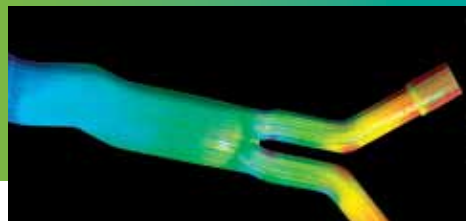
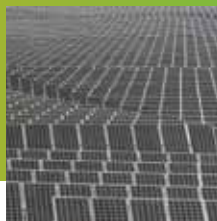


# MIT Portugal

*A Strategy Reexamined*

PUTTING **SYSTEMS THINKING** INTO ACTION  
THROUGH A RESEARCH AND KNOWLEDGE NETWORK  
THAT FOSTERS CHANGE AND VALUE



**JULY 2009**

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MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR



Massachusetts Institute of Technology

*Portuguese industry is reaping the benefits of a*  
**COMPETITIVE ADVANTAGE thanks to the widespread**  
*application of innovative* **SYSTEMS THINKING.**

**IN OUR VISION, PORTUGAL IS BOTH A WORLD LEADER IN TARGETED RESEARCH AT THE FRONTIER OF KNOWLEDGE IN SYSTEMS THINKING AND A CATALYST FOR FORGING STRONG, SUSTAINABLE PARTNERSHIPS BETWEEN SCIENCE AND INDUSTRY THAT ADDRESS IMPORTANT SOCIETAL CHALLENGES.**

JEFF KARP/EDWIN CHAN

PORTUGAL COULD NOT ASK FOR A BETTER PARTNER IN THE WORLD THAN MIT. WITH THIS ALLIANCE, OUR COMPANY IS GUARANTEED ENTRY INTO THE ENERGY SECTOR'S BIGGEST CLUB IN THE WORLD. THE COMPLEX WORK WE DO CONCERNS THOUSANDS OF ENERGY RESEARCHERS AROUND THE WORLD. WHOEVER HAS THE BEST INTERNATIONAL NETWORK GAINS AN ADVANTAGE — AND MIT IS NOW MOBILIZING ITS TROOPS TO HELP US FIND SYNERGIES RIGHT HERE.

**VIANNEY VALÈS**

CEO / SGC ENERGIA

FOR ME, THIS PROGRAM HAS BEEN A MIND-SHIFTING EXPERIENCE. I HAVE GAINED A NEW SET OF SCIENTIFIC AND EXPERIMENTAL SKILLS, BUT ABOVE ALL HAS BEEN WHAT I HAVE GAINED IN HOW I THINK AND APPROACH PROBLEMS. TODAY I FEEL LIKE A SCIENTIST AND AN ENTREPRENEUR, AND I HAVE ALL THE TOOLS I NEED TO FACE THE FUTURE.

**DAVID B. MALTA**

SECOND-YEAR PHD STUDENT / BIOENGINEERING SYSTEMS



THROUGH OUR COLLABORATION, THE MIT-PORTUGAL PROGRAM BRINGS NEW BLOOD AND PROVIDES NEW CHALLENGES TO THE VERY FAST AND IMPRESSIVE GROWTH OF PORTUGUESE SCIENCE AND TECHNOLOGY.

**JOSÉ MARIANO GAGO**

MINISTER OF SCIENCE, TECHNOLOGY AND HIGHER EDUCATION / PORTUGAL

THE MIT-PORTUGAL PROGRAM IS OUR LARGEST PROGRAM IN EUROPE, AND WE ARE GRATIFIED BY THE RESULTS. SEVEN NEW INNOVATIVE GRADUATE PROGRAMS HAVE BEEN DEVELOPED, JOINT RESEARCH HAS BEEN INITIATED, PORTUGUESE FACULTY AND STUDENTS ARE WORKING AT MIT, AND NEW UNIVERSITY-INDUSTRY RELATIONSHIPS HAVE BEEN FOSTERED IN PORTUGAL. WE'RE NOW POISED TO BUILD UPON THIS SUCCESS BY TARGETING THE MOST PROMISING AREAS OF RESEARCH.

**PHILLIP L. CLAY**

CHANCELLOR / MASSACHUSETTS INSTITUTE OF TECHNOLOGY

# ABOUT OUR PROGRAM



JUSTIN KNIGHT

**PORTUGAL HAS MADE** the rapid scientific and technological development of the country a national priority. In this context, the MIT-Portugal Program was launched in 2006 — grounding this development in connections that span national boundaries and oceans. The links we have made between the Massachusetts Institute of Technology, research universities in Portugal, and leading companies provide faculty, executives, and students with an essential global perspective. They give affiliated research centers and industry partners throughout Portugal access to advanced research in areas critical to the nation's future success.

The particular focus of the MIT-Portugal Program is systems thinking and the emerging field of engineering systems. We believe an understanding of systems thinking to be fundamental to the future of scientific and technological education and practice.

Bringing MIT and Portugal together offers many advantages. It provides the opportunity to develop this field of study in a European arena. MIT and its partner institutions in Portugal have significant capabilities in these areas, and Portugal's size and socio-economic characteristics make it an ideal platform to implement research results and demonstrate the value of systems thinking in finding flexible and sustainable solutions to complex, dynamic problems.

The revisited MIT-Portugal strategy presented here results from our close transatlantic cooperation since 2006, and has been refined in discussions with leading experts worldwide. In this booklet, you will read about the vision we have for Portugal and the five pathways in the MIT-Portugal Program mission to achieve that vision. We give you a snapshot of the education programs we have built and describe some representative examples of research and application projects in our targeted areas of endeavor. These include sustainable energy and transportation systems, stem cell engineering for regenerative medicine, and materials and design-inspired products, with an emphasis on new mobility and electric systems.

At MIT, we view Portugal as our key European partner. In Portugal, we see MIT as providing a model of how to implement effective university industry initiatives and as a resource to help develop world-class academic programs. This is a win/win for all of us.

We have set ambitious goals for the future. Together — through the MIT-Portugal Program — we are demonstrating the importance of systems thinking to a nation's economic development.

## PROFESSOR PAULO FERRÃO

DIRECTOR,  
MIT-PORTUGAL IN PORTUGAL

## PROFESSOR DANIEL ROOS

DIRECTOR,  
MIT-PORTUGAL AT MIT



CHRIS TOPHER HARTING

# PORTUGAL AND MIT— WHY THIS COLLABORATION?

*Through a unique and robust public-private partnership, MIT-Portugal leverages the research and educational capabilities and expertise of one of the world's foremost engineering and scientific institutions.*

PORTUGAL HAS MADE A STRONG COMMITMENT to strengthening and internationalizing the nation's capabilities in science, technology, and higher education. The nation's efforts are targeted not only at making Portugal an interesting place to do research at world-class institutions, but at making Portugal an attractive and relevant partner for international collaborations in the knowledge-based, globalized economy. And the efforts have paid off: the country recently achieved the European Union average for researchers per thousands in the workforce and has had the largest rate of growth in R&D investment in recent years. Ultimately, the goal is to

increase Portugal's social and economic well-being by giving Portugal a competitive advantage in international science- and technology-based innovation — benefits that can be enjoyed by all its people.

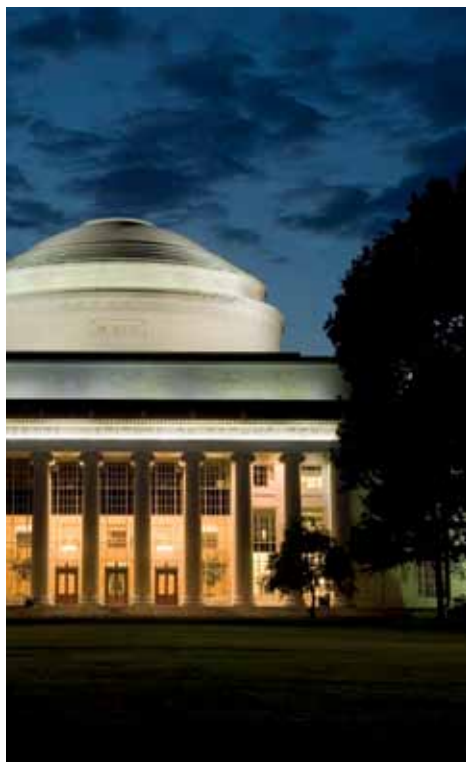
To those ends, the MIT-Portugal Program was born. A large-scale international collaboration, our program involves strategic investments in people, knowledge, and ideas, driving structural changes in the advanced training of human resources and the reform of universities.

Launched in October 2006, MIT-Portugal is already demonstrating the value of such investments. Through a unique and robust public-private partnership, we leverage the research and educational capabilities and expertise of one of the world's foremost engineering and scientific institutions — the Massachusetts Institute of Technology — to enrich some of Portugal's finest research universities, its outstanding research laboratories, and many of the country's and Europe's most forward-thinking companies. The institutions and laboratories that are part of the MIT-Portugal Program interact directly with these companies, and students in our degree programs have opportunities to work on-site at these firms. Further, throughout the program and at every juncture, there is an ongoing effort to developing synergies that allow all of the MIT-Portugal partners — academia, industry, and government — to take

advantage of real-life research that can provide strategic benefits now.

We are fostering a true transatlantic and international partnership at the leading edge of the program's intellectual foundations, engineering systems and systems thinking. Engineering systems integrates management sciences, economics, and policy to achieve the best possible understanding, design, and implementation of the highly complex, technology-based systems on which society is increasingly dependent. Our particular emphases are on the urban metabolism for sustainable energy and transportation systems, stem cell engineering for novel therapies, and engineering design for new mobility systems.

MIT is a world leader in engineering systems, and Portugal's collaboration with MIT gives the country a competitive advantage in Europe and globally in this increasingly important field. The MIT-Portugal Program has helped enable the growth of internationally recognized centers of excellence in a variety of scientific and technological areas. These centers, through MIT-Portugal, are now associated in a growing research and knowledge network that allows Portugal to play a major role in developing systems thinking in Europe. The program has spurred a significant increase in private investment in research as more and more interesting, and successful, business cases have emerged from MIT-Portugal's efforts.



CHRISTOPHER HARTING



We look forward to the next phase of the MIT-Portugal Program, in which we will focus on high-priority projects. All of us have the same goals: advance science and technology, solve problems, and spur economic growth for Portugal and the wider world. We are pleased to see the program transition from a top-down, government-led initiative to a bottom-up program with strong university and industry participation.

—JOÃO SENTIEIRO

PRESIDENT, FUNDAÇÃO PARA A CIÊNCIA E A  
TECNOLOGIA (FCT)

# WHY SYSTEMS THINKING?



**MANY SCIENTISTS AND TECHNOLOGISTS** search for solutions by studying individual aspects, or pieces, of larger problems. They often devote great effort to isolating increasingly smaller pieces of the larger whole. Systems thinkers, though, expand the view from the small pieces to the bigger picture, view that bigger picture as a system, and explore the interactions within that system. When that system is complex and dynamic — as is true of the most difficult, daunting scientific and technological challenges the world faces today — the systems view can mean the difference between advanced, sustainable solutions and another round of failure.

Systems thinking makes it possible to handle increasing complexity and uncertainty. It is the way to deal with the rapid clockspeed of technological change. And it is at the very core of the MIT-Portugal Program, in the classroom and in our research projects. Our conception of systems thinking flows from the burgeoning field of engineering systems, an interdisciplinary field in which the Massachusetts Institute of Technology has played a pioneering role.

To understand complex systems, one must look at many phenomena that are not inherently considered to be about engineering, and that require scientific knowledge. So, as practitioners of Engineering Systems and systems thinking, we focus on engineering solutions that combine approaches from science, management, and the social sciences to take a long-term, lifecycle view of systems. We account for multiple stakeholder perspectives. We explore flexibility, robustness, scalability, safety, security, durability, sustainability, reliability, quality, recyclability, and maintainability — the “ilities” often left out of traditional analysis, but critical to developing lasting solutions.

*Systems thinking makes it possible to handle increasing complexity and uncertainty.*

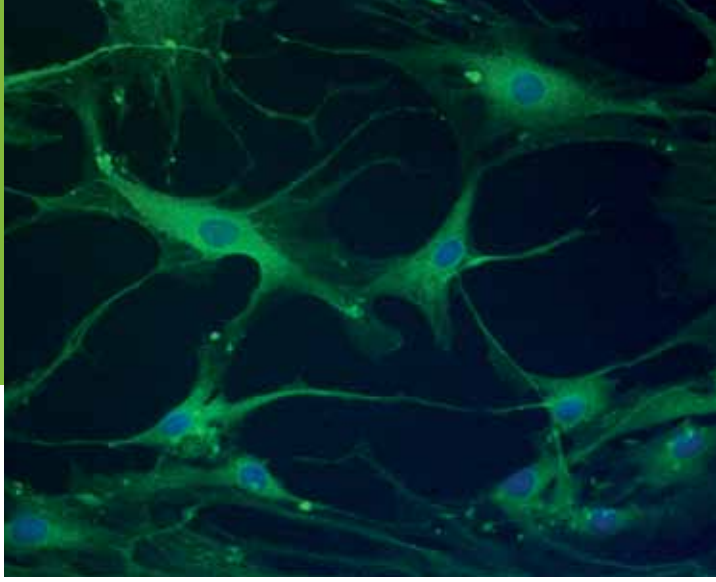
## THE COMPETITIVE EDGE

At every juncture, we are concerned with innovation and design — from a single piece of hardware to an urban transportation network — that will pay off with economic opportunities and benefits for Portugal. Our goal is nothing short of making Portugal a global leader in the real-world application of systems thinking by accelerating the adoption and implementation of best practices.

Systems thinking gives the MIT-Portugal Program a leading role in modern engineering and Portugal a competitive edge. It is an innovative way forward for Portuguese industry, Portuguese

science and technology, and Portuguese higher education. The program gives MIT a unique opportunity to develop new systems thinking and demonstrate its application at a country level.

Through MIT-Portugal, we are helping propel the nation, boldly, onto the international stage. As our vision is realized, Portugal will become a destination for the most advanced higher education and research, and a crucial center for developing sustainable systems solutions that meet the challenges of the twenty-first century.



## Our systems thinking research focus

THROUGH THE MIT-PORTUGAL PROGRAM, RESEARCHERS AT INSTITUTIONS THROUGHOUT PORTUGAL, WORKING WITH MIT COLLEAGUES, ARE DEVELOPING NEW KNOWLEDGE AS THEY EXPLORE BASIC RESEARCH AND THREE CLUSTERS OF METHODS AND MODELS THAT FOSTER SYSTEMS THINKING.

Our research on **DESIGN AND IMPLEMENTATION** spans the disciplines of engineering, logistics, economics and finance, marketing, and human resources to enhance the ways in which ideas and concepts can be materialized into competitive new products or efficient large and multifunctional services and systems. We create new methods and models for requirements development, product architecture and design, and program and project management.

Our research on **UNCERTAINTY AND DYNAMICS** builds advanced methods and models to ensure flexibility in systems and thus makes it possible to address rapid shifts in societal requirements, technical options, and markets. Large-scale systems inevitably face multidimensional uncertainty over their long lives, from ever-changing technologies to financial and political exigencies to economic globalization; this is part of what creates such great complexity. By building flexibility into the development of major products, adaptation becomes smooth and opportunities are not missed.

Our research on **NETWORKS AND FLOWS** is based on the understanding that all engineering systems are characterized by technical, social, and managerial networks and flows. Consider a national electricity grid, or highway network, or air traffic control system. Our research helps create the big-picture view from which the best sustainable solutions to modern challenges can be derived — solutions that address the ongoing lifecycle of system interactions within the network.

**THE GREEN WHEEL** is an innovative, in-wheel electric motor that can be adapted to any kind of bicycle. It is being developed as part of the Smart Cities project, which explores new technologies designed to enhance urban energy efficiency and sustainability.

## Applying our research

WE CONTRIBUTE DIRECTLY TO THE REAL-LIFE DEVELOPMENT OF SYSTEMS, PRODUCTS, AND SOLUTIONS THAT GIVE PORTUGAL A COMPETITIVE ADVANTAGE. OUR FOCUS IS IN THREE BROAD AREAS.

Through **SUSTAINABLE ENERGY AND TRANSPORTATION SYSTEMS** projects, the MIT-Portugal Program helps enhance the sustainability of social activity as well as of the natural and built environments. Specific projects concern high-speed rail and related intermodal issues, biofuels and new energy systems, integrated renewables coupled with smart grids, and the overall urban metabolism. We are focusing on the challenges of regional sustainability. Through projects such as “Green Islands,” we are developing new tools, such as urban metabolism, to evaluate and design complex local systems.

Through projects on **STEM CELL ENGINEERING FOR REGENERATIVE MEDICINE**, we address the development of novel therapies for an aging society, and their clinical implementation in hospitals. We are helping establish a new generation of biotechnology companies that will make Portugal a European leader in this advanced, growing field. This is complemented with work on pioneering medical devices in the health sector that are designed to improve daily life.

Through projects on **MATERIALS AND DESIGN-INSPIRED PRODUCTS**, we integrate the tools of systems thinking to create new, competitive mobility solutions that can be offered by companies developing electric cars and related parts. We focus on providing the necessary scientific base to demonstrate new solutions and systems for electric vehicles worldwide.



# OUR MISSION: FIVE PATHWAYS TO REALIZING OUR VISION

The MIT-Portugal Program vision is being realized along five pathways that comprise our mission.

**TRANSFORM** scientific and engineering training in Portugal, through cutting-edge research and educational approaches, so that the concepts and tools of **systems thinking** become a central part of student knowledge and experience.

**BUILD** a research and knowledge network that creates a partnership between industry, academia, and the government to solidify the transformation of training.

**INVEST** in developing human resources that will help make the vision a reality.

**CULTIVATE** the ongoing development of advanced research methods and models to enhance the value of systems thinking, using the research and knowledge network to involve all the partners in this endeavor.

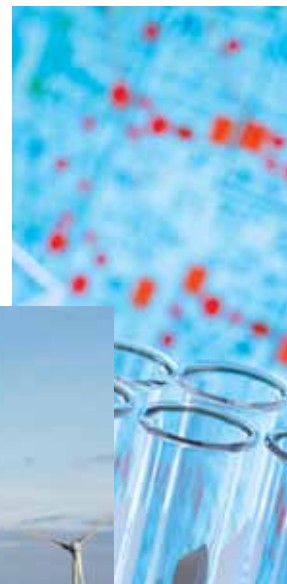
**DEMONSTRATE** the advantage of systems thinking in real-world applications related to sustainable urban/regional energy and transportation, stem cell engineering, and industrial design of electric cars and medical devices that can transform Portugal into an industry leader in these areas.

LIVING AND WORKING IN LISBON HAS PROVIDED ME WITH AN UP-CLOSE UNDERSTANDING OF PRESSING URBAN RESOURCE ISSUES. Now I'm working with colleagues in Portugal to establish the MIT-Portugal Program as a leading force in setting a new research agenda in the emerging field of urban metabolism.

**JOHN E. FERNÁNDEZ**  
ASSOCIATE PROFESSOR, MIT

THE GREEN ISLANDS INITIATIVE IS A UNIQUE OPPORTUNITY FOR PORTUGAL'S MAIN ENERGY COMPANIES. We are developing and deploying innovative solutions in areas such as energy systems integration, smart grids, and electric vehicles. Working with MIT-Portugal has put us in the forefront of a new paradigm — decentralized, intelligent energy systems — that we will make a reality within the next decade.

**ANTÓNIO VIDIGAL**  
CEO, EDP-INOVAÇÃO





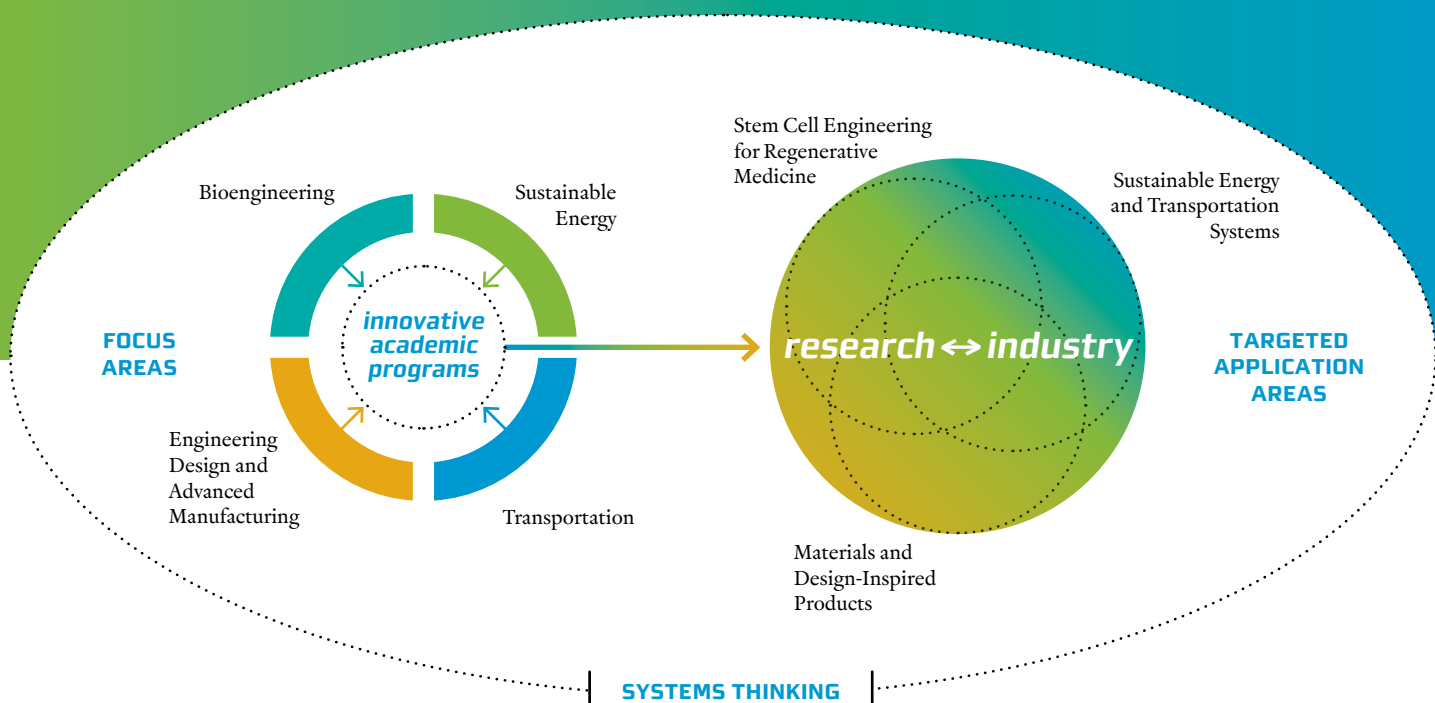


POST-DOCTORAL RESEARCH IN CONJUNCTION WITH THE MIT-PORTUGAL PROGRAM ALLOWED ME TO CONTINUE R&D ON ADVANCED TECHNOLOGIES, improve my project management skills, and build relationships between industry and research partners. Our research teams always included people from several technical disciplines, which gave us a wider view of product and systems development.

**BERNARDO RIBEIRO**

EDAM POST-DOCTORAL RESEARCHER,  
UNIVERSITY OF MINHO

## Our Knowledge-Creation Model



AS A POST-DOCTORAL FELLOW AT MIT, I DID ADVANCED RESEARCH IN STEM CELLS AND BIOMATERIALS, WORKING WITH LEADING AMERICAN AND EUROPEAN SCIENTISTS. I was also exposed to a unique environment for translating scientific and technological research into real-world applications. Now, through MIT-Portugal, I have been given a great opportunity to establish my lab in Portugal while keeping those great contacts. I believe that this international program will educate a new generation of leaders in my field.

**LINO FERREIRA**

PRINCIPAL INVESTIGATOR,  
CENTRE FOR NEUROSCIENCE AND CELL  
BIOLOGY (CNC), COIMBRA

THE MOST OUTSTANDING EXAMPLE OF VALUE IN MY MIT-PORTUGAL COURSE WOULD BE THE INNOVATION TEAMS PROJECT. It was unique, going beyond theory to give me hands-on experience promoting technologies in bioengineering in a market-oriented way. It was a very rich experience, both personally and scientifically.

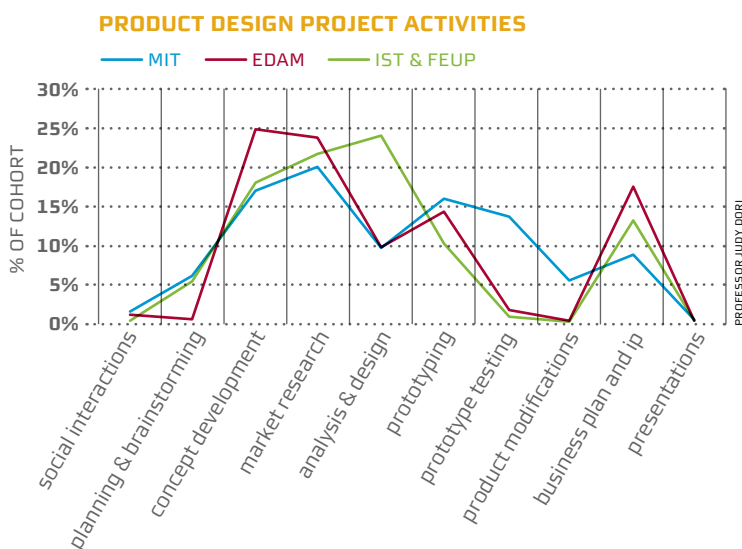
**DANIELA COUTINHO**

SECOND-YEAR STUDENT IN  
BIOENGINEERING SYSTEMS

# TRANSFORM / BUILD / INVEST /



**THE KEY TO REALIZING THE MIT-PORTUGAL PROGRAM VISION** is to place systems thinking firmly at the center of Portuguese industry, research, and training. That means strengthening the investment in research and transforming the way students are trained, so that Portuguese industry can benefit from their expertise and insights. It means establishing a solid partnership between industry and academia to share the fruits of the transformation. And it means, above all, investing in human resources at every level to effect the change.



Research on the innovative Product Design and Development course in our Engineering Design and Advanced Manufacturing programs is being led by Professor Judy Dori (MIT/Technion). Her study shows the categories of activity in which EDAM students, as well as those from MIT, IST, and FEUP, engage during their projects. This research helps drive innovation across the curriculum in these universities.

## NEW APPROACHES TO EDUCATION AND TRAINING

Through the MIT-Portugal Program, we are changing the traditional patterns of teaching and learning. Inspired by innovations in active learning and other teaching strategies at MIT, here are some examples of steps we've taken.

**COLLABORATIVE LEARNING SPACES** We've created special learning spaces at institutions in Portugal and at MIT to promote co-attendance at one site, allow multiple faculty and student mentoring through the use of videoconferencing, and use other advanced collaboration tools. For example, the Sustainable Energy Systems classroom at IST is used for doctoral seminars with participants from MIT, the Universities of Coimbra, Lisbon, and Porto, and from other remote industry and university locations, including in the Azores islands.

**COLLABORATIVE DESIGN STUDIOS** We've fostered the practice of using design studios to train the engineers of the future, with students in the MIT-Portugal Program linked directly to design and industry professionals in Portugal and throughout the world. The studio is a key resource for students in several of the program's areas. As close collaboration between university researchers and industrial partners expands, the multidisciplinary teams that are so important to our projects find the resources of the Collaborative Design Studio to be the foundation for successful project-based learning.



## TRANSFORM SCIENTIFIC AND ENGINEERING TRAINING

In an increasingly complex, networked world, where global economic considerations rule, engineering and science students need to access new types of training. They must be exposed to new ways of thinking — systems thinking — and to the cultures that will comprise the global teams on which they'll work. They need contact with a large pool of researchers and educators, unrestricted by national boundaries. They need to become the Engineers of 2020: what the U.S. National Academy of Engineering envisions as professionals “well grounded in the basics of mathematics and science” but who also “expand their vision of design through a solid grounding in the humanities, social sciences, and economics” to demonstrate “effective leadership in the development and application of next-generation technologies to problems of the future.”

Science and engineering students need core competencies to become successful researchers, and transferable skills to take to the job market. MIT-Portugal students work in dynamic learning environments, and are exposed to innovation and leadership curriculum and experiences, so that they are poised to become technology leaders who can create genuine value for Portuguese industry and society and sustain a virtuous cycle of renewal within a university-laboratory-industry partnership.

The focus is on reinforcing the top level of Portugal's higher education system through leading-edge research conducted with an eye towards solving critical challenges. Our objective is to foster leading academic research centers at the highest international level. We've internationalized research universities and built better links among them within Portugal, and we're attracting researchers and graduate students — including from around the world, in growing numbers — in exciting new ways.

## BUILD A RESEARCH AND KNOWLEDGE NETWORK

We have flourished since 2006, when MIT and six Portuguese engineering schools and their research centers, as well as several academic and industrial research laboratories, came together to collaborate in what became the MIT-Portugal Program. We're building a network to foster innovative post-graduate programs that offer world-class training and future employment opportunities to students at the tops of their fields. The network includes relationships with the best of Portuguese and European industry — companies that have forged strong ties with institutions of higher education as they work together to create value in the global market. The doors of research institutions have been opened to industry, and industry has welcomed in researchers and students. Through this network, we are promoting systems thinking as a tool to address key issues in strategic business areas that represent Portugal's future as a global industrial leader, as described on preceding pages.

Today, we continue to upgrade the nation's educational, research, and technological base. We continue to identify new opportunities for growth. And we continue to build an important new framework for transatlantic cooperation in science and technology. The benefits will be shared by all of Portugal and will contribute to new wealth creation.

**The MIT-Portugal Program has made a significant contribution to changing the culture of Portuguese universities. For the first time, Portuguese universities jointly offer PhD programs in the context of newly created cross-cutting academic and research entities. This has facilitated the growth of a network between industry research and higher education that is aimed at educating a new generation of leaders in technical innovation.**

**— JOAQUIM SAMPAIO CABRAL**

PRESIDENT, IST STATUTORY ASSEMBLY (2009)  
PROFESSOR, BIOCHEMICAL ENGINEERING, IST  
CO-LEADER, MIT-PORTUGAL BIOENGINEERING



## INVEST IN DEVELOPING HUMAN RESOURCES

Realizing the MIT-Portugal vision requires concentrated investment not only in creating programs and research projects, but also directly in the people who make these programs and projects possible and who will become the human resources creating value in Portuguese industry and society tomorrow. At every juncture, industry, academia, and the Portuguese government are investing time, money, and other resources to ensure the conditions for success.

Public funding of the program is provided mainly through the Portuguese Science and Technology Foundation (FCT). Additional sources of public and private funding are secured for specific components of the program, including competitive research projects, fellowships, pilot projects, and other initiatives.

A key aspect is the creation of the University Technology Enterprise Network (UTEN), through which we are helping create an industry-friendly ecosystem in Portuguese research universities, and bringing on board the people to make it happen. UTEN addresses elements such as industrial liaisons, intellectual property management, technology transfer and licensing, and entrepreneurship — all designed to make the bringing of research to the market more effective.

### BY THE NUMBERS

#### Post-doctoral Fellowships/ Research Contracts

Through 2008/09: **38**

Total estimated by 2011/12: **60**

#### Doctoral Students

(4 joint PhD programs in Portugal)

Enrolled through 2008/09: **154**

Total estimated by 2011/12: **250**

#### Master's Students

(3 joint MBE programs in Portugal)

Enrolled through 2008/09: **75**

Total estimated by 2011/12: **155**



The education programs are a unique opportunity to experience a strong and effective link between academia and industry. This new teaching paradigm, in which important knowledge about management and engineering is transmitted through work on real projects, has obvious value for anyone concerned with the development of new products.

—ISABEL FURTADO  
CEO, TMG AUTOMOTIVE

# DEGREE PROGRAMS

THE MIT-PORTUGAL PROGRAM OFFERS A ROBUST PORTFOLIO OF GRADUATE DEGREES TO WHICH MIT QUALITY STANDARDS ARE APPLIED. COURSES ARE CO-TAUGHT BY FACULTY AT PORTUGUESE INSTITUTIONS AND MIT FACULTY, AND TOP STUDENTS HAVE THE OPPORTUNITY TO DO RESEARCH AT MIT COLLABORATING LABORATORIES FOR A YEAR OR LONGER. EACH DEGREE IS NATIONAL, OFFERED BY A CONSORTIUM OF PORTUGUESE INSTITUTIONS.

## DOCTORAL DEGREES

The MIT-Portugal doctoral degree programs are based on educationally coupled research, and have been designed to attract outstanding students not only from Portugal but from throughout Europe and the rest of the world.

**PHD, BIOENGINEERING SYSTEMS** — A unique curriculum that combines engineering, biology, and neuroscience with innovation, leadership, and systems thinking. Our bioengineering doctoral program emphasizes specific emerging technologies targeted to complement and enhance existing Portuguese biosciences and technologies. Through this program, we are training a new generation of bioengineering innovators with systems understanding and experiences.

**PHD, LEADERS FOR TECHNICAL INDUSTRY** — Core courses in product development, engineering and manufacturing systems, operations analysis, and production management are complemented by management and leadership courses, all in the context of systems thinking. Graduates are ready to lead multidisciplinary teams addressing product development and manufacturing operations, innovation strategies for technology-based companies, and programs in industrial environments.

**PHD, SUSTAINABLE ENERGY SYSTEMS** — Unique in Europe, employing a multidisciplinary approach to educate tomorrow's sustainability-aware leaders with expertise in energy systems and economics. The course emphasizes technology and policy development. The focus on energy system design and analysis, research, leadership and entrepreneurship gives graduates the tools to be at the forefront of sustainable alternative energy systems development.

**PHD, TRANSPORTATION SYSTEMS** — Provides the knowledge and skills researchers need to become international leaders who formulate and develop innovative solutions to complex mobility systems challenges. The curriculum combines courses on research methodology, business models and contracts, and policy and institutions with more technical components such as planning and modeling methods and the technologies of various transportation modes.

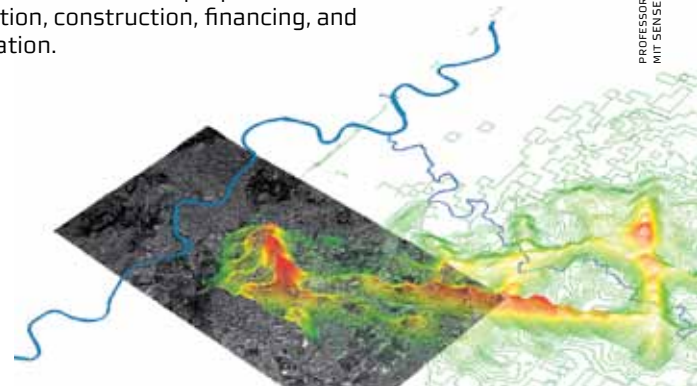
## EXECUTIVE MASTER'S DEGREES

The structure and curriculum of the MIT-Portugal executive master's degree programs are developed in collaboration with our industry affiliates, and respond directly to the needs of their managers, who take advantage of the courses while still working at their firms. Students come to the programs from among technical management staff of Portuguese and European companies, with undergraduate degrees and substantial practical experience.

**MASTER OF BUSINESS ENGINEERING, TECHNOLOGY MANAGEMENT ENTERPRISE (TME)** — Trains managers involved with product development and production systems, providing them with the skills needed to address complex technical and management issues in demanding environments. Graduates lead multidisciplinary teams engaged in innovative product development, advanced processing/fabrication solutions, and optimization of production processes under an integrated perspective of the product cycle.

**MASTER OF BUSINESS ENGINEERING, SUSTAINABLE ENERGY SYSTEMS** — Educates energy systems and economics professionals through a multi-disciplinary approach that focuses on design and analysis. By addressing economics, management, science and policy, environmental analysis and assessment, energy systems, and energy technologies, the program prepares graduates to work at the forefront of sustainable systems development and the implementation of alternative energy strategies.

**MASTER'S DEGREE, COMPLEX TRANSPORT INFRASTRUCTURE SYSTEMS (CTIS)** — Brings together the tradition of a master's in engineering with the insights of an MBA program, building on the three key domains of engineering and project management, financing and contracts, and policy and institutions. A significant component of the curriculum involves students with one or two major international projects. Graduates are prepared to address CTIS conception, construction, financing, and exploitation.

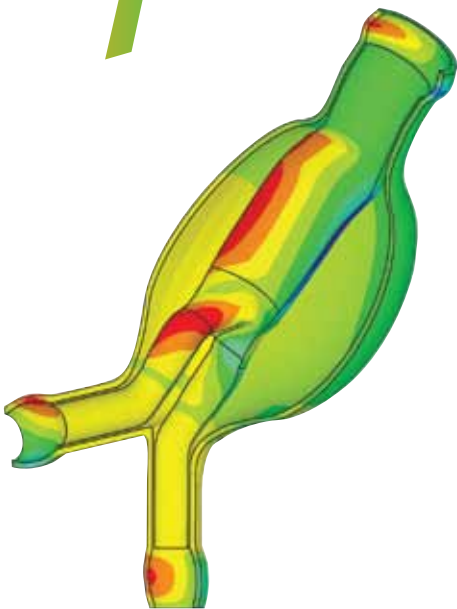


# CULTIVATE

## THE ONGOING DEVELOPMENT OF ADVANCED RESEARCH METHODS AND MODELS

The research and knowledge network we've built, and that we continue to strengthen, is the locus of systems thinking throughout Portugal. MIT-Portugal Program researchers in higher education are working with their counterparts in industry to develop the next generation of tools that make it possible to actuate systems thinking and, ultimately, apply it in the real world.

### 4 *examples*



#### 1.

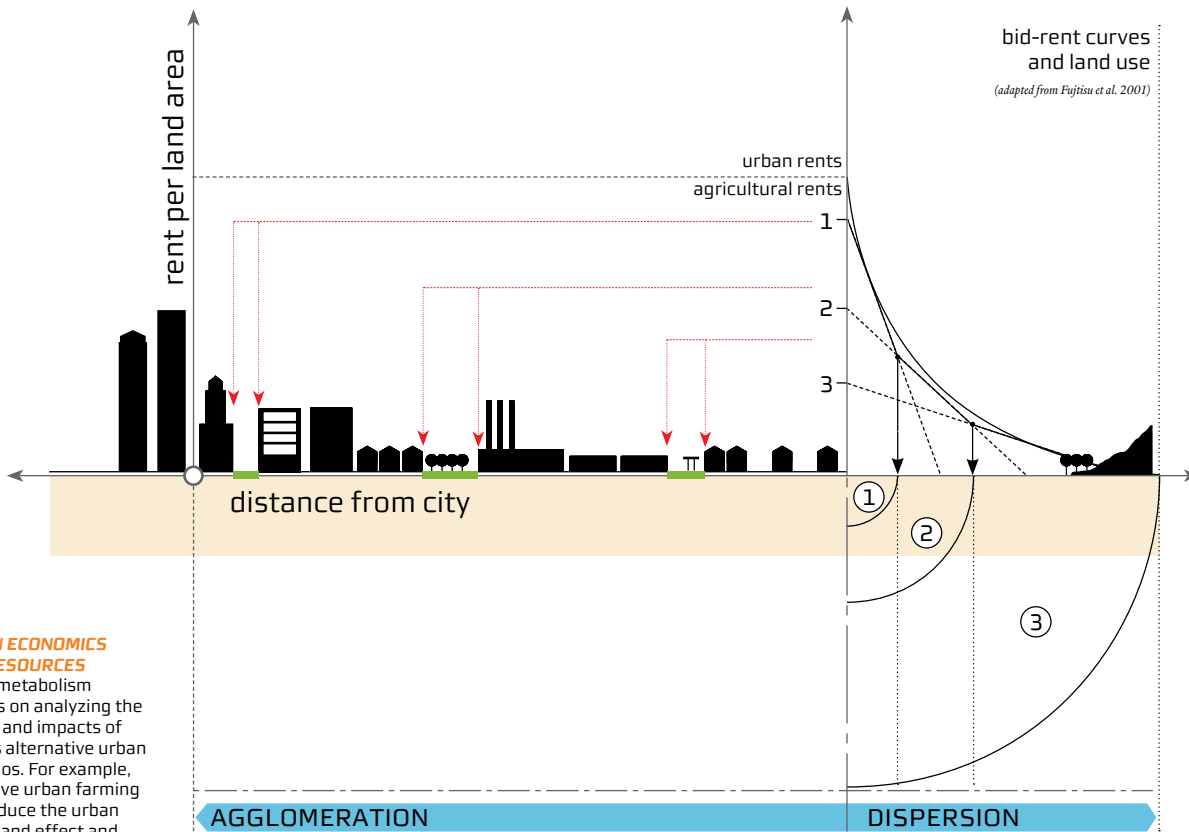
##### NEW CAPABILITIES IN THE AUTOMOTIVE SECTOR

The essence of the automobile hasn't changed much in a century; it still has an internal-combustion engine, four wheels, and a cabin. With the introduction of the electric car, though, a total change is on the horizon — not only the vehicle, but the business model. In fact, the advent of the electric car will create entire new companies and industries that produce the components of electric cars and that serve as system integrators. Portugal has an opportunity to be at the forefront. Our research is helping identify and create new value-added activities for the existing auto sector in the country and develop space for new players who can bring novel products to the market, particularly in power supply and management and communications systems. Part of our effort involves the Mobi-Design Studio Network, which is providing new benchmarks for research and validation of methods for the design of advanced vehicles, with an emphasis on smart interiors and integrated systems for electric vehicles. The network is based at the Center of Excellence for the Automotive Industry (CEIIA), in Maia, Portugal.

#### 2.

##### UNCERTAINTY AND DYNAMICS IN THE PORTUGUESE FOREST INDUSTRY

Forest fires are highly uncertain: where and when they might occur, weather, forest growth, and other factors all play a part. Fires adversely affect Portugal's important forest industry and present substantial social challenges as they threaten nearby communities. They are a problem that can benefit from systems thinking, which is why we are employing a systems approach — integrating technology, management, and policy — as we look for ways to minimize the impact throughout the country. Working with our partners in the Portucel/Soporcel industrial group, we are building an understanding of the mechanisms that favor and retard the spread of fires, including how resources could be deployed more strategically. We are identifying changes that need to be made as part of a systems solution. As we develop the answers, we are building a prototype for how to address other engineering systems challenges throughout Portugal.



**URBAN ECONOMICS AND RESOURCES**

Urban metabolism focuses on analyzing the drivers and impacts of various alternative urban scenarios. For example, extensive urban farming may reduce the urban heat island effect and lower the embodied energy of urban food imports, resulting in lower overall energy consumption in the city. A systems analysis of this scenario requires coupling material flow accounting with urban economics, especially with regard to land rent gradients.

**3. THE URBAN METABOLISM**

Urban metabolism is the study of resource flows required to support the array of urban activities that characterize today's contemporary city. With more than half of the world's population, urban centers now account for most of the world's material and energy consumption, carbon emissions, and waste production. Our research focuses on the systems behavior of a variety of resource-efficient urban scenarios: alternative vehicles and power distribution systems, energy-efficient buildings, urban farming and the heat island effect, urban material reclamation and recycling, and green construction. This work is in association with current green city efforts in Lisbon and other cities. It engages civic authorities such as the Câmara Municipal de Lisboa with critical resource providers such as EDP (electricity and gas), GALP Energia (oil and natural gas), EPAL (water), and others. Bringing fine resolution to our understanding of the resource consumption of our increasingly urban world will better enable the development and implementation of effective policies toward urban sustainability.

**4. DEVELOPING CARBON-EFFICIENT STRATEGIES FOR SUPPLY CHAINS**

Reducing carbon footprints is central to addressing the problem of global climate change. A lot of energy is consumed in the course of delivering goods and services to end consumers, a result of current paradigms for supply chain design. We are developing new methods and models for measuring a product's carbon footprint along the supply chain. Our focus is on a "carbon label" designed to facilitate the communication of real information about product attributes among firms in the supply chain, as well as other stakeholders such as consumers and environmental agencies. In the course of our work, we are developing attributes and evaluating standards of measurement needed for this approach, combining Life-Cycle-Assessment (LCA) methodologies with cost accounting and logistics performance metrics. Using network optimization and dynamic systems modeling, the project will identify ways to evaluate standards and ultimately design a supply chain with carbon efficiency in mind. In the Portugal context, we are creating a paradigm for the actual design of a carbon-driven supply chain.

# DEMONSTRATE

## THE ADVANTAGE OF SYSTEMS THINKING IN REAL-WORLD APPLICATIONS

We conduct all our research with an eye toward applying what we learn in the real world. Teaming with our industrial affiliates, we are taking ideas and prototypes from the laboratory and putting them to work, creating opportunities, solving problems, and improving lives.

# 3 examples

## 1.

### CITYMOTION

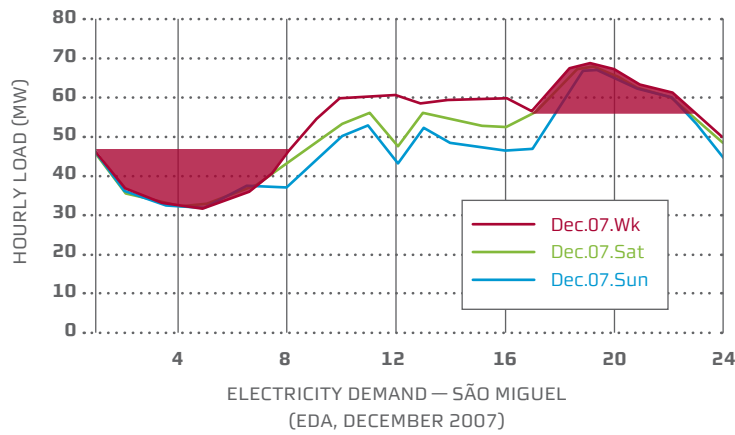
MIT-Portugal's CityMotion project aims to improve the urban traveler's experience in Portugal and elsewhere. The project involves setting up and exploring an infrastructure that gathers data on a city from various heterogeneous sources, and includes developing data fusion algorithms that transform a rich amount of data into knowledge about the city; making that knowledge available at various levels of abstraction; and then developing on top of that knowledge new computational solutions for energy efficient and environmentally sustainable intelligent transport systems. As part of the project, researchers have adapted and demonstrated software developed at MIT that could make it easier for traffic managers to assess road conditions and ease congestion in real time. Using data collected on a section of highway often congested with commuters traveling to Lisbon from neighboring Cascais, researchers employed the "DynaMIT" traffic simulator, which makes it possible to integrate and analyze data from a large array of information sources, including road sensors, electronic toll collection devices, automatic video processing, global positioning systems, mobile sensor networks, and smart phones. DynaMIT predicted travel time, speed, traffic intensity, and density – information that could prove useful in the future to predict recurrent and incident-based traffic conditions, as well as devise real-time traffic management support strategies. The next step in the research is to create a way to estimate and predict short- and medium-term traffic conditions and design a framework to evaluate its benefits for road operators and drivers. The demonstration was conducted in partnership with Brisa, Portugal's largest toll road management company.

MIT-PORTUGAL TRANSPORTATION SYSTEMS/CITYMOTION





## 2007 ELECTRICITY DEMAND



## 2.

### GREEN ISLANDS

On São Miguel and several other islands in the Azores, our research and education work is targeted at helping our partners in industry, academia, and government increase significantly the contribution of renewable energy sources in the next decade and beyond — as well as reduce dependence on fossil fuels and lower greenhouse gas emissions. Ultimately, the aim is to create a model for similar efforts throughout the world. The project includes developing a detailed characterization of the dynamics and socio-economic trends of energy demand. Our work involves assessing the building stock; retrofit and replacement opportunities; transportation options (including electric transportation); industrial and agricultural opportunities for efficiency and renewable/waste fuel production; microgeneration and smart grid/energy box integration; and new transportation systems management options based on information and communication technologies. These are all components of designing a robust, affordable, and implementable sustainable energy system for the Azores — which can only be accomplished with systems thinking that integrates local energy supplies and demands. The new knowledge generated will have a positive impact on economic development. This project, which we call “Green Islands,” is a partnership between the MIT-Portugal Program and our affiliate universities including the Universidade dos Açores, the Government of the Azores, and Portuguese companies in the energy sector, including EDP, Galp, Efacec, Martifer, SGC Energia, and EdA. Moving this project forward has required that we create powerful simulation models and design tools that help us understand the dynamics of renewable energies, energy markets, and consumer behavior. We have also developed methods that address the uncertainties of technology development, energy prices, and social acceptance of new ways of living. In addition, the project has employed new methods for measuring and controlling the interaction flows within multi-layer (information, transportation, energy) sustainable systems networks.

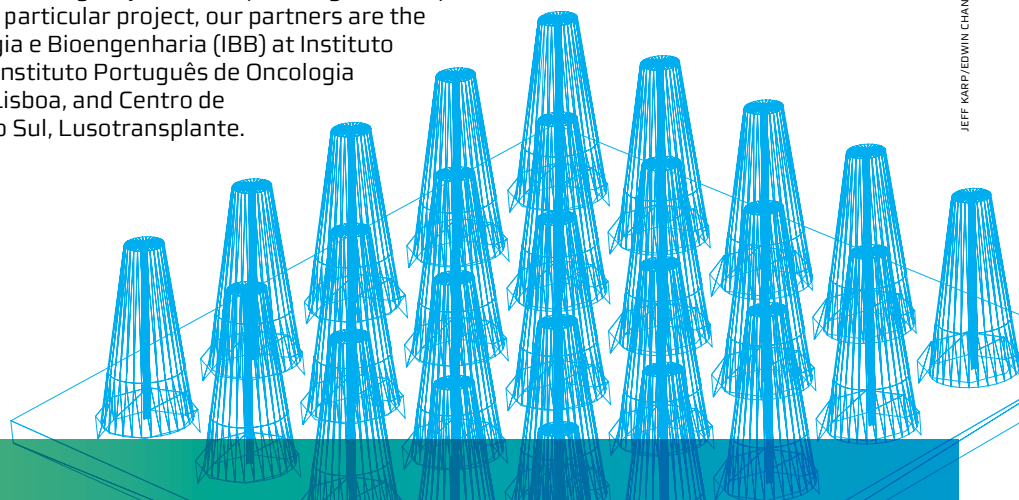


## 3.

### STEM CELL-BASED THERAPIES

Since late 2007, MIT-Portugal has been partnering on a project to expand human mesenchymal stem cell (MSC) research to the clinical scale and treat patients with severe hematological diseases. It is part of our work on Regenerative Medicine, which integrates physical and engineering sciences with the life and medical sciences to restore the structure and function of damaged tissues and organs in vivo and to create tissues in vitro for implantation. This new field is supported by research and development of new bioengineering techniques to improve fundamentally the treatment and prevention of disease; assess the effectiveness and outcomes of new biological materials, processes and devices; and develop advanced engineering techniques for conducting biomedical research at multiple scales. A variety of novel approaches are used to address tissue/organ insufficiency including: stem cell-based therapies for the regeneration of damaged tissues; tissue engineered synthetic implants (artificial organs) and bio-hybrid organs to replace tissue function. For this particular project, our partners are the Instituto de Biotecnologia e Bioengenharia (IBB) at Instituto Superior Técnico (IST), Instituto Português de Oncologia (IPO) Francisco Gentil, Lisboa, and Centro de Histocompatibilidade do Sul, Lusotransplante.

**NANOSCALE IMAGE OF THE “GECKO BANDAGE” (BELOW)** The waterproof “gecko bandage” — “one of the 20 new biotech breakthroughs that will change medicine” (*Popular Mechanics*) — mimics the properties that allow the lizard to adhere even to wet surfaces. A potential alternative to sutures and staples, it closes external wounds, patches internal injuries, and eventually dissolves — no removal required. A team in the lab of renowned MIT Prof. Robert Langer developed the bandage; it included Dr. Lino Ferreira, now on the MIT-Portugal bioengineering faculty.



# OUR EDUCATIONAL CONSORTIUM

The MIT-Portugal Program brings together a dynamic consortium of research institutions from throughout the country, along with MIT entities, to collaborate in high-quality teaching, learning, and research.

## *Schools of Engineering, Science and Technology*

Escola de Engenharia da Universidade do Minho (UMINHO)  
Faculdade de Engenharia da Universidade do Porto (FEUP)  
Instituto Superior Técnico da Universidade Técnica de Lisboa (IST-UTL)  
Faculdade de Ciências e Tecnologia da Universidade de Coimbra (FCT-UC)  
Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (FCT-UNL)  
Faculdade de Ciências da Universidade de Lisboa (FCUL)

## *Other Associated Schools*

Faculdade de Economia da Universidade de Coimbra (FEUC)  
Instituto Superior de Economia e Gestão da Universidade Técnica de Lisboa (ISEG-UTL)  
Instituto Superior de Ciência do Trabalho e da Empresa (ISCTE)

## *Associate Laboratories*

Centro de Neurociências e Biologia Celular (CNC), Coimbra  
Instituto de Biotecnologia e Bioengenharia  
Instituto de Engenharia de Sistemas e Computadores do Porto, Inesc-Porto  
Instituto de Nanoestruturas, Nanomodelação e Nanofabricação, Minho  
Instituto de Sistemas e Robótica, Lisboa  
Instituto de Tecnologia Química e Biológica  
Laboratório Associado de Química Verde Tecnologias e Processos Limpos, Requimte  
Laboratório Associado em Energia, Transportes e Aeronáutica (LAETA)

## *Industrial Research Laboratories*

Centro de Excelência e Inovação na Indústria Automóvel  
Instituto Nacional de Engenharia e Gestão Industrial  
Pólo de Inovação em Engenharia de Polímeros

## *National Laboratories*

Laboratório Nacional de Engenharia Civil, LNEC

## *Massachusetts Institute of Technology (MIT)*

Aeronautics and Astronautics  
Anthropology  
Architecture  
Biological Engineering  
Biology  
Brain and Cognitive Sciences  
Center for Technology, Policy, and Industrial Development  
Center for Transportation & Logistics  
Chemical Engineering  
Civil and Environmental Engineering  
Computer Science and Artificial Intelligence Laboratory  
Deshpande Center  
Economics  
Electrical Engineering and Computer Science  
Engineering Systems Division  
Harvard-MIT Division of Health Sciences and Technology  
History  
Laboratory for Information and Decision Systems  
Materials Processing Center  
Materials Science and Engineering  
Mechanical Engineering  
Media Laboratory  
MIT Energy Initiative  
Operations Research Center  
Science, Technology, and Society  
Sloan School of Management  
Urban Studies and Planning

# OUR INDUSTRIAL AND INSTITUTIONAL AFFILIATES

The MIT-Portugal Program engages industrial and institutional affiliates as active participants in developing educational programs and conducting research projects, and as key partners in the application of research in real-world settings.

Alfama, INC.  
Altakitín CORP.  
Alstom  
Amorim Industrial Solutions  
AREAM — Agência Regional da Energia e Ambiente da Região Autónoma da Madeira  
ARENA — Agência Regional da Energia e Ambiente da Região Autónoma dos Açores  
Associação Industrial Portuguesa — Confederação Empresarial  
Associação Empresarial de Portugal — Câmara de Comércio e Indústria  
Ciência Viva  
BANIF — Banco Internacional do Funchal, s.a.  
Bento Pedroso / Odebrecht  
Bioalvo s.a.  
Biotecnol, s.a.  
Biotempo, LDA.  
Biotrend — Inovação e Engenharia em Biotecnologia, s.a.  
BRISA  
Cabo TV Madeirense, s.a.  
Celoplás — Plásticos para a Indústria, s.a.  
Cimentos Madeira, LDA.  
CIPAN — Companhia Industrial Productora de Antibióticos, s.a.  
Crioestaminal — Saúde e Tecnologia, s.a.  
DEIMOS, s.a.  
DSM, The Netherlands  
ECBio — I&D em Biotecnologia, s.a.  
EDP, s.a.  
EDP, Inovação  
EFACEC, s.a.  
Empresa de Electricidade da Madeira, s.a.  
FLAD — Fundação Luso-Americano para o Desenvolvimento  
Fomentinvest SGPS, s.a.  
Fórum de Administradores de Empresas (FAE)  
Galp Energia, s.a.  
Grupo Bial  
Grupo Frulact  
GRUPO SOUSA, Investimentos, SGPS, LDA.  
Horários Do Funchal — Transportes Públicos, s.a.

Iber-Oleff — Componentes Técnicos de Plásticos, s.a.  
IMTT - Instituto da Mobilidade e Transportes Terrestres  
Inapal Metal, s.a.  
Inapal Plásticos, s.a.  
Martifer, s.a.  
M. C. Graça, LDA.  
Mota-Engil  
Nutroton Energias, s.a.  
Ordem Dos Engenheiros  
Plasdan Portugal  
Proforum — Associação Para o Desenvolvimento da Engenharia  
RAVE / Refer  
REN — Redes Energéticas Nacionais, s.a.  
Rolls-Royce plc, UK  
SGC Energia  
Siemens  
Simoldes Plásticos, lda.  
Stematters, Biotecnologia e Medicina Regenerativa LDA.  
Sunviauto, s.a.  
TMG Automotive  
Unicer Bebidas, s.a.  
Universidade dos Açores  
VW Autoeuropa



We capture two opportunities through our MIT-Portugal connection. We get to train our human resources on the design and development of future sustainable energy systems, and we are now part of research projects that are testing and validating new business models for energy services at the urban level. These may well become part of our portfolio in the near future.

—MANUEL FERREIRA DE OLIVEIRA  
CEO, GALP

As we reform the Portuguese higher education system, MIT-Portugal provides us with a demanding, exciting network to draw from. It contributes to the development of new graduate curricula, which translates into opportunities to challenge and improve our faculty — all in the context of strengthening our international recognition. It also gives us a model for promoting multidisciplinary approaches and creative environments, and for coupling research and education more effectively.

—ANTÓNIO M. CUNHA,  
DEAN OF ENGINEERING, UMINHO;  
CO-LEADER, MIT-PORTUGAL ENGINEERING DESIGN  
AND ADVANCED MANUFACTURING

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