defined by its power system. Today, the fact that a vehicle is electric is a selling point, a “customer perceived feature” in marketing parlance. In the long run, though, the “electric” feature will become irrelevant to the consumer.

Technological innovations are needed to manage the customer’s needs and desires for mobility and driving experience. New methods for delivering motive power present opportunities to reshape the character of mobility. For example, range and acceleration capabilities will be shaped not only by innovative traction power

systems, but also by the ways in which energy is stored and distributed. The power budget will necessarily become a fundamental design element and organizing constraint for vehicles.

Finally, enhancing consumer experience offers a host of technical challenges. For example, a vehicle’s design may allow integrating it into a “smart grid,” not only to recharge the vehicle using off-peak power, but also to use the vehicle, when connected to a household electrical system, to provide load leveling during periods of peak demand.

TRANSPORTATION

Transportation Systems

The Transportation Systems program's research has focused on integrated systems, intelligent transportation systems, air systems, and high speed rail systems. The program emphasizes cross-cutting research and interdisciplinary collaboration. An emergent research strand on inter-modal mobility strategies has examined issues across the Transportation Systems spectrum.

The Transportation Systems research model maintains a cohesive focus on the core research topics of airline networks, high speed rail development, and integrated transportation systems, while simultaneously allowing projects to take advantage of newly emerging opportunities and areas of interest, including data-mining, sustainable energy, and governance issues.

Newer projects study electric vehicles, biofuels, and the connection between infrastructure strategy (such as the development of high-speed rail) and economic growth. The newer crop of projects has attracted increased involvement from additional Portuguese universities.



The next generations of aircraft, too, will present new design and manufacturing challenges suited to a systems approach. While the airline industry seeks to improve fuel economy and reduce operating costs, passengers in the competitive marketplace expect improved comfort and added amenities. The Engineering Design and Advanced Manufacturing program's research approach incorporates social science methods into the design process, in this case to discover and include consumer preferences.

Highlights of the research results for individual projects include:

- ▶ SOTUR: Development and calibration of two integrated land-use/transportation simulation models.
- ▶ SCUSSE: Assessment of new transportation modes and services, together with the implementation of parking enforcement policies and dynamic congestion schemes.
- ▶ CityMotion: Prototype of the Portugal Brisa A5 Motorway online laboratory and analysis of preliminary results on the quality of traffic estimation and prediction.
- ▶ CityMotion: Visualizations of mobility patterns for Lisbon and development of density matrixes, origin-destination matrixes, and clustering results involving different transportation modes.
- ▶ AirNETS: Four different network models, which will soon have impact on airline network management in Portugal.
- ▶ HSR-LCC: Numerical evaluation of dynamic loads on railway tracks for high-speed lines.
- ▶ HSR-RISK: Enhanced geology decision-making model to predict/avoid major accidents during tunnel construction.

FACULTY PROFILE

Carlos Lisboa Bento is an aggregated associate professor at the University of Coimbra. His recent research has been in the convergence of artificial intelligence and ubiquitous computing. He has projects in the areas of intelligent transport systems and energy sustainability for smarter cities and has approximately 100 international publications. Carlos is principal investigator for the CityMotion project (a real-time fusion of mobility data). In addition, he also coordinates a large national project in the area of Intelligent Transport Systems TICE, Mobility, and project CROWDS—a three-year research project funded by Fundação para a Ciência e Tecnologia. He is the founder and director of the Ambient Intelligence Lab of CISUC (AmIlab), and head of the Laboratory of Informatic Systems at Instituto Pedro Nunes, an institute for technology transfer.



TRANSPORTATION

Newer projects include:

- ▶ EXPRESS (Exploration of Portugal's high speed Rail and Economic development Strategy Solutions)
- ▶ Capturing uncertainty in biofuels for transportation—resolving environmental performance and enabling improved use
- ▶ Economic and environmental sustainability of electric vehicle systems

Partnerships and applications continue to develop:

- ▶ MISC: Partnerships with the company BioDevices, which is providing clothing/technology integration, and RadioTaxis, a taxi company that will enlist drivers to test a project prototype
- ▶ SAVED: Simulation model including a mix of safe drivers and hazardous drivers and the rate of accidents
- ▶ AirDev: development of a simulation model of interactions between airport and stakeholders to support the analysis of different business models
- ▶ Leveraging the research into a broader international consortium, including partners across Europe and MIT research in Asia and elsewhere
- ▶ TICE.mobilidade: New research on data-based mobility services, emerging directly from the CityMotion project
- ▶ The Bus Rapid Transit Center of Excellence, an international research collaboration

Industry, Government and Academic Impact

Engagement with private partners in several projects has led to advances in industry and improvements to Portugal's mobility, for example:

- ▶ The AirNETS project has had success in partnering with airlines and aviation officials to adopt network models for practical applications. Potential partners are interested in the possibility of near-term congestion reduction and mobility improvements.
- ▶ CityMotion's work on innovative, data-based operational techniques is very close to having real-world impact on Portugal's transportation and infrastructure management, particularly through the highway provider Brisa and the involvement of several companies.



STUDENT PROFILE

João Pita is in the final stage of his PhD in transportation systems at the University of Coimbra, supervised by Professors António Antunes (University of Coimbra) and Cynthia Barnhart (MIT). His main area of research is air transportation, particularly the application of optimization methods to flight-schedule and fleet-assignment problems. During his PhD studies he spent one year at the MIT International Center for Air Transportation. In addition, João has been very active in academic activities as a student representative. Currently he is a European expert on quality assurance and has participated in several conferences and workshops about the Bologna Process for academic quality assurance.



Green Islands

The Azores, an archipelago of nine islands in the Atlantic, provides a real-world laboratory where the MIT Portugal Program is collaborating with the Regional Government of the Azores, the University of the Azores, and local energy suppliers to investigate ways of dramatically reducing fossil fuel use and greenhouse gas emissions.

The operational constraints and economic realities the islands face today reflect those mainland Portugal and the rest of the world will face tomorrow. This makes the Azores an ideal place to conduct cutting-edge research on energy and transportation systems.

SUSTAINABLE ENERGY

Sustainable Energy Systems

Sustainable Energy Systems focuses on the use of new models, coupled with high resolution data in space and time, to design and operate “smart” energy technologies and systems. The main themes of the research so far have been in energy planning, including economics, sustainable built environments, and smart energy networks. Each theme includes innovative and overlapping research topics and technologies, such as:

- ▶ Policies to promote cost-effective investment in renewable energy technologies.
- ▶ Design of buildings and neighborhoods to dramatically reduce energy and other flows such as water and waste.
- ▶ Integration of electric cars, smart houses, and electricity storage into local and regional grids.

The new cross-disciplinary energy and transportation themes of integrated Green Island systems can use new technologies to dramatically reduce fossil fuel consumption in the Azores, and in integrated urban systems where real-time information from vehicles, homes and mobile devices allows optimizing transportation and energy services in cities.

New methodologies that use such data are a key aspect of the MIT Portugal Program research, and represent a major shift from traditional, static approaches offering only generic estimates of energy consumption, renewable resources, and transportation needs.

The Azores presents a natural test bed for designing and deploying integrated energy and transportation systems, whether on São Miguel with its geothermal resources or remote Corvo where fuel delivery can be challenging in the winter.

University of the Azores research has provided a baseline measurement of the islands’ energy needs, as well as the dynamics of the islands’ renewable resources such as geothermal, wind, solar, hydropower, biomass, and waste. Collaborative research has focused on how to use this information both strategically—long-term energy scenarios for the islands—

as well as nearer term strategies, such as “smart neighborhoods” and the introduction of “grid aware” electric vehicles.

Key insights from current research show many near-term benefits could result from implementing smart systems in the Azores, such as electricity storage, smart variable charging of electric vehicles, and efficient homes and businesses that respond to real-time island energy conditions. These technologies can help the islands’ power grids operate more smoothly now, thereby saving money and reducing emissions.

The MIT Portugal Program is designing the next phase of Green Islands research

to build on these insights, in collaboration with government, industry, and academia, at local, national, and international levels. The integrated, focused work of the Green Islands Project can help Portugal become a world leader in innovative, cost-effective, environmentally responsible energy and transportation research.

FACULTY PROFILE

João A. Peças Lopes is full professor in the Faculty of Engineering of University of Porto, where he teaches at the undergraduate and graduate levels. He is director of the sustainable energy systems PhD program at FEUP. He is also currently a member of the board of directors at the Institute for Systems and Computer Engineering of Porto.

João has worked on several EU-funded research projects relating to electric generation and electrical grids. His main domains of research include large-scale integration of renewable power sources (wind generation), power system dynamics, microgrids, smart metering, and integration of electric vehicles in electrical grids.



SUSTAINABLE ENERGY

Examples of innovative energy systems research include:

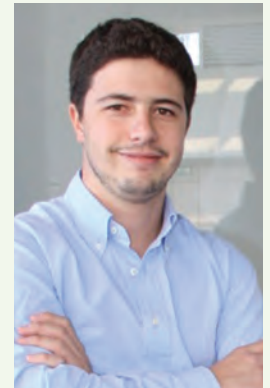
- ▶ Implementation of electric vehicles programs that cost-effectively meet transportation needs, while improving local and regional grid operations and overall environmental performance.
- ▶ Identifying when and where wind generation in the Azores is most valuable—not only where the average annual wind speed is highest, but where it is windy at the best time relative to the energy needs of an island's economy.
- ▶ Investigating the all-energy smart meter, which balances household or business energy demand with market conditions and distributed generation—including building-integrated solar, micro-generation, and vehicle-to-grid systems to maximize both end-use and network performance.
- ▶ Examining energy and material flows within and across city boundaries in support of research to integrate urban planning and “urban metabolism.” Partner cities Lisbon and Porto are helping identify opportunities for urban revitalization, long-term reduction in energy and water use, and decreased production of waste and greenhouse gases.

The design of future intelligent energy systems which are “green,” “smart,” and “efficient” requires an understanding of existing systems, including detailed characterizations of their energy and transportation networks, their supplies and demands, and understanding of the main factors influencing the evolution of those supplies and demands, including renewable resources, and socioeconomic and behavioral dynamics.

By integrating new and existing methodologies, aimed at not only the characteristics of new energy, transportation and information technologies but at how they interact with one another, innovative new approaches to meeting future energy and other service needs can be developed. To effectively confront these challenges, highly integrated, multi-disciplinary research teams are needed. Such research will need to explicitly address potential links between high resolution spatial and temporal information systems in both planning and operations, to meet the needs of future energy, transportation, water, and waste systems, as well as the needs of private enterprise.

STUDENT PROFILE

Gonçalo Pinto Mendes is a PhD student in Sustainable Energy Systems. As a finishing PhD candidate, Gonçalo has witnessed the evolution of the program over the last four years, and has been able to contribute to the success of the program, as well as take advantage of the opportunities it provides. He was able to showcase his research internationally, to access world-class education, and develop deep ties with industry leaders. Meanwhile, he has become part of the wide network of relationships and synergies, and the growing critical mass for innovation that is MIT Portugal. And, as one of the many students who show their entrepreneurial spirit by initiating projects or events, Gonçalo further participated as co-founder of the MIT Portugal Energy Club.



IMPACT

Global Recognition

In a recent independent assessment, the Finnish National Academy recognized MIT Portugal and its Portuguese sister collaborations as an excellent and commendable initiative, interesting to the whole European research area. The assessment called the program a model of good practice and applauded the program's many successes, including national collaboration, internationalization, and attention to quality.

The Academy found MIT Portugal to have a very solid success record with regard to the three goals of collaborative research projects, excellence in teaching and training, and effective commercialization/entrepreneurship.

A Sustainable Network

MIT Portugal has pioneered a globally unique model of collaborative education and research that unites Portugal's universities, industries, and government behind a shared agenda of excellence and innovation. On an institutional level, MIT Portugal has created strong, globally visible research clusters in key focus areas that are crucial for the future of Portugal. Students and faculty alike benefit from the dense consortium network and the high connectivity of the program with leading groups around the world.

Becoming a Model

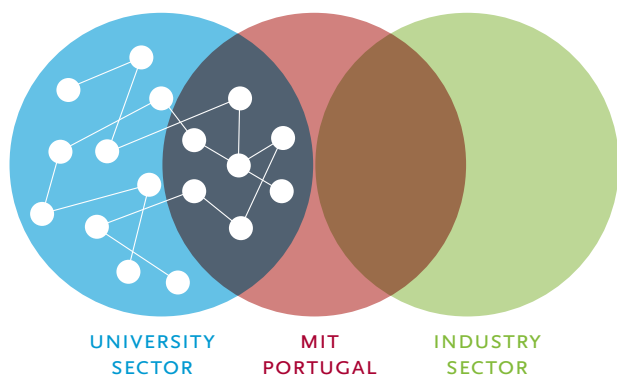
From its inception, MIT Portugal has strived to become a model international program where innovative research and educational programs from around the globe combine to address some of today's greatest technical, economic, and social challenges. It has been both the driver and the result of important ongoing reforms of the Portuguese higher education system.

The program has left its mark in curriculum design and innovative practices at Portuguese universities—a mark that other programs now seek to emulate. MIT Portugal faculty share their program experience and practices, while the program as a whole has provided incentives for forming clusters of excellence and creating broader systemic change.

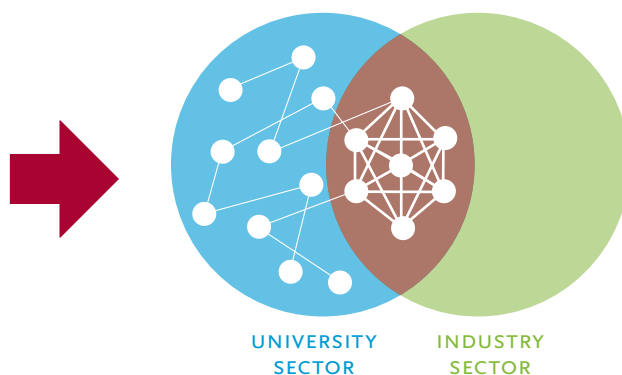
The international student body stands witness to the growing global visibility of Portuguese universities initiated by this unique transatlantic partnership. The MIT Portugal Program has added a distinctively Portuguese edge to the global science and innovation community.

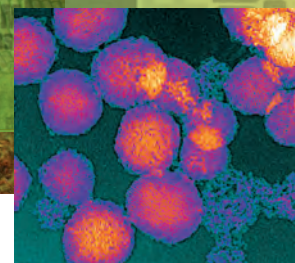
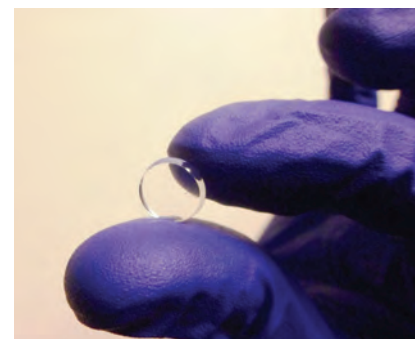


A Unique International Partnership



Critical-Mass University-Industry Consortium with Engineering Systems Core





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