MIT Portugal

A PROGRAM SPONSORED BY THE PORTUGUESE SCIENCE AND TECHNOLOGY FOUNDATION

MIT PORTUGAL 2006-2011

A research platform involving Portuguese Universities and the Massachusetts Institute of Technology to promote the advancement of knowledge and the capacity of business and industry to access markets worldwide:

Bioengineering Systems
Sustainable Energy and Transportation Systems
Engineering Design and Advanced Manufacturing

Submitted to the analysis of the External Review Committee and the Portuguese Science and Technology Foundation

DRAFT

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Executive Summary

The MIT Portugal Program vision is to contribute world-class targeted research, competitive economic advantage, and human development leveraging multidisciplinary training to address critical societal challenges. A prime research objective is to focus on topics that will enable Portugal to become more competitive in knowledge-based industries. Over the past 5 years, we have built a research platform for cutting-edge concepts in 3 promising areas of science and technology, specifically, novel biomedical therapies and devices, sustainable energy and transportation systems, and integrated product design. The MIT Portugal Program targets test bed development and demonstrations and envisions Portugal as a scalable living laboratory and model for the world. We are designing, testing, and implementing systems, new products and modeling capabilities for markets worldwide.

Systems thinking is the foundation for our research perspective. By integrating engineering, policy and innovation we can develop, implement and evaluate system-level solutions in health care, energy and transportation, and product design. For example, in energy and transportation, rather than focus on a particular technology, the research combines various technology and policy options to achieve a sustainable energy future. The Green Islands project is an example of this approach, creating a living laboratory where new technologies and policies are first modeled, then integrated, and then can be tested for their marketplace potential. The systems perspective requires an interdisciplinary approach for all MIT Portugal Program research projects. In Portugal, the program has attracted world-class researchers, provided new opportunities and positions, and helped build capability and excellence among collaborating universities throughout the country. At MIT, faculty and researchers participate from all four schools, 17 departments, and nearly 1/3 of the 70 MIT faculty members involved are affiliated with the Engineering Systems Division, which has pioneered multidisciplinary, systems thinking. All MIT Portugal Program research projects benefit from collaboration among multiple Portugal universities and multiple MIT researchers, with the Portuguese research teams coming from a wide range of universities, with an overall objective of creating or expanding scientific excellence in each of the three specified research areas.

A primary focus of the research is on real world applications. In the area of medical devices, for example, an innovative powered ankle-foot orthosis is being developed by Portuguese and MIT faculty and students in collaboration with a Portuguese biomedical start-up company that will improve locomotion, muscular rehabilitation, and increased autonomy – all leading to improved quality of life. This real world orientation requires close coupling of research with the private sector and other primary stakeholders. Relationships were established with specific companies and consortia of companies were also formed. In the biotechnology area, a principal focus is on innovation and entrepreneurship, and several new startup companies have been launched. In Bioengineering Systems, partnerships and collaborations with hospitals have become the primary mechanism for real world application of the breakthrough research. For example, a project on improving the survival of critically ill hospital patients is being conducted with two major medical centers (in both Lisbon and Boston), with the results targeted at systems-related adjustments that will improve patient survival rates in intensive care units.

Throughout the first phase of the MIT Portugal Program we developed and refined multiple innovation activities geared to ecosystem development, education, development of a new attitude

towards technological innovation, and venture formation. These activities grew organically as distinct experiments, which allowed us to research and pilot the adaptation of the lessons from the MIT innovation ecosystem to Portugal. Faculty from IST, UMinho, Nova, Coimbra and Porto University designed these activities jointly with MIT. We believe there is an opportunity to implement coordinated innovation activities for the purpose of establishing, in Portugal, a lasting channel for innovation and communication that can stimulate action-oriented participation from the ecosystem inside and outside academia and research laboratories; one that outlasts a programmatic connection between Portugal and MIT. In bioengineering systems, from 2008 to 2010, bio-teams attracted the participation from 26 Portugal Principal Investigators that contributed 18 Portuguese technologies to teams of students (54 students) that explored the commercial viability of these technologies. Twelve of these projects have already acted on the student recommendations to develop a startup, refocus research, develop new IP, discard research avenues, or develop new partnerships. 56 professionals from industry contributed as active community mentors and experts in the bio-teams experience and an estimated 200 professionals from the local ecosystems in Minho, Porto, Lisbon, and Coimbra participated as audience/reviewers in the different events.

As of 2010, innovation activities have resulted in 4 startups and 6 new partnerships involving a research laboratories and industry. Two of the startups came out of bio-teams course immediately, and 2 alumni created two additional startups. The MIT Portugal Program trained 15 Portuguese faculty on the pedagogy behind i-Teams at MIT. Several of these faculty joined the distributed team leading bio-teams. In EDAM, we further explored mechanisms to leverage the i-Teams pedagogy to strengthen the collaboration with UTEN. Additionally, at least one course inspired in the i-Teams pedagogy was created at IST in the area of clean technologies. In 2010, a venture competition in Portugal was initiated that trained twenty (20) early stage teams on go-to-market strategies, which and resulted in greater than €2,000,000 in awards and institutional investments. Portuguese finalist teams were hosted at a business development boot camp at MIT, including networking with 100 US-based entrepreneurs, and provided opportunity to pitch to VCs who manage over $3,000,000,000 in risk capital funds. Overall, in the venture competition we developed a US-based Catalyst program with ten (10) serial-entrepreneur volunteers (Catalysts); involved twenty (20) international judges to select awardees; and attracted eight hundred (800+) innovators and investors in audience participation over three events.

Beginning in 2008, all new research funding was awarded through an open process of Calls for Proposals, providing a high level of competitiveness and encouraging a wide expansion of MIT Portugal collaborative research into sectors of industry and academia that had not yet been reached. There have been two rounds of Calls for Proposals, providing a mechanism through which we have attracted industry and other non-academic participation to the program. One of the unique aspects is that every research grant requires industry participation. In this way, we are creating and reinforcing real practical working connections with companies involved in the MIT Portugal Program and ensuring that we continue to attract new companies.

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1 Introduction

1.1 Main Achievements

The program has successfully built productive research partnerships between Portuguese university groups and industry in our target application areas: Stem Cell Engineering for Regenerative Medicine, Sustainable Energy and Transportation Systems, and Materials and Design-Inspired Products.

Projects on Stem Cell Engineering for Regenerative Medicine involve faculty, students, and collaborators in developing novel therapies and their clinical implementation. Research in this area has focused on the treatment of cancer, hematological and genetic disorders, and autoimmune diseases, and addresses both development and implementation. As neurobiologist and MIT President Susan Hockfield has said, efforts such as these involve "the great convergence of the life sciences with engineering and the physical sciences."

By working to develop Sustainable Energy and Transportation Systems, researchers aim to enhance the sustainability of economic activities in harmony with the natural and built environments. Research centers and companies in Portugal work with the MIT Energy Initiative and bring together city officials and urban experts from around the world to benchmark sustainability and help design, test, and implement new policies for greener cities. We explore new concepts and solutions for urban mobility and leverage the emerging field of urban metabolism. This effort builds on test beds developed recently in Portugal to demonstrate various forms of electric mobility integrated in smart energy grids that may increase the use of renewable energy generation sources.

Research on Materials and Design-Inspired Products creates competitive solutions for targeted markets in the mobility industries and the health sector, where our pioneering work on medical devices designed to improve daily life complements the regenerative medicine research. The MIT Portugal research is based on an application-driven approach and promotes knowledge-based manufacturing and competitive product development.

In addition to the three application areas we have seeded research in the Fundamentals of Engineering Systems. This roots the MIT-Portugal collaboration firmly in this emerging field that integrates engineering, management, and social sciences to achieve the best possible understanding, design, and implementation of highly complex, technology-based systems. Holistic thinking about complex systems is at the core of the entire program.

1.2 Evolution of Research Topics

Research and education are two intrinsic components of all collaborative projects and programs between MIT and the Portuguese universities. As a consequence, the research emerges as a crosscutting activity between the four doctoral education programs, namely:

- Bioengineering Systems,
- Engineering Design and Advanced Manufacturing Systems,
- Sustainable Energy Systems,
- Transportation Systems

The research activity stem from the PhD thesis developed by the first student that started in September 2007 and focused on high-priority projects, using an application-driven process, based on targeted research and advanced industry-science relationships, as described below for each of the areas.

In **Bioengineering Systems**, the objectives included educating a new generation of leaders in bioengineering technical innovation in Portugal, creating new knowledge through research and development, and promoting industrial, health-care and environmental biotechnology education and research that make possible new start-ups, which implement new models of interaction between universities and enterprises, government, and society. We also successfully created a new inter-institutional doctoral level education program. Building on acquired expertise with a critical mass of Portugal and MIT faculty and students, it was possible to make significant research contributions in Bioengineering Systems, specifically in research thrusts that cover the spectrum from "the bench to the bedside" in healthcare and emerging technologies.

Bioprocess and Biomolecular Engineering has contributed novel technologies and has overcome some challenges associated with the production and purification of recombinant proteins, plasmid vectors and bulk and specialty chemicals. Cell and Tissue Engineering contributed to implementing biomaterials and/or signaling molecules, including engineering design, to delineate efficient culture systems for the ex-vivo expansion of stem cells and their highly controlled differentiation into specific cell types and tissues for regenerative medicine. The Computational Bioengineering, Genomics, Systems and Synthetic Biology research provided experimental design techniques in the context of System Biology, and promoted knowledge of functional and structural genomics, computational prediction of gene function, and models of complex biological systems for industrially relevant bio-products. The Biomedical Devices and Technologies research contributed with novel designs and new knowledge in orthoses and wearable sensors to aid individuals with mobility and musculoskeletal disabilities. The medical devices theme has successfully brought together faculty and students from Bioengineering Systems and Engineering Design and Advanced Manufacturing for research and new curriculum offerings. The Innovation of Biomedical Systems research promoted innovation, management and policy in Bioengineering resulting in successful collaborations among engineers, doctors, hospitals, and policy makers to realize improved healthcare. The new generation of bioengineering systems professionals trained in this context is empowered to understand the innovation path and is successfully translating their academic research into practice and new start-ups.

Engineering Design and Advanced Manufacturing Systems was aimed at developing high quality research coupled with innovative post-graduation initiatives fostering knowledge-based manufacturing and competitive product development. Four lines of approach were followed for the research: use of design methodologies for more efficient development of competitive, high added-value products, through integration of engineering tools with market expectations and new business models; innovative integration of enhanced materials with new design solutions and advanced manufacturing processes; novel design and manufacturing solutions for the development of bio-inspired solutions and novel smart functions; and improved sustainable supply chains adapted to new business models and increased demands for flexibility in a changing economy. The EDAM focus area structured its research around six thrust areas: EDAM in automotive; EDAM in aeronautics; EDAM in medical devices and micromanufacturing; Integrated cost and life cycle considerations in

engineering design and manufacturing; Sustainable solutions; and Social and human aspects in engineering design and manufacturing

EDAM in Automotive contributed to strengthening the Portuguese position in the worldwide automotive industry by introducing new and multidisciplinary approaches in the design and production of complex systems and products with high added value. EDAM in Aeronautics contributed to the development of the Portuguese aeronautical industry, including new approaches in aeronautic solutions combining mechanical and electronics assembling processes, regarding optimization of product performance and the reduction of the production cost. EDAM in medical devices and micromanufacturing was committed to innovative product development of medical devices, including the design of novel products and solutions and the use of advanced manufacturing technologies. Integrated cost and life cycle considerations in engineering design and manufacturing integrated traditional (e.g., mechanics and electronics) and emerging (e.g., nanomaterials) disciplines in engineering design and manufacturing activities in order to meet the required specifications for complex systems and assure service performance. It aimed at the combination of design methodologies with competitive manufacturing processes and strategies (ex. Lean manufacturing). Sustainable solutions supported the design process (functional, performance and assembling) with a systematic and embedded analysis of the effects in the relevant ecosystems caused by-products and processes to be developed in order to achieve solutions with minimized environmental impact. Social and human aspects in engineering design and manufacturing associated human perceptions and technical aspects of a product, bringing together technical and human disciplines to enable a positive perception of the product by potential consumers and users.

Since its inception, EDAM negotiated with industry partners in order to contribute to fulfill some of their specific needs, within the research scope described above. Each industry project was then developed by LTI or TME students.

The mission of the **Sustainable Energy Systems** focus area was to engage academia, industry and government in innovative research and educational programs that apply Engineering Systems approaches to the design of integrated sustainable energy technologies and infrastructures, and educate a new generation of sustainability aware energy leaders.

Faculty in Portugal and at MIT have designed the research program promote collaboration across the universities in three overarching Sustainable Energy Systems research themes: a)Energy Planning including Economics; b) Sustainable Built Environment; and c) Smart Energy Networks.

The Energy Planning including Economics (EPE) area have built upon energy and environment values and economic domains, at the level of energy systems analysis and design. EPE research focused on developing new modeling frameworks to support national efforts in sustainable energy planning and forecasting emphasizing the dynamics of energy demands and incorporating the local and regional renewable energy resources, including distributed renewables and customer-based generation's impacts on electricity supply. Sustainable Built Environment (SBE) focused on the development of a spatially comprehensive and temporally broad physical accounting of resource consumption of urban centers. Particular emphasis was given to - Urban Metabolism approaches where the resource consumption characteristics across cities of different characteristics including geography and topography, economy, and social and demographic composition were characterized. A special emphasis was given to analyzing the energy consumption in buildings and to provide new and

innovative solutions to promote the concept of “Sustainable Buildings”. Smart Energy Networks (SEN) focused on the active management of distribution grids, dispersed generation (DG), storage and new dynamic end-uses such as electric vehicles and demand response in local and regional energy systems that improve system operation and reliability. This included the development of new hierarchical energy system architectures for improved monitoring, control and management of network assets, market-based integration of technologies such as smart meters and smart chargers of EVs, and the development of new network capabilities in the real, near, and medium-term.

The research conducted in these three areas has engaged with Portuguese energy companies and government agencies, including national laboratories. These include the Azores Green Islands Project, which looks at integrated energy supply and demand for constrained regions, and the Sustainable Urban Energy Systems (SUES) topics, which bridge smart and efficient building technologies up to neighborhood and city scales. Sustainable Energy Systems’ researchers also engaged in several non-MIT Portugal Program-led activities at national and EU levels. This includes InovCity(on smart cities) and Mobi-e, focusedon the introduction of electric vehicles, collaborations with the City of Porto on improving the energy and carbon footprint of its historic downtown, or the EU MERGE project which is upgrading power systems analysis tools to examine the impacts of the large scale introduction of electric vehicles. PhD students are engaged in those projects, with MIT joint research supervision. For some students, the Doctoral Program included research stays at MIT laboratories (12-18 months) as part of joint projects with Portuguese research groups.

The **Transportation Systems** mission was to develop high quality research linked with innovative post-graduate educational programs, addressing the complexity that always characterizes the launch and sustained operation of large transport infrastructure projects and associated services. The ultimate goal was to provide Portugal with a leading knowledge base in this domain, to allow for improved decision making about large transportation projects, not only in the investment phase but also in the different stages of their lifecycle, while also acting as a basis for international recognition of this capacity and subsequent export of associated services, in education as well as in consultancy. This endeavor, based on a joint effort of MIT and major Portuguese universities, covered three main lines of intervention in these systems: engineering and project management; finance and contracts; and policy and institutions. A derived coherent and integrated research agenda was organized in four areas of research: a) Transportation Systems Integration, b) Intelligent Transportation Systems (ITS), c) Airport and Airline Systems, andd) High Speed Rail (HSR).

Transportation systems integration aimed at providing a research and analytical platform for integrating across the other three research areas. A specific research project, SOTUR, provided a better understanding of how urban development might be affected, on the local and regional scale, by the various transportation services and modes being examined by ITS and high-speed rail research. Under Intelligent Transportation Systems, within one of the research projects (SCUSSE) new smart transportation services and modes, such as congestion and parking pricing, incident detection and speed adaptation systems, car-sharing and one-way car rentals were conceived and organized making use of advanced simulation tools.. Another intimately related ITS project (CityMotion) aimed to develop several types of information technologies that could be deployed within the Portuguese transportation system in order to improve mobility services, provide new information for infrastructure and service design, and allow users to make better-informed decisions about their mobility via seamless integration of the necessary information (including prices and

externalities) and convenient delivery of this information when and where it is needed. The Airport and Airline Systems research focused on an issue of crucial importance to Portugal and many other countries around the world: deriving a coherent understanding of airports as systems. A specific research project, AirNets, quantifiedthe effects on airline and air transportation system performance and configuration of various proposed technologies and policies aimed at addressing airport congestion, including next-generation air traffic control systems, airport location and number, slot allocations, and congestion pricing. Under the High-Speed Rail research, two inter-related projects focued on critical elements in the successful implementation of high-speed rail in Portugal and elsewhere. One project developed new lifecycle costing models and infrastructure and risk management programs to effectively derive design and maintenance strategies for high-speed rail infrastructures and operations. The second project, RISK, developed a generalized global risk assessment for the HSR network, enabling the effective consideration of technical and natural hazard risks in project assessment and management. The objective was to create robust decision models for proactive risk management.

Once the research activity was launched, and critical mass of PhD students was available, as of 2008, new funding for research through this collaborative venture has been awarded through an open process of Calls for Proposals, providing a high level of competitiveness and encouraging a wide expansion of MIT-Portugal collaborative research into sectors of industry that had not yet been reached. Thus far, there have been two rounds of Calls for Proposals, and they have proven to be a powerful mechanism to attract industry and other non-academic participation to the MIT Portugal Program, as every research grant to be provided requires industry participation. In this way, the research network is fully open and fosters research excellence and industry-science relationships that create value in the global market in key strategic areas of major public/private relevance .

1.3 Research Highlights

MIT Portugal is a research platform for cutting-edge concepts in emerging areas of science and technology. Emphasis has been placed on novel biomedical therapies and devices, sustainable energy and transportation systems, and new engineered products. Research is conducted by faculty, students and scientists at the universities and laboratories that make up a unique educational consortium, in close collaboration with companies and other institutions. Long lasting connections among academia, research centers and industry were created in a successful “entrepreneurship ecosystem” akin to the one for which MIT is renowned, in which marketable products and technologies are developed along with new knowledge in each research discipline.

Projects have been undertaken in many subjects, under a multidisciplinary approach. Some respond to medical issues, others to energy and transportation challenges. Some intend to generate new products, others to change public policies. All of them are being undertaken in areas with high potential to advance in their fields in the next decades, namely by supporting Portuguese companies to develop new products and services in an international context that facilitates exports.

Improving the extent and quality of life is one of the main goals of the research being conducted in the program. In partnership with hospitals, enterprises and startups, scientists at laboratories and universities are developing intelligent medical devices that will enhance the movement of those with disabilities or assist in fostering non-invasive heart surgery. Stem cells expanded through innovative methods that allow for faster growth have already been tested in humans through the administering of cell therapies. In addition, , the design of models that can predict negative outcomes for patients was developed to permit early diagnosis of problems and save lives through a quick response .

Saving lives is also a main concern in some of the transportation research. The development of safer vehicles that can adapt speed limits to the temporary or permanent limitations of the driver and driving conditions is under study, along with the transformation of roads into mega-sensors that can interact with in-vehicle sensing systems in order to improve traffic flow. Other ways of enhancing circulation in public roads are being assessed, and proposals range from the sharing of taxis to the development of smart carpooling initiatives that take into account a number of variables. The integration of transport, land use, and energy data may also assist in the revitalization of urban areas and in policy making for better resource use.

Not all transportation happens on the ground. Air travel is a key topic, and the study of networks, congestion, and future scenarios has facilitated the design of models for airport development – a main issue in the Portuguese political agenda for the next few years. Companies and public enterprises have already shown an interest in testing these transportation models, and are involved in their development through the sharing of data and the creation of business models that will integrate them.

Another area that will bring major changes to policy and habits is energy. With the predictable expansion of electrical vehicles, their impact on the grid must be optimized, particularly to bring energy demand closer to its supply in the context of a high renewable energy contribution.. Though their use is still limited, they will soon become a major part of the automotive pool, bringing a significant reduction in CO2 levels by facilitating the penetration of renewable energies. However, this will represent a significant level of stress in the energy matrix. Preparing for this upcoming

reality is necessary, as there will be an increase both in energy demand for electric vehicle charging and in the production of soft and hard interfaces to assist this process.

The energy matrix itself is currently undergoing major changes. The share of renewable energy is growing all over the world, and Portugal is at the forefront of this renewal. With the support of MIT and Portuguese researchers in association with the local government and enterprises, the archipelago of the Azores is being transformed into a living laboratory for testing innovative technologies to be developed by Portuguese companies, and to foster a living test bed where by 2018 75% of the energy production should come from renewable sources. Furthermore, the small island of Corvo will soon become self-sufficient in generating production, with the wind and the sun as its main resources. This model has great potential to be used in other isolated islands throughout the world, and ultimately will be a small scale representation of the Earth itself, thus leveraging the capacity of Portuguese companies to export products and services worldwide. Bio-energy production is also a topic under study, looking particularly at the viability of electron transfer between microorganisms and solid substrates.

Other microbial organisms being researched are the E. coli bacterium, this time with a focus on the development of improved cell factories with the ultimate goal of generating an overproduction of amino-acids for the food industry. The association with companies, including major players in Portugal and the universities, is fundamental to these developments. Another major company involved in the program is part of a project regarding forest fire management and control. A contribution in terms of data gathering and methodological innovation on its analysis is expected, with the potential to generate new policy and improvements in operations.

The extent to which laboratories, companies, and universities have come together to implement this research can be seen in Table 1 below. Though all projects are still under way, significant results have already been achieved, and others are expected soon. These are described further in the highlights (Section 2) and research call projects (Section 3) portions of this report.

Table 1. Research Highlights

Research Highlight	Subtopic	Main Researchers and Stakeholders	Associated Laboratories and Companies	Universities/Schools
1. Extending life through faster stem-cell development		Joaquim Sampaio Cabral, Cláudia Lobato da Silva, Pedro Andrade, Francisco Santos, Joana Boura, David Malta	IBB	IST/UTL
		Sangeeta Bhatia		MIT
		Manuel Abecasis	Instituto Portugues de Oncologia	
			Crioestaminal	
			Life Technologies, Inc.	
2. Biomedical Devices	a) Enhancing mobility with hybrid orthoses	Miguel Tavares da Silva, Jorge Martins		IST/UTL
		Paulo Flores, Luis Ferreira da Silva		U. Minho
		Hugo Gamboa	Plux	
	b) Saving Lives With Stent Grafts	João Paulo Carmo	Algoritmi	U.Minho
		Anabela Carvalho	ICS	
		Luis Rocha, Júlio Viana, António Pontes, Alexandra Sepúlveda (LTI student)	IPC	
		Joaquim Gabriel Mendes, Isa Santos (LTI student), Cristina Oliveira	IDMEC-Porto	U.Porto
		João Tavares	INEGI-Porto	
		José Machado da Silva	INESC-Porto	
		Alexandra Rodrigues, Bin Li, Lígia Figueiredo	ICEMS	IST/UTL
		Brian Wardle, Fabio Fachin		MIT
		Roncon de Albuquerque, Sérgio Sampaio	Hospital de São João	

Research Highlight	Subtopic	Main Researchers and Stakeholders	Associated Laboratories and Companies	Universities/Schools
3. Models for the Design and Operation of Integrated Energy Systems Enabling Large Scale Renewables	a) Green Island	João Peças Lopes	INESC-Porto	U. Porto
		Vitor Leal	LAETA	
		António Vallera, João Serra		FC/UL
		Paulo Ferrão	ISR	IST/UTL
		Carlos Silva, Tiago Farias	LAETA	
		Francisco Botelho	EDA	
		António Vidigal	EDP	
		António Carrapatoso	EFACEC	
		João Nuno Mendes	GALP	
		Luis Quaresma	Novabase	
		José Cabral Vieira	Regional Government of Azores	
		David Marks		MIT
		Steve Connors		MIT
	b) Massive Deployment of Plugged-in Electric Vehicles	Carlos Henggeler Antunes	INESC-Coimbra	U. Coimbra
		João Peças Lopes, Manuel Matos	INESC-Porto	U. Porto
		Pedro Lima	ISR	IST/UTL
		Carla Silva, Carlos Silva, Christos Yoakimidis	LAETA	
		António Vidigal	EDP	
		António Carrapatoso	EFACEC	
		João Nuno Mendes	GALP	
		José Basílio Simões	ISA	

Research Highlight	Subtopic	Main Researchers and Stakeholders	Associated Laboratories and Companies	Universities/Schools
4. Modeling Mobility and Metabolism for Urban Sustainability	a) Sustainable Urban Mobility	António P. Antunes, Gonçalo Correia		FCT/UC
			Geotaxis	
		José Manuel Viegas, Luís Martinez, Rosário Macário, João Abreu, Silva, Gonçalo Santos (PhD student), Tomás Eiró (PhD student)		IST/UTL
		Christopher Zegras, Moshe Ben-Akiva, Joseph Ferreira, William Mitchell, Joseph Sussman		MIT
			EasyBus, ISA, S.A.	
	b) Integrated Transports and Energy Modeling	Francisco Câmara Pereira, Ana Almeida		FCT/UC
		Teresa Galvão, Ana Camanho, Carlos Bento		FE/UP
		João Abreu, Samuel Niza, Leonardo Rosado		IST/UTL

Research Highlight	Subtopic	Main Researchers and Stakeholders	Associated Laboratories and Companies	Universities/Schools
5. Developing Systems for Smart Vehicles	a) Adapting the Vehicle dynamic parameters to the driving Environment and Driver capabilities	José Manuel Viegas, Silvia Shrubsall, Luis Picado Santos, Ana Paiva, João Dias		IST/UTL
			INiR, Tranquilidade, PRP	
		Jorge Santos		U. Minho
		Nancy Leveson, Qi Hommes		MIT
	b) Integrated Systems for Smart Interiors	Francisco Pires, Pedro Camanho, António Torres Marques, António Carneiro de Araújo		FE/UP
		António Ribeiro, Elsa Henriques, Filipe Cunha, Mihail Fontul, Marta da Silva Carvalho		IST/UTL
		Higino Correia, João Paulo Carmo, Paulo Mateus Mendes	TMG Automotive, Sunviauto, Fibersensing, Iber-Oleff	U. Minho

1.3.1 Extending life through faster stem-cell development

Stem cells are one of the "hot topics" of the moment. While its possible uses are increasing rapidly, discussion about which of them should be allowed for research and treatment can evoke passions. Meanwhile, at the MIT Portugal Program, the first successes have been achieved through their faster development and the production of a cellular therapy. A partnership with the Portuguese Institute of Oncology (IPO) Francisco Gentil has allowed for its testing in humans, with very encouraging results. Those have originated a startup (Cell2B) that intends to produce the therapy in larger scale, and the Portuguese company (Crioestaminal) shall further develop knowledge related to the expansion of such cells.

Mesenchymal stem cells (MSC) are currently exploited in numerous clinical trials to investigate their potential in immune regulation, hematopoiesis and tissue regeneration. The frequency of MSC is considered to be as low as 0.01% of BM MNC in a newborn, declining with age to 0.001–0.0005%.

Currently applied doses are in 1–5 millions MSC/kg body weight range, thus a fast reliable, and Good Manufacturing Practices (GMP) compliant, ex vivo expansion method is needed to meet the highly demanding cell dose.

The ex vivo expansion of BM MSC for clinical applications is, presently, a very time consuming and expensive cell culture process. Moreover, the time frame to achieve clinical relevant cell numbers is normally within 3–5 weeks, which may be a considerably long period of time in the settings of cellular therapy, such as the treatment of acute graft-versus-host disease. The optimization of the expansion process should then consider all these aspects and focus on the maximization of cell yield, while reducing cell culture time, which will, as a result, reduce total process costs (which include equipment/facilities/ specialized human resources costs as well as culture-associated costs).

The work highlighted below has shortened the culture period to one week, allowing in this way to have the typically 80-120 millions of cells needed for a transplant available in about 3 weeks. The process involved permits savings of 10-20% of total costs.

Objectives & Motivation

Human mesenchymal stem cells (MSC) have become one of the most promising candidates for Tissue Engineering and Regenerative Medicine applications, mostly due to their differentiative potential and intrinsic immunologic properties. By combining a cross-disciplinary approach of Stem Cell Bioengineering and Experimental Hematology, the main objective of this project is the establishment of a reproducible, robust and efficient ex-vivo expansion system for MSC from human sources namely the bone marrow, adipose tissue and umbilical cord matrix. Therapeutic applications of MSC have progressed as far as phase III clinical trials for the treatment of therapy-resistant severe acute graft-versus-host disease (GVHD) and Crohn's disease. Clinical trials are also under way to use allogeneic MSC for treatment of myocardial infarcts, stroke and spinal cord injury, and cartilage and meniscus repair. However, due to the very low titers of human MSC in their niches, namely the bone marrow, an effective approach to isolate and expand those cells ex-vivo is needed to meet the needs of the increasing MSC clinical applications. Overall, the development of novel culture platforms for the effective and fast amplification of MSC under GMP conditions is expected to boost all medical uses of MSC.

Main Scientific Achievements

A low oxygen environment - Hypoxia

In their bone marrow (BM) niche, self-renewal and/or differentiation of MSC are governed by a complex microenvironment signaling that involves cell-to-cell interactions, soluble factors, mechanical forces and oxygen tension. A 2% O2 hypoxic environment was found to improve BM MSC expansion levels by inducing an early start of the exponential growth phase, with cells starting cell division earlier in culture compared to normoxia. In addition, we observed an increase of cellular metabolism efficiency, associated to the adaptation of BM MSC to the low oxygen tension environment. These results gave important insights on how hypoxia culture favors human BM MSC ex-vivo expansion, being advantageous towards the maximization of cell yield in a clinical-scale MSC expansion process (Fig. 1) [1].

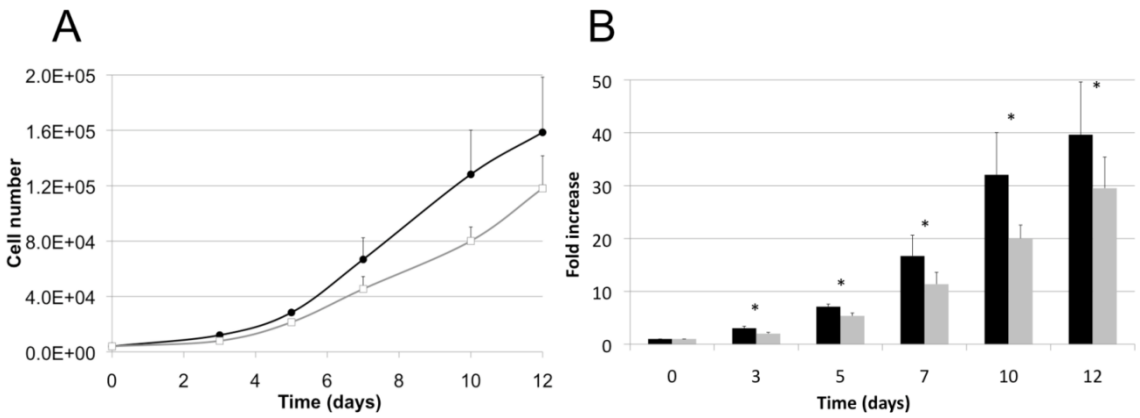


Figure 1: Ex-vivo expansion of human BM MSC under hypoxia (2% O2) and normoxia (20% O2). Total cell numbers (A) were determined throughout the culture for both hypoxia (black circles) and normoxia (white squares) and the fold increase values in total cell number (B) obtained for hypoxia (black bars) and normoxia (gray bars) are presented as mean ± SEM (*p < 0.05) [1].

Culture under Stirred conditions

MSC cultures have been performed in traditional culture flasks under static conditions, which are limited in terms of cell productivity, their non-homogeneous nature, resulting in concentration gradients (pH, nutrients, metabolites...), difficulty of monitoring and an extensive handling requirement for feeding/harvesting procedures and limited productivity. Therefore, the development of a reproducible and robust process is required for the production of clinical relevant human MSC numbers. We demonstrated the feasibility of using a microcarrier-based stirred culture system for the efficient expansion of both BM and adipose tissue (AT)-derived MSC under stirred conditions, using a low-serum medium (Fig. 2) [2].

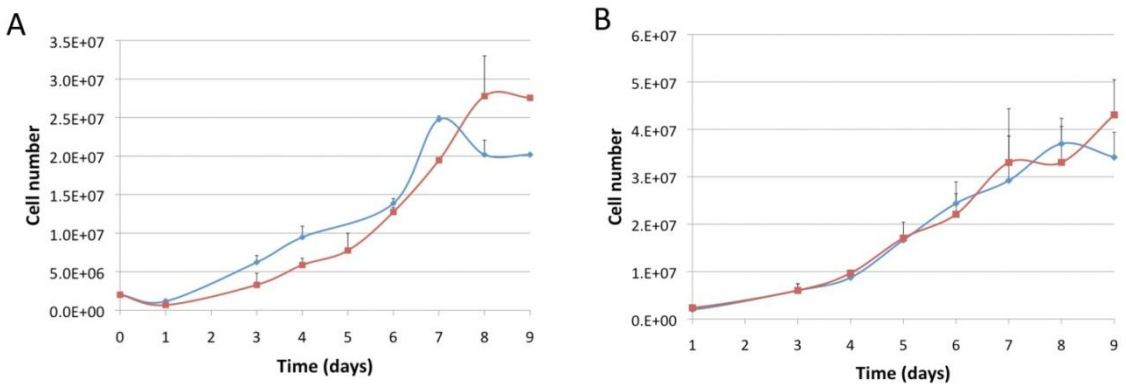


Figure 2: Expansion of BM (A) and AT (B) MSC in spinner flasks using low serum (2% Fetal Bovine Serum) media. We compared Cultispher S gelatin-microcarriers (blue line) with the animal-free plastic microcarriers (red line) as support for MSC adhesion and proliferation. Results are presented as mean ± SEM.

More recently, we successfully adapted our microcarrier-based culture system to xeno-free conditions, being also able to support the expansion of BM- and AT-derived MSC, but also those obtained from umbilical cord matrix, while maintaining the characteristic immunophenotype and multipotency differentiation potential. These results represent a major breakthrough towards the clinical-grade production, GMP compliant, of safe and effective MSC for cellular therapies.

Clinical-scale production of MSC for Cellular Therapies

The consortium between IBB-Institute for Biotechnology and Bioengineering/Instituto Superior Técnico (IST), Instituto Português de Oncologia de Lisboa Francisco Gentil and Centro de Histocompatibilidade do Sul, worked on the isolation and ex-vivo expansion of MSC under GMP conditions for Cellular Therapies, which was established in 2007. Since then, 8 patients have already benefited from this pioneer treatment. MSC were used in the treatment or prevention of graft-versus-host disease (GVHD) and also to facilitate allogeneic hematopoietic stem cell engraftment and decrease regimen-related toxicity. The clinical cases under this project for the last years include:

Acute GVHD
Extensive chronic GVHD
Hurler's syndrome
Familial hemophagocytic lymphohistiocytosis
Aplastic anemia

Figure 3: Images of an ex-vivo expansion of human MSC for cellular therapy under GMP-conditions in a clean room at Centro de Histocompatibilidade do Sul, Lusotransplante, Lisboa.

References:

[1] dos Santos F, Andrade PZ, Boura JS, Abecasis MM, da Silva CL, Cabral JMS, Ex vivo expansion of human mesenchymal stem cells: a more effective cell proliferation kinetics and metabolism. J Cell Physiol. 223: 27-35, 2010

[2] Eibes, G., dos Santos, F., Andrade, P. Z., Boura, J., Abecasis, M. M., Lobato da Silva, C., and Cabral, J. M. S. Maximizing the ex-vivo expansion of human mesenchymal stem cells using a microcarrier-based culture system. Journal of Biotechnology. 146: 194-197, 2010

Potential economic/social impact of the results achieved

The research on stem cell biology and bioprocessing and related scientific activity in the Stem Cell Engineering for Regenerative Medicine initiative within MIT Portugal Program will enable us to improve the fundamental knowledge of stem cell features and potential uses, towards the delineation of effective clinical-grade technologies for the controlled expansion and/or differentiation of adult stem cell populations. The full implementation of these novel technologies will potentially improve the quality of life and further extend the lifespan of the patients suffering from different hematological diseases. During the next years we anticipate that more patients could benefit of this stem cell-based therapy, and we also envisage a broadening of its application to non-hematological diseases.

A comprehensive study of MSC obtained from the alternative sources to the bone marrow as adipose tissue of umbilical cord matrix can potentially lead to an increase in MSC availability which can be considered for clinical application. These cells can be used either “fresh” or upon cryopreservation; the creation of biobanks for cryopreservation of expanded MSC would fulfill MSC needs for a wide range of applications, decreasing the delay in the time period to infusion. These

cells can also constitute the starting material for many Tissue Engineering settings such as the generation of cartilage or bone grafts for tissue regeneration/repair.

The fundamental knowledge and technologies related to the expansion of MSC from the UCM might be further developed by the Portuguese company Crioestaminal – Saúde e Tecnologia SA.

In January 2011, Cell2B, a spin-off from IST, was launched by four enthusiastic PhD students. Cell2B is dedicated to the development of a MSC based-therapy to prevent and treat organ rejection in patients undergoing organ or tissue transplants.

Role of non-academic partners

Instituto Português de Oncologia (IPO) Francisco Gentil, Lisboa: IPO Lisboa is responsible for the selection of the patients to be enrolled in the trials, as well as BM harvesting from third-party donors and MSC infusion.

Associação Portuguesa Contra a Leucemia (APCL) and Grupo Mello Saúde provide funding support.

Life Technologies, Inc., Carlsbad, CA, USA: Life Technologies provides commercialized and early stage prototype reagents (e.g. xeno-free media) and protocols to be applied to the culture systems employed at IBB-IST.

Crioestaminal – Saúde e Tecnologia S.A.: Crioestaminal is contributing to the project with technical support on umbilical cord processing and banking, as well as funding support.

Statement of a major stakeholder

The MIT Portugal research application area of Stem Cell Engineering for Regenerative Medicine (StemCellnet) was named in December 2009 by MIT President Susan Hockfield as “an area in which Portugal could be globally competitive”. As the scientific problems we tackle “grow more and more complex,” she said, “we must all grow more adept at working in flexible teams – across the boundaries of our disciplines, between institutions, and around the world. StemCellnet will be an important tool for creating such wide-ranging scholarly connections.”

Susan Hockfield, MIT President

Main Researchers Involved

IBB (IST/UTL): Joaquim Sampaio Cabral, Cláudia Lobato da Silva, Pedro Andrade, Francisco Santos, Joana Boura, David Malta
IPOFG: Manuel Abecasis
MIT: Sangeeta Bhatia

Companies Involved

IPOFG, Crioestaminal, Life Technologies, Inc.

1.3.2 Biomedical Devices

Medical devices can substantially increase the quality of life for those with specific limitations. Whether patients have a motion disability or suffered a heart aneurysm, resorting to an instrument that will assist in bringing their lives back to normal or mitigate problems that have always been there can make all the difference. At the universities and companies that constitute the MIT Portugal Program's open research platform, a smart stent graft is being developed and shall foster the use of this device – implanted by minimally invasive therapy – by diminishing the need for post-surgical monitoring. Likewise, an ankle-foot orthosis will support patients in the recovery of lost mobility or the mastery of movements they were previously unable to make. These two examples are highlighted in the next sections.

a) Enhancing mobility with hybrid orthoses

Ankle-Foot Orthoses (AFOs) are technical aids that promote locomotion and rehabilitation of individuals with gait pathologies. Every pathology has its own requirements and this has led to classical solutions that are far from optimal in terms of comfort and overall performance for restoring the human gait.

In this work, a computational multibody dynamics approach is adopted. A multibody model of an active AFO is developed and integrated in a whole-body multibody human model developed in the MATLAB environment. The two subsystems are interconnected using a contact/friction interface model. The proposed model has the major advantage of allowing the analysis of the phenomena associated with the use of an orthosis at a local and global level. At the local level the design for comfort is addressed by calculating the pressures resulting from the interaction forces generated between the orthosis and the biological structures. At the global level, the effects of the additional weight of the AFO are analyzed by calculating the moment increase at the knee and hip joints for the prescribed movement.

The obtained results shows that the integrated system is sensitive to the contact points, their number, location, the properties of the surfaces in contact and the orthosis characteristics in terms of mass properties and strap adjustment (or pre-tension) between the orthosis and the lower limb.

The presented results also provide means for a better understanding of the interface phenomena and suggest that the proposed model may now be used to perform the sensitivity analysis of the system to specific design parameters and also its numerical optimization in order to achieve optimal orthosis designs.

Objectives & Motivation

Our collaborative research in biomedical devices aims to significantly enhance human mobility. The DACHOR project contributes multibody dynamics and control modeling for the development of an innovative powered Ankle-Foot Orthosis (AFO) with hybrid actuation to aid individuals with reduced mobility and neuromuscular disabilities. The innovative aspects of this project include the analysis of the musculoskeletal dynamics of an integrated biomechanical model of the patient and orthosis; the development of a hybrid actuation solution, with dynamic scaling of the control authority between a functional mechanical actuation, provided by an external power drive, and functional electrical

stimulation (FES) from select muscles; and the development of an adaptive control law that dynamically regulates the amount of support and rehabilitation provided by the orthotic device. Our innovations strive to improve locomotion and enhance muscular rehabilitation, while providing wearable sensing and devices that realize power, size and weight benefits. Faculty from multiple Portuguese universities, a Portugal biomedical start-up, and MIT are successfully leveraging their experience and passion to dream about the possibility of a world without disability, where everybody is abled through human-machine hybrid devices and designs.

Main Scientific Achievements

1. Development of advanced computational models for the integrated design of the hybrid AFO

Several computational models were developed, using a multibody formulation with fully Cartesian coordinates, to provide insight to the development of the physical prototypes. These models encompassed:

i) The development of a control architecture for the control of a partial multibody model of the human ankle joint by providing the proper set of muscle activations to a group of Hill-type muscle actuators:

The purpose of this work is to create a control architecture, responsible for generating the adequate muscle activations, enabling a biomechanical model to track a pre-defined reference, in an accurate and precise way. The multibody system used in this study was a representation of the anatomic segments of the lower leg, the ankle and the foot. As represented in Figure 1, the model is composed by the two rigid bodies, the lower leg and the foot, linked to each other by a revolute joint, the ankle joint. The biomechanical model is also composed by the twelve muscles that are inherent in the motion of the referred joint. From the muscle apparatus of the ankle-foot anatomic system, only four muscles were chosen to be actively controlled. The other muscles were included in the biomechanical model, regarding the potential passive forces they could produce, which could interfere during the gait and are also represented in Figure 4.

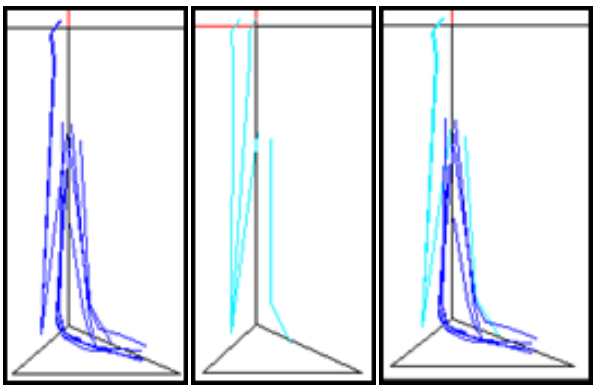


Figure 4. The biomechanical model together with the muscle apparatus under analysis, depicting three different views of all muscle apparatus. In light blue, the muscle actively controlled.

Using a combined feedforward/feedback approach, the controlled angle was almost coincident with the predefined reference, and it can be concluded that the performance of the controller improved with the adopted feedforward methodology.The activation patterns and muscle forces generated by the four muscles actively controlled are presented in the Figure 5. The controller results exhibit co-

activation of muscles which indicates cooperation between antagonistic muscular functions, as it occurs in the human body.

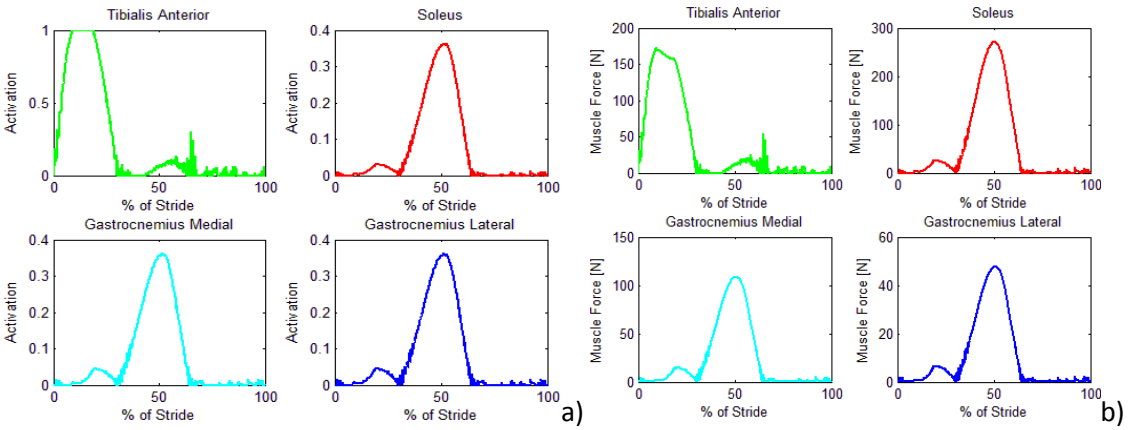


Figure 5. Muscle activations (a) and muscle forces (b), for a combined feedforward/feedback approach.

ii) Development of a novel Hill-type muscle actuator with an integrated three compartment fatigue model:

The aim of this work was to develop a versatile muscle model and robustly implement it in an existent multibody system dynamics code with natural coordinates. Two different models are included: the first is a Hill-type muscle model that simulates the functioning of the contractile structures, both in forward and in inverse dynamic analysis; the second is a dynamic muscular fatigue model that considers the force production history of each muscle and estimates its fitness level using a three-compartment theory approach and a physiological muscle recruitment hierarchy. The functioning of both computational models is schematically depicted in Figure 6.

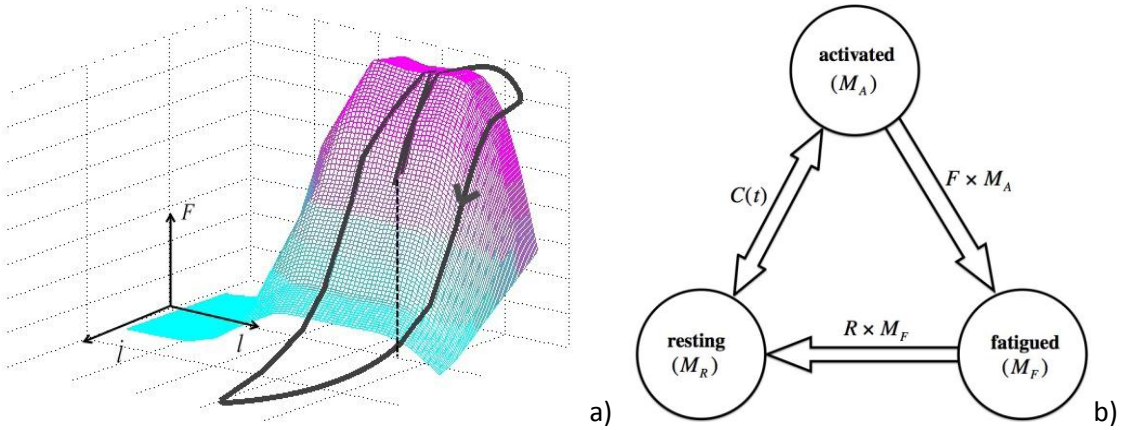


Figure 6. Schematic representation of the functioning of the implemented muscular models: Hill-type for muscle contraction dynamics (a) and three compartment for muscle fatigue (b).

The equations of motion of the existent multibody formulation were rearranged to include the referred models using the Newton's method approach. This allows, in a forward dynamics perspective, for the calculation of the system's motion that results from a pattern of given muscle activations, or, in a forward dynamics perspective, for the computation of the muscle activations that are required to produce a prescribed articular movement which is particularly important for the

integrated design of orthotics. In both perspectives the system presents a redundant nature that is overcome in the latter case using a SQP optimization algorithm.

The methodologies and models were tested in a feedback control system with muscle actuation, compelled to maintain a reference configuration of posture. Due to fatigue, muscular activations increase, in order to preserve the desired stance as depicted in the results presented in the Figure 7.

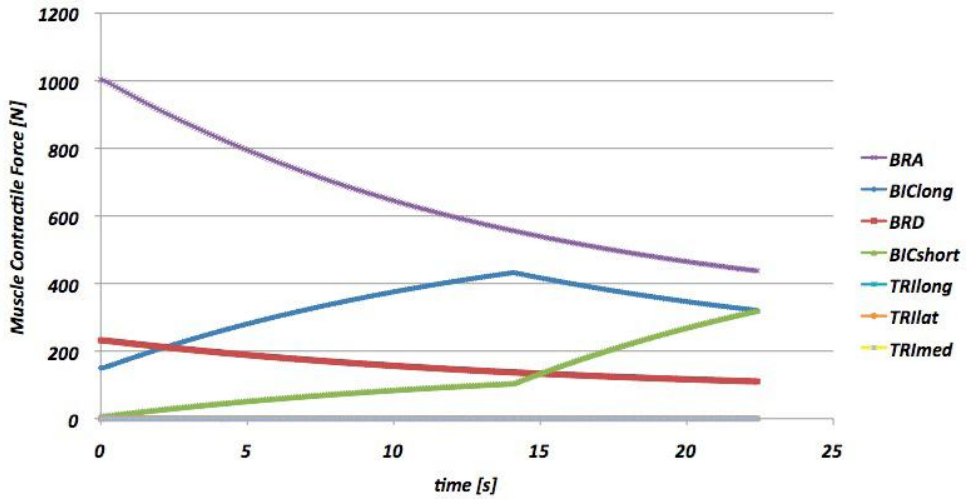
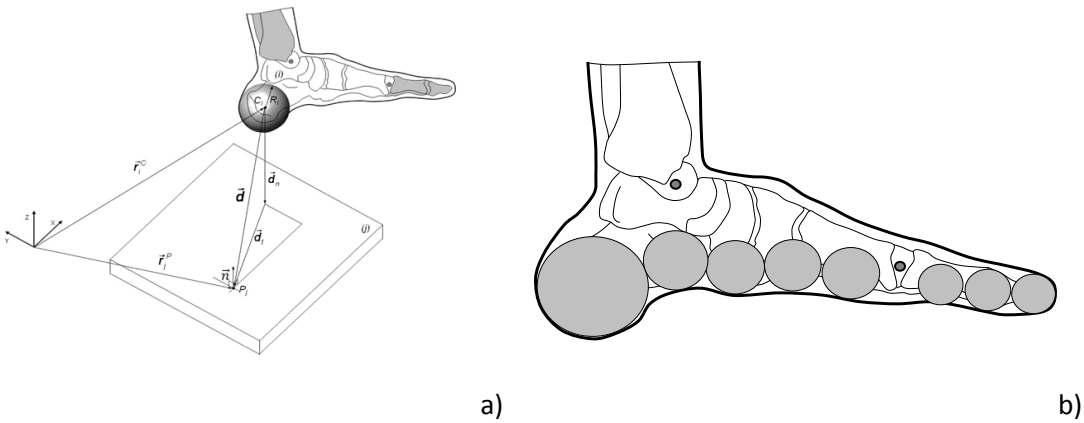


Figure 7. Resultant muscle forces of the contractile element of the biomechanical model when susceptible to fatigue dynamics.

iii) Development of a comprehensive model for the simulation of the foot-ground iteration using a non-linear continuous contact force model with viscous friction:

The main purpose of this work was to develop a three-dimensional computational multibody model that was able to characterize the interaction between the foot and ground, for serving as a computational tool in the simulation of the human gait during the stance and swing phases. The model proposed consists of the implementation of a sphere-plane contact detection algorithm, between the foot and ground, which depends on the dynamic configuration of the system. For that purpose a set of spheres, located under the plantar surface of the foot, is used for detection purposes as schematically illustrated in Figure 8.



a) b)

Figure 8. Sphere-plan contact detection methodology: Geometric representation (a) and anatomical sphere distribution on the plantar surface of the foot (b).

When contact exists, appropriate constitutive laws for the contact phenomena are applied to simulate the interaction between the foot and ground surfaces. These laws take into account the vertical reaction force as well as the friction phenomena, namely the Coulomb friction effect and the viscous elastic effect. The importance of these two effects is demonstrated through several numerical simulations. The model proved to be a very straightforward model producing very consistent results, as illustrated in Fig. 9.

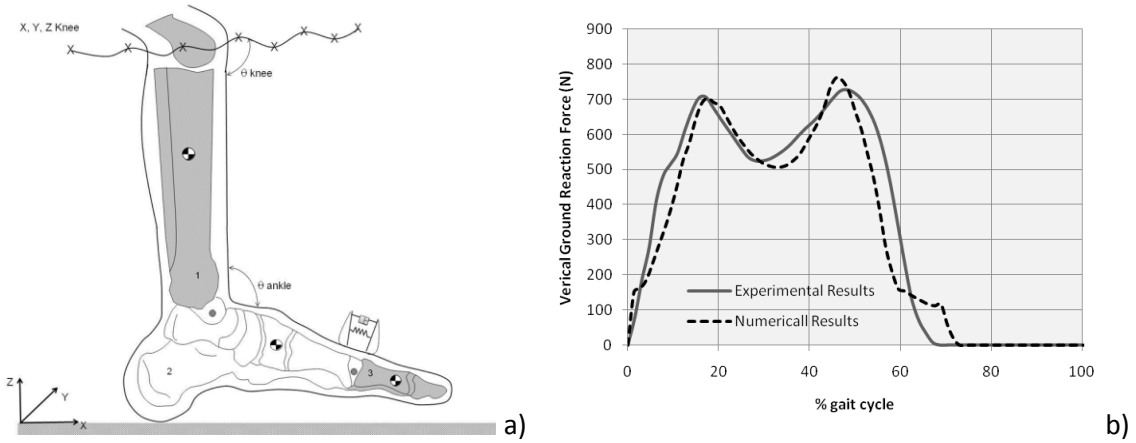


Figure 9. Foot-ground contact model representation (a) and compared results (b)

2. Construction of a physical prototype of the FMA solution that includes the construction of a series elastic actuator (SEA) regulated by impedance control (IC)

First a computational model was created to support design decision. Movement kinematics were prescribed for the knee joint and leg, and the correct movement of the ankle joint, during gait cycle, was achieved by the controller. For controlling the ankle movement, impedance control (IC) was used to mimic the human control by considering an ankle stiffness and damping during gait cycle. With impedance control, different stiffness's and damping values were set for the different phases of the gait cycle. In Fig. 10 the bloc diagram of the impedance controller is presented.

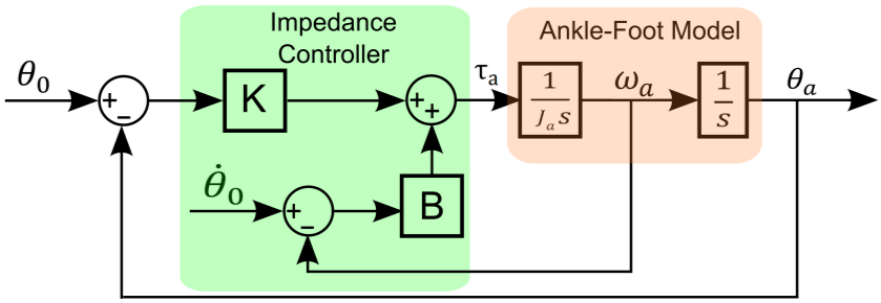


Figure 10 - Block diagram of the implemented impedance controller

From the results produced by this model an active AFO was designed for assisting the ankle movement during gait. The AAFO characteristics were based on the biomechanical requirements of an individual with a body mass of 70kg. A series elastic actuator (SEA) provides the active control of the AAFO. The SEA was designed to be lightweight, compact, and with enough power to provide the correct ankle movement during both stance and swing periods of gait. The developed AAFO is

expected to be autonomous and assist the ankle movement in all phases of the gait cycle. In Fig. 11 a schematic representation of the solution being constructed is presented.

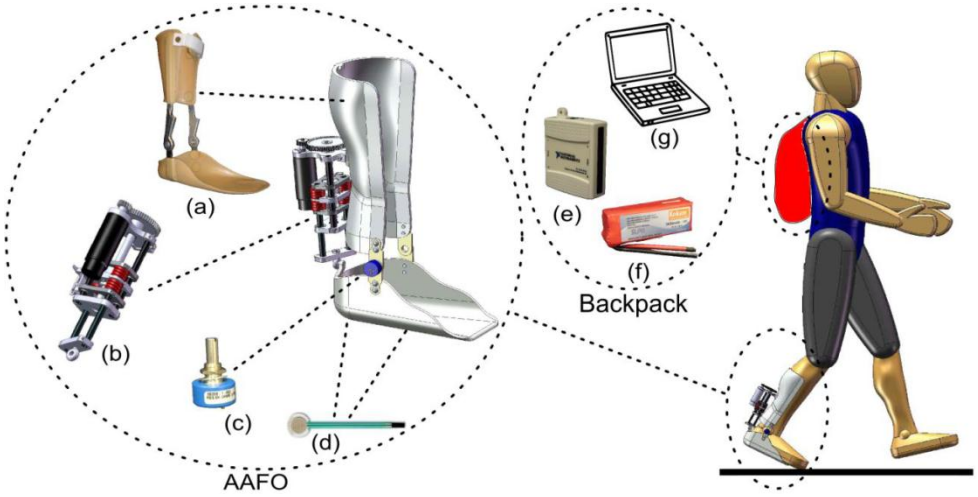


Figure 11. Representation of a patient endowed of the FMA AFO with batteries and processing unit in a backpack: (a) Ankle-foot orthosis, (b) Series Elastic Actuator, (c) Rotary potentiometer, (d) Flexible event switch sensor, (e) National Instruments DAQ unit, (f) Kokam LiPo battery pack, (g) Processing unit (Lap-top).

3. Construction of a physical prototype of an asynchronous 4 channel FES unit

A physical prototype of a FES unit was designed and constructed for the stimulation of four independent skeletal muscles. The unit has 4 asynchronous channels that deliver programmed electrical pulses, modulated in amplitude and time, to each one of the selected muscles. It is an embedded system, with custom electronics and open software, in order to allow testing of different action potential profiles. The system communicates with an external real-time controller through a serial bus, allowing the model identification and the closed loop control of the muscle contractile dynamics and the consequent control of the ankle-joint angle. The devised FES unit, presented in Figure 12, had recently the approval of the ethical committee and is presently being tested in non-pathological subjects for parameter identification of the muscle-device integrated dynamics, as also represented in Figure 12.

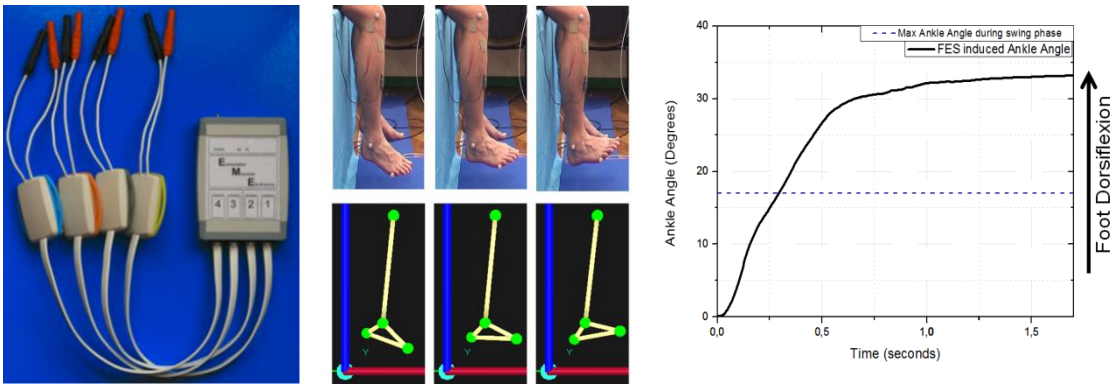


Figure 12 - Functional prototype of the FES unit developed at IST (a) and its application to the stimulation of the tibialis anterior muscle (responsible for the dorsiflexion of the foot, at the ankle, towards the leg)

4. Advanced computer methods for acquisition and analysis of pathological and non-pathological human gait patterns:

A comprehensive protocol for gait analysis is proposed that consists of an effective and yet efficient methodology for subject instrumentation and laboratory setup, which enables the study of the time-distance, kinematic, kinetic and electromyographic parameters of gait. In order to automate data processing and database generation, a set of routines is developed in Matlab that allows for the calculation of average gait patterns and standard deviations associated to a given population. Additionally, these routines also allow performing straightforward comparative analyses between individual gait patterns and those averaged in the database. The developed interface is user-friendly, as illustrated in Fig. 13 and 14, suggesting its future use in clinic and in physical rehabilitation environments.

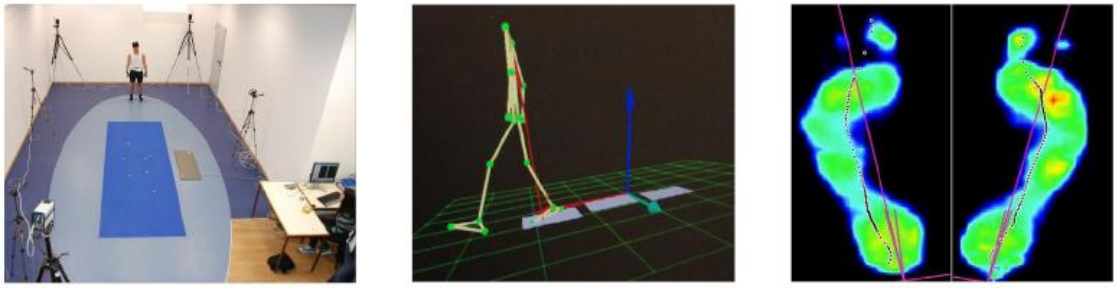


Figure 13 - General view of the movement laboratory at IST with a non-pathological instrumented subject, and aspects of the respective kinematic and kinetic data acquisition

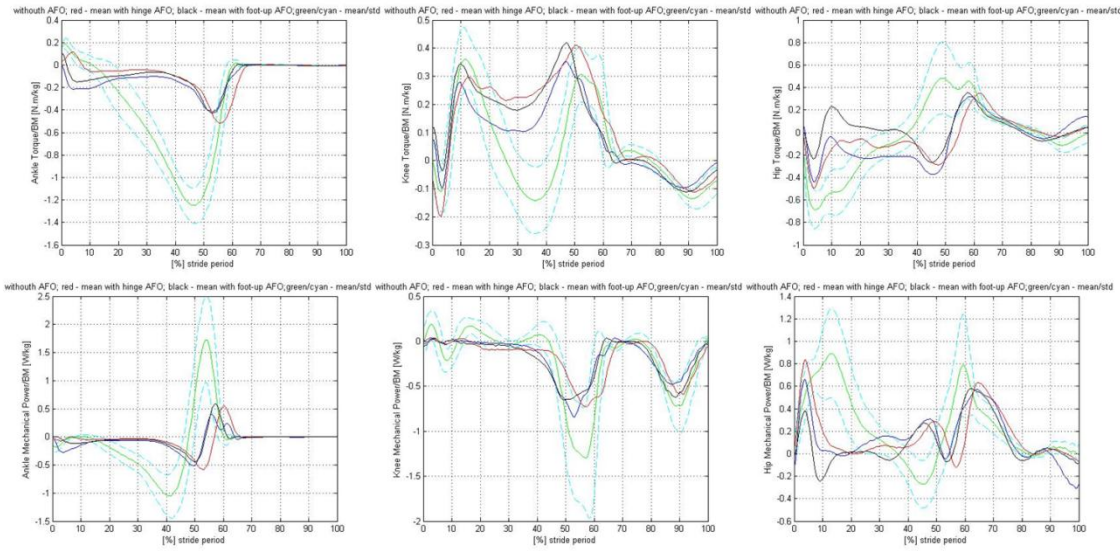


Figure 14 - Representation of torques and mechanical power for a pathological subject without orthosis (blue), with hinged orthosis (red) and with foot-up orthosis (black), and for a normal pattern (green/cyan): a) ankle torque; b) ankle power; c) knee torque d) knee power e) hip torque f) hip power.

Inverse dynamic analyses are performed making use of natural coordinates for the calculation of the articular moments and the reaction forces at the joints. If required, the redundant muscle forces associated with the observed movement are quantifite using a hill-type muscle model, an objective cost function and SQP optimization tools. The proposed methodology is applied to the analysis of the gait parameters of three non-pathological groups of the Portuguese population (children, male

and female adults) and the gait patterns of pathological subjects, being the results compared and stored in a movement database.

Potential economic/social impact of the results achieved

The project is an inter-institutional venture that joins together two MIT Portugal Program Higher Education Schools (IST and UMinho) and a Portuguese start-up company in the area of acquisition and processing of biosignals (PLUX Wireless Biosignals). It involves the participation of 3 current MIT Portugal Program PhD students that are developing their PhD programs in topics related with the DACHOR project, as well as it has involved already more than 8 MSc students from Biomedical and Mechanical Engineering who have successfully developed and defend their MSc thesis in subjects related with the scope of the project.

The outcomes of the project span from new computational modeling tools and control methods to new mechanical designs for hybrid human-machine systems. This is expected to render the creation of a new knowledge base through R&D that is disseminated through the publication of PhD and MSc theses, refereed journal papers, workshops, conference articles and media coverage. Additionally the project is already generating a forum of discussion that creates new models of interaction between universities, clinicians, companies and social end users.From the economic point of view, it is expected that several of the ideas and concepts generated within the research carried out in the scope of the DACHOR project lead the creation of new rehabilitation products in a near future and serve as proof of concept tools to the development of future assistive devices.

Role of non-academic partners

The role of Plux Wireless Biosignals, the industrial partner of the DACHOR project, is to support the development of the physical prototypes providing technical advising whenever necessary.

Statement of a major stakeholder

“Knowing that our lack of movement can one day be overcome by an external device to the body, which allows us to regain a lost motor function has a huge impact at the corporate level”.

Hugo Gamboa, Plux Wireless Biosignals, CEO in JN Negócios 24-Sep-2010

Main Researchers Involved

IST/UTL: Miguel Tavares da Silva, Jorge Martins

U. Minho: Paulo Flores, Luis Ferreira da Silva

Companies Involved

PLUX

b) Saving Lives With Stent Grafts

Researchers from University of Minho, Faculty of Engineering of University of Porto, Instituto Superior Técnico and MIT are piloting the technologies to enable a new generation of “smart” stent-grafts to save lives in the treatment of aneurysms. Most of the stent-grafts that exist today still present some post-surgery complications but as endovascular aneurysm repair (EVAR) becomes more commonplace, a new generation of implantable stent-grafts is required. With the collaboration of the Vascular Surgery Division of Hospital S. João the specifications for the new “smart” stent-grafts have been defined and a new technology based on nano-engineered materials is being developed for the fabrication of the flexible pressure sensors that will be embedded in the stent-graft. Due to the characteristics of the delivery mechanism, the smart stent-graft must be thin, flexible, with enhanced medical performance and embedded with the capability to diagnose bad placement and detect leaks.

Compute fluidic dynamic models are being used to assess the feasibility of using pressure sensors to detect endoleaks and the results suggest that endoleaks can be monitored, as well as the structural integrity of the stent-graft. Moreover, as the developed technology enables the placement of a cluster of sensors, a better understanding regarding the evolution of the aneurysm after the EVAR will be available for the medical community. First pressure sensor prototypes show a sensitivity of 14fF/mmHg for a pressure range between 6-47 mmHg, in agreement with the required application specifications.

Using novel biocompatible materials, and employing telemetric circuit design, these project aims to demonstrate that the infrastructure and know-how to integrate sensors in stent grafts at minimal costs is available in Portugal, and to validate new methods for developing medical devices. Both goals speak directly to maintaining a vibrant and sustainable medical device industry in the country.

Objectives & Motivation

An abdominal aortic aneurysm (AAA) is a permanent and irreversible localized dilatation in the aorta having at least a 50% increase in diameter compared with the normal one. Currently, it is estimated that more than 12 per 100 000 persons-year are affected by this relatively indolent but serious condition. Two treatments are currently available for the treatment of aneurysms: conventional surgical repair (open surgery) and endovascular aneurysm repair (EVAR). EVAR is a minimally invasive procedure in which a stent-graft is used, but after the procedure, regular monitoring/surveillance is required.

The objective of this project is to prove the feasibility of a smart stent-graft, a stent-graft with some in-device mechanism to perform a given function with communication capabilities to an external element. Therefore, the project tackles in a multidisciplinary way the technological challenges (fabrication and design of flexible biocompatible microsensors and graft materials characterization) as well as the social and cost benefits of an integrated solution for the treatment of aneurysms, as illustrated in Fig. 15. Novel design methodologies incorporating the cost-benefit analysis are also envisaged in the project goals.

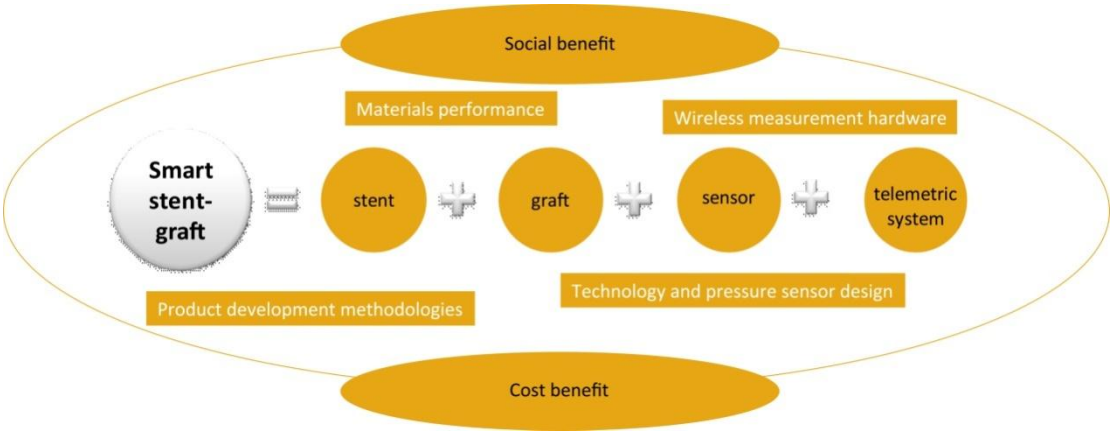


Figure 15 - Project overview

Main Scientific Achievements

1. Concept selection in the development of medical devices

When EVAR was introduced, it revolutionized the treatment of aortic aneurysms. However, after 20 years of use, questions are being raised regarding the follow-up costs. Hence, in order to reduce or even eliminate the need of expensive and (potentially) harmful imaging exams, the development of a smart stent-graft is being considered as an alternative.

The development of products starts with the identification of the customer needs. In the case of a smart stent-graft two needs were identified: devices with better performance and the reduction of EVAR's follow-up costs. The customer needs were gathered by reviewing the literature and conducting surveys of both patients and vascular surgeons. However, other techniques, such as interviews, could have been use. In order to rank the needs, a Kano analysis can be performed.

Considering the ranked needs, concepts can be defined as a group of features that the new device should have without referencing the technology necessary to accomplish them. Ideally, the design team would analyze the multiple concepts and select one or combine the best features of each idea creating a new one. However, since the development and approval of a medical device is a long process, a new method for treating aortic aneurysms could be introduced or open surgery or laparoscopy could be improved in such a way that a smart stent-graft would no longer be needed. The result is a full set of decisions that the design team could make where the option that provides the higher expected value (EV) should be selected. The expected value is defined by:

$$EV=p\cdot D\cdot\sum qm\cdot\prod ql, \qquad (1)$$

in which p represents the probability of a healthy outcome, D the demand, qm the quantitative parameters that can be expressed in monetary units and ql the qualitative parameters expressed as scaling factors.

While the demand and the probability of a healthy outcome are independent of the point of view adopted, the patient, the health professional and the person that pays may perceive the qualitative and the quantitative parameters differently. Some authors argue that the development of medical devices benefits from the involvement of healthcare professionals and the ultimate end users. However, these persons are rarely the ones that decide to buy and/or pay for a device. When

evaluating the concepts for a new medical device, each person will use different criteria not conveying the actual needs. In order to mitigate this difference, the proposed concept selection adopts the point of view of an altruist patient responsible for the full payment of the device and/or treatment.

This formulation constitutes a major advancement in the selection of concepts for other medical devices, by changing some of the quantitative and qualitative parameters, even if the problem being addressed is the development of a new endoprosthesis. Further research is needed to select the most appropriate way to calculate the willingness to pay and the quality of life.

2. Material characterization

Information regarding biocompatible materials used for stent-grafts is very scarce. From the literature review and the contacts with medical community two polymeric materials used in endovascular applications were identified and are being studied in terms of mechanical properties and textile production:

- PET - poly(ethylene terephthalate)

- ePTFE - Polytetrafluoroethylene

A third material, not currently in use in stent-grafts, but with increase interest for biomedical applications, is also being studied, for comparison:

- UHMWPE – Ultra High Molecular Weight polyethylene

The properties of the materials under study were compared when delivered as fibers. The industrial process for fiber production, changes the material properties drastically due to the fact that polymer chains become better oriented and more crystalline, increasing intermolecular bonding forces. The results presented in Fig. 16 compare properties like young modulus, tensile strength, density and tenacity. It is concluded that UHMWPE exhibits an excellent behavior, compared with PET and ePTFE. However there are properties, like abrasion resistance and fatigue limit stress that were not found quantitatively measured in literature. Those properties are very important to quantify, for a proper material selection procedure. On the other hand the extremely high Young's Modulus of UHMWPE, reduces fibers flexibility, which is a very important property to control and should be the highest possible.

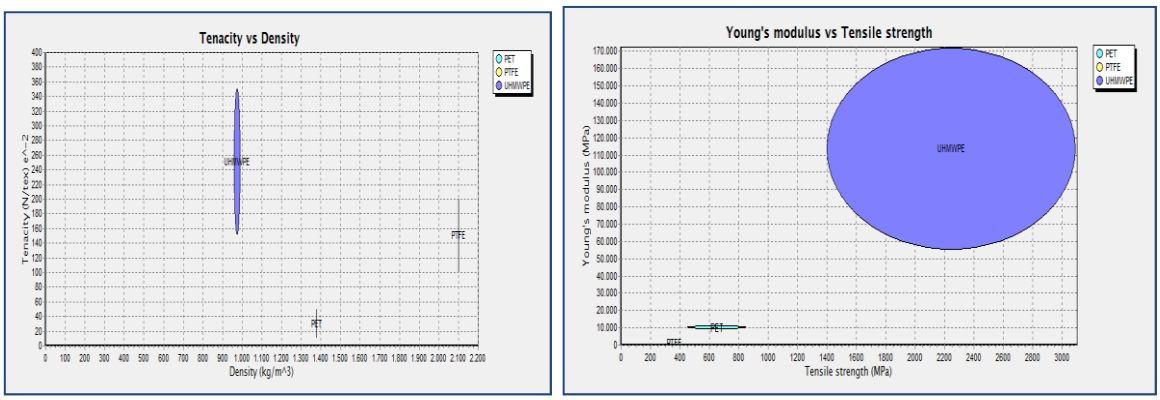


Figure 16 - Materials properties comparison

Stress values for the fibers under blood flow were computed and results show that any of the 3 fiber materials can support them. In order to improve knowledge on the materials, abrasion tests were performed on PET and ePTFE fibers. Wear resistance tests show better results for PET grafts with ruptures observed after 65000 cycles, while ePTFE exhibited ruptures between 40000 and 50000 cycles (Figures 17 and 18). A new developed material, PET (low profile), is currently under study showing considerable increase of resistance to wear. Tests conducted until 100000 cycles didn't reveal any ruptures. It is concluded that this new material can be an excellent alternative for the next generation of smart stent-grafts, since wear resistance is one of the most important properties for the endoprosthesis application.

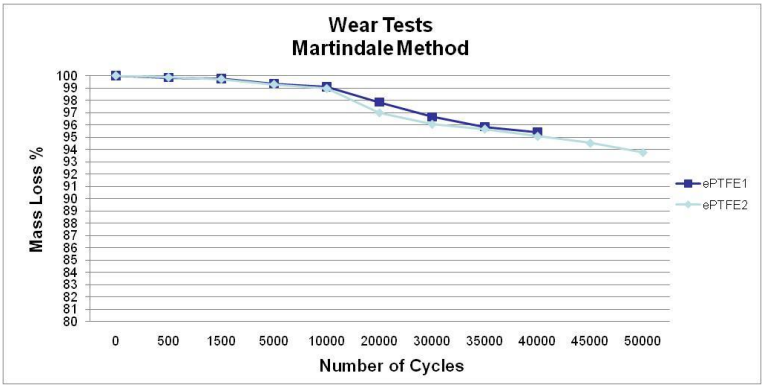


Figure 17 - Wear tests with ePTFE

3. Flexible sensor design and fabrication

A key component for the smart-stent graft is the sensor. A pressure sensor is being developed with the specification that it must be flexible, enabling its conformability to the stent-graft and thus the aorta. This aspect brings several advantages, in comparison with available devices, since the sensor can be attached to the stent-graft and delivered in a single procedure and it enables the placement of more than one sensor (a sensor cluster) contributing to a more comprehensive study of post-EVAR aneurysm evolution (that is currently not possible).

Optimizing the technology process flow to enable the fabrication of a flexible pressure sensor is the purpose of the project, and is schematically presented in Fig. 18. Acrylic moulds are produced by CNC milling (Figure 18a) for posterior fabrication of the PDMS membranes. This technique has low costs and fast production times, but it is associated with poor dimensional control (dimensions less than 50 μm are difficult to achieve). The electrical components are based on aligned CNTs, as shown in Figure 5b. Chemical vapor deposition (CVD) is used to grow forests or “carpets” of vertically-aligned CNTs. A silicon substrate with patterned Fe/Al2O3 catalyst is placed on a horizontal quartz tube furnace at atmospheric pressure at 750 ºC for the CNT growth. This method has the advantage of allowing the growth of high purity, high yield and vertically aligned CNTs. Next, the CNTs are embedded into the polymer matrix (PDMS). This step is schematically represented in Figure 18c. The substrate is placed against the moulds, and the PDMS is introduced in the cavities through a hole, followed by the curing of the elastomer.

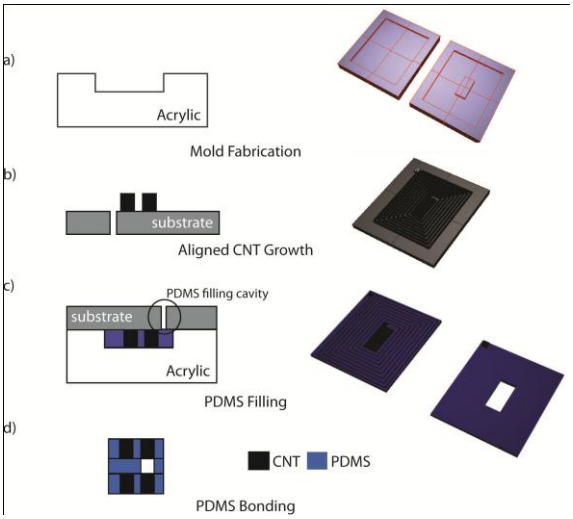


Figure 18 - Fabrication process flow for the development of a flexible pressure sensor with aligned-CNT/PDMS nanocomposites.

Three flexible membrane layers are required to fabricate the sensor, with the top and bottom layers defining the inductor and the electrodes, and the middle one defining the dielectric (air). This configuration requires bonding of PDMS membranes. The uncured PDMS adhesive technique is being used to build the sensors, Figure 19.

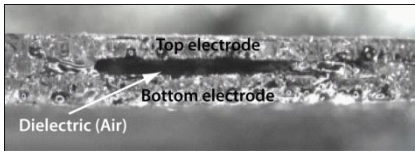
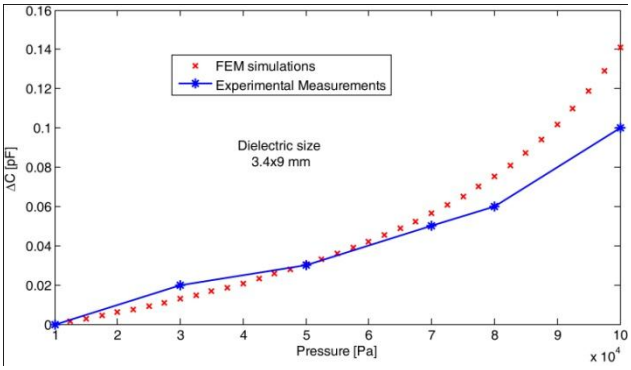


Figure 19 - Cross section of a CNT/PDMS flexible pressure sensor.

Experimental results using non-optimized PDMS/CNT flexible pressure sensors are presented in Figure 20. The tested sensors have a mechanical layer thickness of 670 m and an area of 3.4 x 9 mm3 (L x W). Despite the crude sensor resolution (the geometry was not optimized since the devices aimed just the proof of concept), capacitive changes were measured when the sensor was placed inside a controlled pressure chamber (the dielectric is hermitically sealed at ambient pressure), and the results are very encouraging.

a)



b)

Figure 20 - Experimental results of a non-optimized CNT/PDMS flexible pressure sensor. a) capacitive changes vs. pressure and b) image of the sensor with 10000 Pa external pressure.

4. Telemetry circuit

The telemetry circuit is an important feature of the smart-stent graft since it will enable the measurement of the sensor without any contact while providing the required energy for the measurement, and developing it is the objective of another project. An overview of the devised system is depicted in Figure 21.

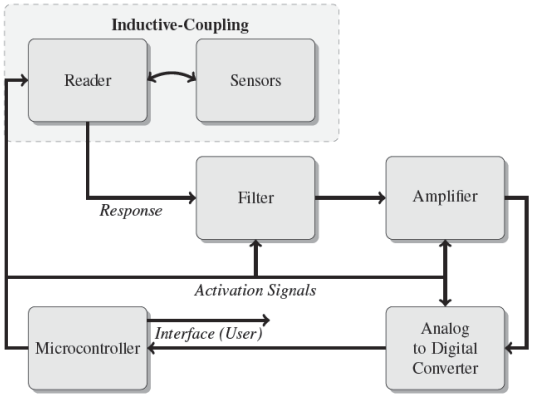


Figure 21 -Telemetry system overview

After some initial tests using current available techniques, where transmition distances were small, a new differential approach is proposed (Figure 22). The approach includes a new twin circuit added to the first part of the reader that recreates the undesired harmonic signals by simply isolating one of the inductors from the sensor. By duplicating the undesired signal, the sensors' oscillation frequency is obtained by subtracting the two signals using the instrumentation amplifier. During the subtraction operation, the common-mode noise is also eliminated, increasing the output signal's quality.

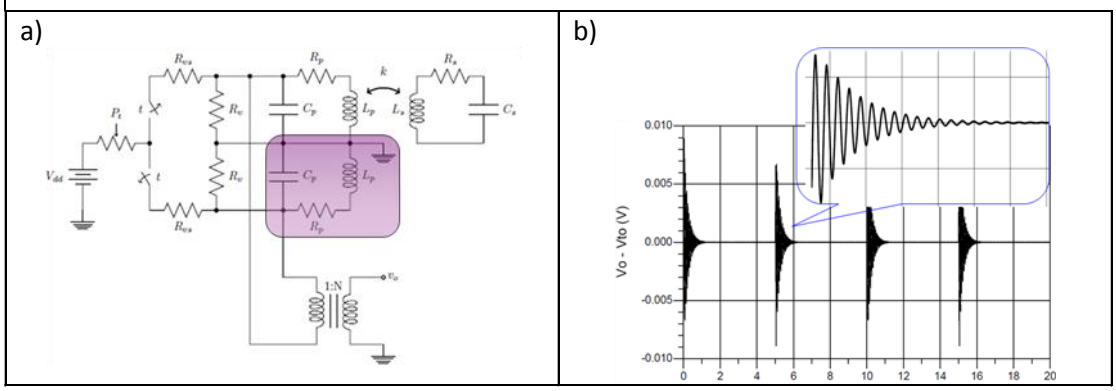


Figure 22 - Novel differential approach. a) schematic and b) simulation results.

The novel configuration developed in this project is being tested using COTS (Components-Of-The-Shelf) and a validation with optimized designed pressure sensors is being prepared to analyze the new device feasibility.

Potential economic/social impact of the results achieved

This project has a high technical content, and therefore, the potential economic impacts related to the technology are not restricted to the medical device area, but can be applied to other areas. A particularly interesting area is the textile industry, where flexible sensors can be easily integrated in the textiles, and withstand the characteristic drying and washing cycles.

Regarding the main target application, the main potential and social impact of the research achievements are twofold: on one hand, the developed methodology for concept selection will be able to access the real social and economic benefit of new medical devices, but particularly the new smart stent-graft. This is an important tool for medical device's industry and will help to focus on the development of the features that actually bring social and economic benefits for both the users and the healthcare professionals at an early stage of the development process – concept selection.

On the other hand, the technological innovations involving work being developed at three different Portuguese universities plus MIT, are paving the road to a new class of microsensors – low-cost flexible sensors. The technology is new in the field of microsensors and this type of technology is not limited to biomedical applications. A measurable indicator of the research achievements is an industrial project that will start March 2011, where the technology to build flexible pressure sensors is going to be adapted to build a flexible platform with pressure sensors to place in wheel chairs in order to monitor patient posture.

Role of non-academic partners

The main non-academic partner involved in this project is Hospital S. João (HSJ). The angeology and vascular surgery division of HSJ is actively collaborating in the project and is providing the necessary medical input for the development of the novel endoprosthesis. Moreover, they are helping defining the required costumer needs and provide access to patients.

SPACV – Sociedade Portuguesa de Angiologia e Cirurgia Vascular (Portuguese society of angeology and vascular surgery) is also collaborating, helping with the distribution of the questionnaires to their associates.

Besides these two active partners, the team is in contact with Cook (stent-graft producer), which provided a few endoprosthesis for analysis, Fitexar, a textile producer that has the means to produce the grafts, and Malmö Vascular Center - Lund - Skånes University Hospital, that performs applied medical research with stent-grafts (on aneurysm treatment) and provides technical advice on materials.

Statement of a major stakeholder

"The participation of Hospital de São João in the project SenseCardioHealth (Massachusetts Institute of Technology, Cambridge, USA; Faculdade de Engenharia da Universidade do Porto; Instituto Superior Técnico; Universidade do Minho) is relevant for the following reasons: a) diversification of the research lines of the angeology and vascular surgery division – medical devices development is an area not usually tackled by the clinical services in Portugal; from this participation doctors are exposed to new technologies and methods, resulting in the development of new capacities; b) institutional and personal networking, from which new research opportunities might arise for the future; c) the expected product resulting from this research project, regardless of its complexity, is certainly of clinical importance, enabling the capability to prevent large complications through information until now not available, improving current treatments used pos-complications."

Dr. Roncon de Albuquerque, head of the angeology and vascular surgery division at Hospital S. João

Main Researchers Involved

Algoritmi (U.Minho): João Paulo Carmo
HSJ: Roncon de Albuquerque, Sérgio Sampaio
ICEMS (IST/UTL): Alexandra Rodrigues, Bin Li, Lígia Figueiredo
ICS (U.Minho): Anabela Carvalho
IDMEC-Porto: Joaquim Gabriel Mendes, Isa Santos (LTI), Cristina Oliveira
INEGI-Porto: João Tavares
INESC-Porto: José Machado da Silva
IPC (U. Minho): Luis Rocha, Júlio Viana, António Pontes, Alexandra Sepúlveda (LTI)
MIT: Brian Wardle, Fabio Fachin

Companies Involved

Hospital de S. João

1.3.3 Models for the Design and Operation of Integrated Energy Systems Enabling Large Scale Renewables

A major challenge to meeting climate change, energy security and other economic, social and environmental goals is the ability to integrate renewable energy and other dynamic energy options into national, regional and local energy systems. The highlights below describe research, which is developing new tools for the design and operation of future energy systems that will allow the cost-effective and reliable deployment of renewable energies, energy efficiency and new options such as electric transportation at large-scales.

Characteristic of these research highlights on "smart energy" are new models, which extend or replace existing approaches. These new approaches to energy system design and operation are essential to the future energy industry in Portugal and beyond, since the large scale introduction of wind, solar and other resources requires coordination with other generation sources, new efficient and dynamic end-uses, smart grids, price-responsive homes and businesses, as well as electric vehicles.

As shown below, these new approaches not only inform policy makers regarding potential clean energy opportunities, but assist companies and consumers–big and small–to enter the clean energy market in a competitive manner. These new tools, which look at the use of renewable energy in combination with other energy options, show how well coordinated investments and advanced operational approaches can make the best use of both large and decentralized renewables, while at the same time maximizing the benefits of clean transportation technologies, and smart homes and businesses, as well as avoid energy sector unnecessary investments and get the most out of the existing system. Two examples highlight the advancement and application of the models developed in the context of an island (Green Islands) and of the electric mobility (massive deployment of plugged-in electric vehicles).

a) Green Islands

Objectives & Motivation

The design and implementation of energy systems that make better use of local and less carbon-intensive natural resources in a cost-effective manner, is an international priority for governments, companies and the scientific community. This requires a highly integrated systems view of the energy uses, networks and resources in space and time, particularly when high renewable energy penetration and new dynamic energy uses add to the challenge of reliable and smart energy technologies, operations, planning and investment.

The main objective of the Green Islands Project is to promote scientific advances that foster new methods for enabling low-carbon energy systems design, and new technological developments that may contribute to internationally relevant demonstrations of "smart" highly integrated energy technologies involving the participation of the Portuguese companies, government agencies and academia to develop expertise in these new areas, both locally and internationally, with a high potential for exports.

The Green Islands Project has developed and begun implementation of several demonstrations in the Azores in the areas of low energy schools and home; electric vehicle deployment; and distributed generation, as well as a series of renewable resource and energy demand characterization. The Regional Government of the Azores has set ambitious goals for the deployment of renewable generation by 2018, as well as end-use electric vehicles and power grid modernization. The Green Islands Project represents a set of partnerships that were developed under the MIT-Portugal Program and that involve MIT, the Portuguese scientific community and Portuguese companies, who together seek to develop new products and services that can be demonstrated in the Azores and then deployed worldwide.

Main Scientific Achievements

Among the various scientific developments reached so far, we highlight the following four.

1. Development of a synthetic wind model including diurnal effects

A high penetration of renewable electricity generation requires an improved understanding and modeling capability of renewable energy resource dynamics. This research develops such a capability for wind. Using historical hourly wind speed data, an enhanced methodology for modeling wind, which included seasonal, daily and locational factors has been developed.

A shortcoming of existing methods such as Markov models and auto-regressive (moving average) AR(MA) models generally used for synthetic wind speed data generation is that they do not contain low frequency information, and as a consequence, stronger winds during longer periods of a day, e.g. afternoon winds, are not well captured. When planning an energy system with high levels of wind power, it is essential to look beyond average wind resource patterns, and develop new methods for estimating how, when and where large scale wind will contribute to the system. This is critical information, especially for island energy systems where there is no opportunity for "averaging" winds across a larger geographic region.

A new model that generates synthetic wind data taking into consideration the variability of the wind at different temporal scales (hourly, daily, seasonal, annual) was developed in order to allow the accurate evaluation of wind power production in energy systems with large penetration of renewable resources. The methodology builds on characterizing wind resources considering their variability, including various hourly, daily and seasonal patterns, and then generating wind penetration scenarios that reflect the various possible outcomes based on historical statistical analysis.

The model was successfully applied to wind data from locations with high average wind speeds but little diurnal effects to other locations with lower average wind speeds but a clear diurnal cycle. In the figure below, the distribution of wind speeds is shown for three locations, coastal, mid-island and offshore, for three islands in the Azores archipelago. Wind speed distributions are shown in Fig. 23, for five day types where is there are morning, afternoon, evening or night time winds, or no daily pattern at all. This approach represents a significant improvement for the design of energy systems, since it shows that although some locations may have less wind, it may be much better timed with the demand for electricity, reducing the need for other power system investments.

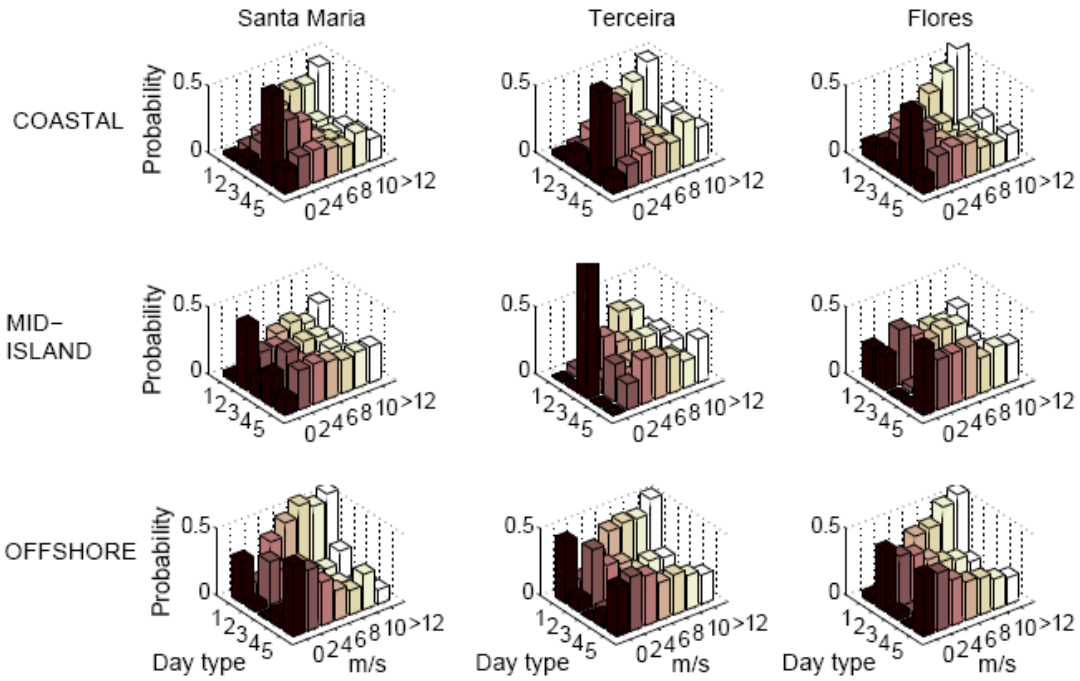


Figure 23 - Characterizing diurnal effects for different types of locations in different islands in Azores

2. Modeling hourly electricity dynamics in long-term scenarios

The formulation of new energy policies is often supported by energy models that look at long time horizons (years to decades) but fail to capture key shorter (hourly) dynamics of supply and demand. This is a major shortcoming, as the majority of new energy options such as renewable generation, electricity storage, and smart loads including electric vehicle charging, are defined by their “duty cycle” on a daily if not shorter time scale.

A new application of the TIMES energy model for long-term investment decisions was developed that considers seasonal, daily and hourly electricity supply and demand dynamics. The inclusion of these dynamics enables the model to produce more accurate results concerning the impacts of introducing energy efficiency policies and increases in electricity production from renewable energies.

Comparing model results to historical data from São Miguel (Azores, Portugal) for the years 2006-2009, the results expressed in Figure 24 show that this method overcomes several of the limitations of the current modeling platform. The figure below shows that using only one time period per day (24 hrs), significantly overstates the contribution of wind energy production on the island. However when the time periods are increased, these overestimates disappear. When the higher time resolution is used to evaluate increased wind in combination with a load reduction strategy using energy efficiency, the enhanced methodology shows that it provides more accurate prediction of the renewables contribution. These are important insights for both the design of technology strategies, and cost-effective policy measures.

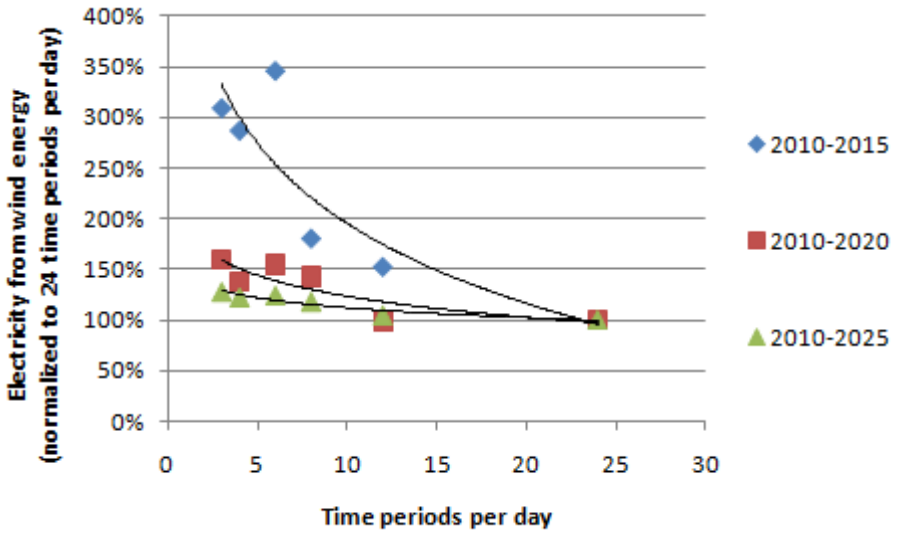


Figure 24 - Modeling the surplus of wind capacity installation considering different time resolutions

3. Modeling Demand Side Management (DSM) dynamics in long-term scenarios

The intermittence of most renewable resources can create problems to electricity grids in energy systems with high penetration of renewable resources. Energy storage systems are often used, but are usually expensive and might not be implementable.

One solution, especially before electricity storage technologies become available, is to address the issue of renewable intermittence with DSM, which can have the double effect of reducing overall electricity consumption and allow greater efficiency (and flexibility) in electricity production.

A new application of TIMES energy model was developed to analyze the impact of DSM strategies in the evolution of the electricity mix. The model was applied to Flores island in the Azores archipelago, which has highest share of renewable energy in the Azores. The model optimizes the investment and operation of wind and hydropower plants until 2020 based on scenarios for demand growth, deployment of demand response technologies in the domestic sector, and the use of standby thermal generation. The decision tree in Fig. 25 shows the various combinations of the three options as the island increases its use of wind and hydropower. The figure on the left shows how the evaluation of strategies with this mix of flexible options allows the island to maximize its use of renewable generation, and reduce overall costs including investments in standby power.

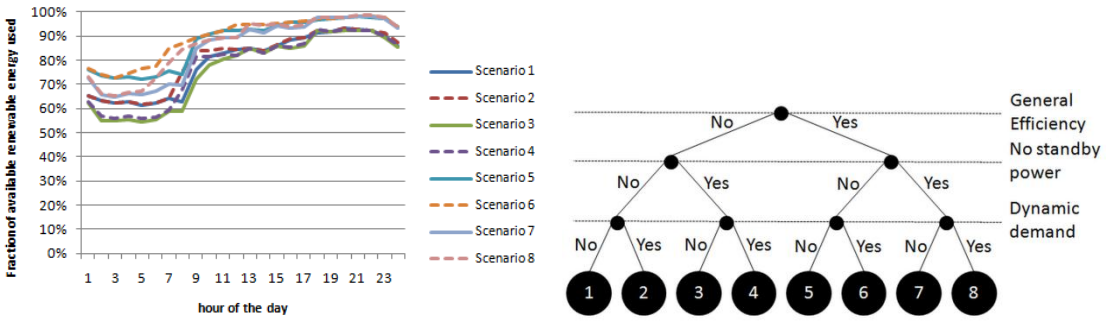


Figure 25 - Modeling the impact of different demand side management options in the renewable electricity penetration

4. Modeling the impact of electric vehicles in the electric system

Technological developments in the automotive industry, leveraged by national policies, point to a significant penetration of electric vehicles in coming decades. Such a market shift in personal transportation may induce significant impacts–positive and negative–on local and regional electric power networks.

A new tool was developed to model the penetration of electric vehicles in the electric network and provide insights to all types of stakeholders when EVs start to be massively connected to the grid. In particular, the model tests adequate grid operation strategies to overcome several technical issues, in particular by embedding EVs with Smart Grid capabilities, like Vehicle to Grid (V2G) as a storage option for power systems with large penetrations of renewable energy resources.

The model was applied not only to the Azorean islands but also to the Portuguese mainland and the results demonstrate the importance of having smart charging strategies as a regulation and storage option to the electric system when there are high penetrations of renewable energy resources. As shown below for mainland Portugal, the ability to shift the charging of electric vehicles to night time hours not only reduces peak generation needs, but also increases the use of renewable generation.

Potential economic/social impact of the results achieved

The main potential and social impact of the research achievements include the development of a set of tools that enables the design of a new generation of energy systems that is emerging worldwide. This set of tools, whose results are illustrated in Fig. 26, enables the understanding of the limits of renewable penetration in the electric system without further development of energy storage systems; the technical and economic design and evaluation of additional investments in renewable energy systems; the evaluation of the impact of demand side management strategies and the role of the consumers in its implementation; and the challenges that the adoptions of EV will pose to the electric system and the mobility patterns as we know them today.

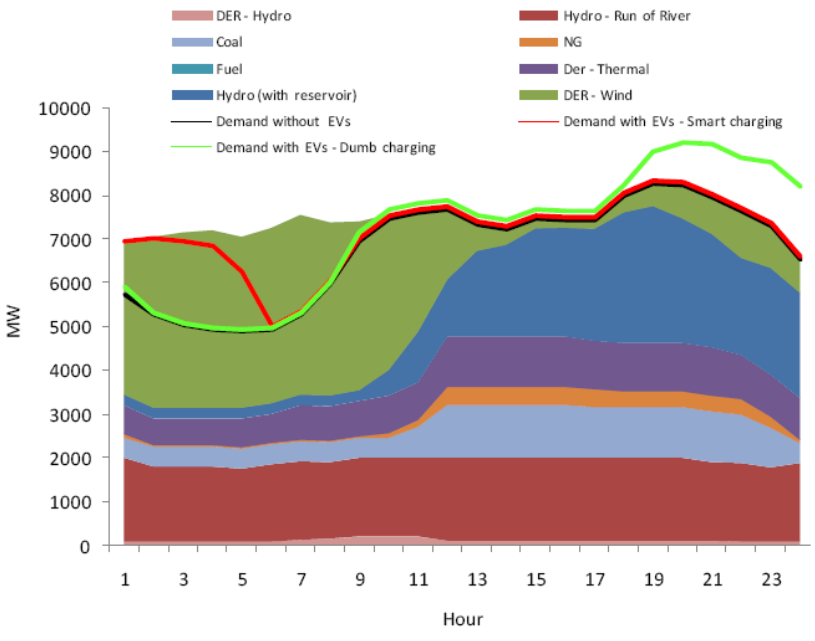


Figure 26 - Impact of EV charging strategies in Portugal mainland (winter 2012, 10% EV)

This set of tools has been used in the dialogue with the Government of Azores, EDA and Portuguese industry and is leading to the implementation of several innovative demonstration projects, such as a major deployment of a low carbon intensity energy systems for the island of Corvo, as a demonstration of the Portuguese industry/academia capacity to develop and deploy this class of systems worldwide.

Role of non-academic partners

The role of the Regional Government of Azores, in particular though the Energy Regional Director, has been essential to the project's development. It provided the financial support given to the Azores University to put numerous energy supply and demand characterization and demonstration design projects in motion, including the financial, legal and logistical support via the regional energy agency, ARENA in cooperation with the University of the Azores.

The role of local electric utility, Electricity of Azores (EDA), has also been fundamental, since its direct participation with regards to experiences in deploying renewables, electricity storage and other technologies provides significant insight, as well as essential information on electricity supply and demand to conduct research like that outlined above. Finally, Portuguese companies such as EDP, EFACEC, GALP, NOVABASE and others have been supporting the project with technical advice in the scenario development phase of the projects, and will now work collaboratively on the technical developments required to implement select project components.

Statement of a major stakeholder

"Sometimes, it is necessary to have ambitious objectives in some matters, like Energy. The Azores region has the ambitious objective of having 75% of renewables in electricity in 2018 and the MIT Portugal Program is helping the region to achieve this objective while promoting the creation of local know-how by establishing a network of regional, national and international research teams"

José Cabral Vieira, Azores Regional Director for Energy

"The green islands initiative is a unique opportunity for Portugal´s main energy companies. We are developing 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 will make a reality within the next decade." António Vidigal CEO, EDP-Inovação

Main Researchers and Stakeholders Involved

EDA: Francisco Botelho
EDP: António Vidigal
Efacec: António Carrapatoso
FCUL: António Vallera, João Serra
GALP: João Nuno Mendes
INESC-Porto (FEUP): João Peças Lopes
ISR (IST): Paulo Ferrão

LAETA (FEUP): Vitor Leal
LAETA (IST): Carlos Silva, Tiago Farias
Novabase: Luis Quaresma
Regional Government of Azores: José Cabral Vieira

Companies Involved

EDA, EDP, EFACEC, GALP, Novabase, Regional Government of Azores

b) Massive Deployment of Plugged-in Electric Vehicles

Objectives & Motivation

Massive deployment of plugged in electric vehicles (EV) requires careful analysis of their impact on the existing electric power system.

The main objectives of this research are related with: a) The identification of management architectures and control concepts capable to deal with smart charging and vehicle to grid (V2G) concepts; b) The developments and adaptations of power system simulations tools capable to evaluate the impacts in power system operation resulting from a massive deployment of EV; c) The development of several impact studies in distribution, transmission and generation system in interconnected networks and in grid islands, involving also the evaluation of the benefits that may result to the system of a presence of both EV and large scale variable intermittent power sources.

Main Scientific Achievements

The main scientific achievements to-date include:

1. Development of new management and control concepts

New control and management architectures were identified, including the definition of new electricity market "agents" (such as aggregators of EV). Also new control strategies capable of allowing EVs to respond to local or regional power system dynamics were developed.

An identification of the fluxes of information involving all the new agents (public or private charging points, fast charging stations, managers of charging areas, aggregators) and already existing entities like DSO, TSO and markets was also defined. All the iterations among these entities were identified.

2. Development of specific electronic interfaces between the grid and EV

Specific electronic hardware and software interfaces between the grid and EVs, capable of responding to external set points and to local system conditions, like frequency and voltages, were developed with particular attention on the minimization of harmonic distortion, costs and the capability to provide controllability of these interfaces, especially bidirectional power flows. This includes the necessary hardware developments for the EV-grid interface. Prototypes of these devices are currently being developed.

3. Study of different smart metering and communication protocols

Smart meters can be used to support the integration of EV for both billing and control purposes. Advanced versions of the smart meter for home charging have been defined in order to incorporate additional functionalities that are essential to enable advanced charging strategies, i.e. Variable Smart Charging (SC) and V2G. The same infrastructure can be used in the communication between EV and System Operators / Aggregators. A specification for these meters has been defined, which includes: Basic HMI, Energy measurement, Bidirectional communications, Periodic metering, Gateway to local systems, Data storage, Seamless connectivity, Privacy and security, Authentication, Data encryption, Logging, Clock, Firmware updates, Contract selection, Communication fault procedures, Remote parameters definition and Roaming.

4. Study of different EV battery charging strategies, including the smart charging.

Different EV charging strategies were identified, which includes namely dumb charging, dual tariff charging and variable smart charging. The smart charging strategy was carefully studied and several algorithms were developed for this purpose in order to minimize energy losses in the grid while meeting grid operational restrictions.

5. Identification of impacts on steady state behavior

Identification of the impact on distribution grids and transmission networks from the adoption of the different charging strategies was developed. This involved the adaptation of existing simulation tools for steady-state analysis, taking into account the expectable pattern behaviors of EV drivers. This involved the study of several LV, MV and transmission grid infrastructures that exist in Portugal and other European countries.

6. Identification of impacts on dynamic behavior

Identification of impacts on dynamic behavior in isolated and large interconnected grids resulting from the presence of EV, including also a large presence of renewable power sources was performed. This involves adaptation of existing simulation tools, like PSS/E and EUROSTAG to accommodate new dynamic injectors and the new control strategies identified. This involved the study of several MV and transmission grid infrastructures that exist in Portugal and island grids, like in the Azores.

7. Inclusion of EV in a Smart Grid environment using multi-agent systems

An innovative approach was designed that involves the definition of network blocks which share the responsibility of frequency control in distribution grids having distributed generation and EV participating in frequency control when in islanded mode. The control block abstraction was particularly designed to support the transition from regular grids to smart grids. In addition, the control schemes were developed using an agent based paradigm. Hence, an agent-based simulation platform was implemented using libraries from the Java Agent Development Framework (JADE). The control schemes were evaluated using a test system with different sorts of distributed energy resources and modelled in the EUROSTAG environment.

8. Evaluation of system reserve needs in scenarios with large scale presence of EV

In order to assess the impact of EV on the long-term operational reserve, an enhancement of a previous tool developed in a joint project of INESC Porto, REN and REE for the assessment of the security of supply in terms of the static and operating reserve adequacy is to be made. This model is based on a sequential Monte Carlo method (MC), the simulation is organized chronologically in order to preserve the relation between load variations, wind power variation, hydro conditions and other variables, such as, maintenance management, pumped storage operation, CHP generation, and small hydro generation and, more recently, EV behaviour. As a result, it constitutes an adequate basis to assess the impacts on the long-term adequacy of the system from the EV integration in the electric systems. For that purpose, models of the additional features associated with the massive EV are developed and integrated in the tool's algorithm, enabling representing different scenarios of EV integration and mobility patterns. With this approach it was possible to evaluate the reliability of a generation system and the reserve adequacy of the same system when massive presence of EV is foreseen.

9. Evaluate impacts of EVs on electricity markets, CO2 emissions

Tools capable to simulate the daily electricity market behaviour were developed in order to evaluate the impact of different charging strategies in the market prices.

Evaluation of CO2 emission reductions were also calculated taking into account the composition of the generation system and the grid losses for different charging strategies.

10. Study of different business models and regulatory models to accommodate the presence of EV in electrical grids.

Different business models for retailers, aggregators, charging point managers, distribution system operators as well as transmission system operators were developed, assessing the threats and opportunities for each agent under this new situation. A classification of the different EV charging modes, according to their location in private or public locations with private or public access was developed. Furthermore it was identified that DSOs are entities being the best option for developing public charging infrastructure because of the existing incentive regulation of natural infrastructure It was also identified that IT-suppliers might play an important transversal role in linking different agents during the charging process. EVs charged during valley hours could benefit the integration of renewable energy, mainly wind, in systems with high penetration levels while presenting an opportunity for TSOs to increase system security by providing system services such as frequency control when operated in V2G modes. EV charging introduces a new load uncertainty in the system therefore new forecasting tools are required for TSOs.

Potential economic/social impact of the results achieved

The main economic, social and environmental potential impacts that may result from the achieved results are:

- Contributions for the development of new standards to allow for EV with plug-and-play capabilities.

- Contributions for more efficient management of electrical power grids under this new scenario;
- Contributions for reduction of CO2 emissions and mitigation of climate change.
- Contributions to improve quality of life by decreasing traffic noise, namely in urban environments;
- Contribution to the increase of the public awareness regarding the correct use of energy.
- Contribution to the increase of employment in the automotive industry including all the complex supply chain of small medium and large suppliers as well as by creating new job positions in the electric manufacturers industry that will have to develop and produce new devices.
- Contributions to increase Portugal export potential in High Tech for the related technologies.

In the present economic crisis it is crucial to identify innovative and cutting edge solutions that promote a leap towards a new automotive business paradigm. Such shift will contribute as a leverage element that will push the global economy out of the crisis and to a sustained development. This push can be partially obtained through the response of the automotive industry to this challenge.

Role of non-academic partners

Non academic partners are of two types: a) System Operators and b) Industrial manufacturers;

Their contribution has been, on one side, the delivery of key data related to the description of electrical systems used to evaluate the anticipated results from the use of new management and control strategies for EVs and also, through the development of a dialogue with industry, an advanced awareness of key issues, potential solutions, and novel communications and control hardware and software that will enable a faster, more reliable, and cost-effective development of electric mobility products and services for Portugal, the European Union and beyond.

Main Researchers Involved

EDP: António Vidigal
Efacec: António Carrapatoso
GALP: João Nuno Mendes
INESC-Coimbra: Carlos Henggeler Antunes
INESC-Porto: João Peças Lopes, Manuel Matos
ISA: José Basílio Simões
ISR (IST/UTL): Pedro Lima, Christos Ioakimidis
LAETA (IST/UTL): Carla Silva, Carlos Silva,

Companies Involved

EDP, EFACEC, GALP, Intelligent Sensing Anywhere, S. A.

1.3.4 Mobility and Metabolism for Urban Sustainability

Of the many complex systems being studied today, the urban scenario reveals to become one of the most important and challenging. For its strong impact in planet life and its future, a current urgent endeavor is to understand better and, mostly, to improve it to minimize environmental impact while at the same time affecting its subsystems in a small way.

These subsystems include energy, transport, built environment, waste treatment, to name the immediately most important ones. In fact, it is hard to enumerate them isolated since they are intrinsically linked to each other. Transport needs energy and obeys to the built environment constraints, energy demand directly depends on how the city is constructed, how citizens live. An apparently small perturbation in one side will have impact in the other (e.g. raising energy prices will affect transportation and the cost of goods, lowering consumption, etc).

Here we offer two examples related to Sustainable Urban Mobility and Integrated Transport and Energy Modeling, which are described in the next sections.

a) Sustainable Urban Mobility

- Smart Combination of passenger transport modes and services in Urban areas for maximum System Sustainability and Efficiency (SCUSSE)
- Strategic Options for Urban Revitalization based on Innovative Transport Solutions (SOTUR)

Objectives & Motivation

This group of projects aims to assess the potential impact of the introduction of significant stimulus to the urban mobility system and evaluate how the system would react, both in terms of the reconfiguration of mobility options and in the rearrangement of urban activities, as represented in Fig. 27, towards more sustainable organization of the urban system.

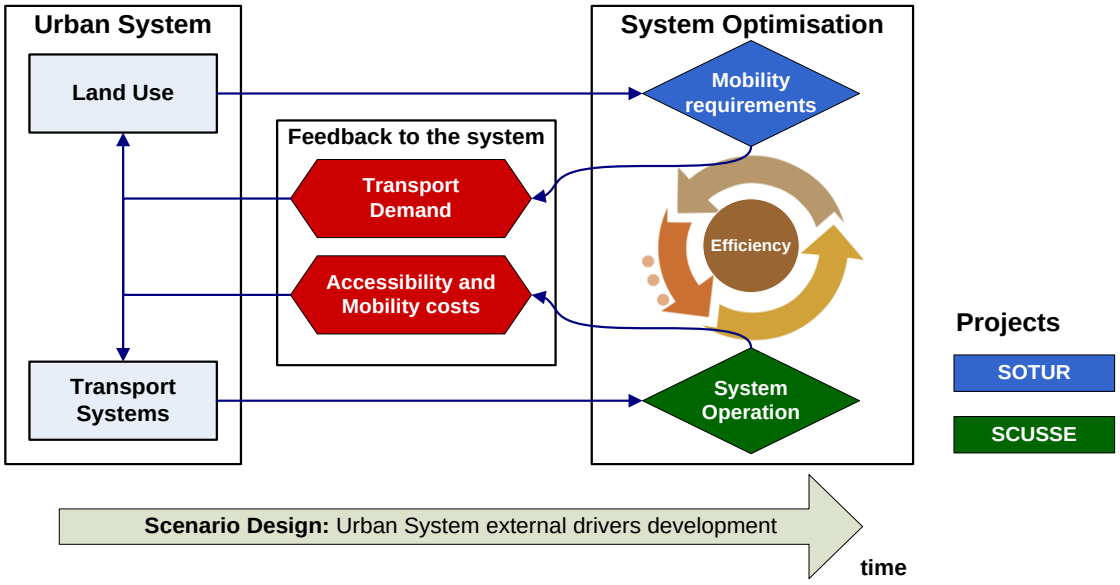


Figure 27 - Urban Scenario Design

The first project **(SCUSSE)** aims to conceive and organize the deployment of new intermediate transport solutions, combining them with the existing individual and collective transport, improved

fit with evolving lifestyles and better sustainability and efficiency, namely through increased occupation of private and public transport vehicles, and lower delays overall in the urban mobility system.

This project focuses on the following alternative transport solutions, opening potential new business models: shared taxi, express minibus services, car sharing and carpooling. This research will study the best market configurations of these new services, which rely on improved ITS solutions (information, coordination and fare collection), using a set of simulation and optimization tools. This relies on a fine spatial-temporal characterization of transport demand and travel patterns, which was obtained by available mobility databases and new surveys that were performed specifically for the project.

The second project **(SOTUR)** seeks the definition of solutions for innovative strategies on the interaction between Land Use and Transport, especially aimed at the revitalization of urban areas and with sufficient economic power of attraction for private investment that may leverage innovative transportation solutions and contribute, overall, to more sustainable urban development patterns, in special to increase the attractiveness and livability of decaying urban areas. A particular focus of the work is on the revitalization of urban districts in areas with low availability of street space. An innovative aspect of the project has been the definition of scenarios of evolution of urban areas based on a participatory approach.

Main Scientific Achievements

SCUSSE:

This research project contributed to the existing body of knowledge by analyzing in depth, some aspects of the development of new urban transport solutions and how they interplay with traditional transport modes and their fit with current travel patterns and lifestyles. This research encompassed the development of several surveys and optimization and simulation models, all of them presenting innovative approaches and modeling formulations, which contributed significantly to expand the ability to characterize transport demand and supply design with a detailed spatial-temporal resolution.

We can group the main scientific achievements of the project in three main groups:

1. Revealed and stated travel preferences survey design and modeling:

During the project two different revealed and stated travel preferences surveys were developed, a part of several focus group meeting in order to conceptualize the new intermediate transport modes attributes for the Lisbon Metropolitan Area (LMA). Both surveys presented significant innovations on their design and estimation procedures, which included hierarchical decision (within each transport mode group and then global comparison of previously selected transport modes), multiple dimensions on the respondent selection, including preferred departure time and number of persons to travel with; and the use of disaggregate real data to generate the attributes of the transport alternatives for mode choice selection.

Several discrete choice models were obtained to estimate the main attributes that can potentiate these new modes and estimate their potential market shares

2. Activity and travel demand modeling:

The demand modeling of new transport alternatives that may present small market shares and require trip matching procedures, entails a more detailed space and time discretisation of mobility than traditional modes. For this reason, the research team developed new activity and travel scheduling models.

The developed model introduced some principles of fuzzy logic inference processes, which allow for the production of a synthetic population of trips with a continuous representation of trips in space and in time. The proposed procedure uses a statistical approach to trip dispersion, using a Monte Carlo Simulation process, based on the survey data and the land use characteristics in order to preserve the mobility patterns observed in the survey. The procedure was applied to the Lisbon Metropolitan Area (LMA) and the results show a good match with the original data, but with a greater, more realistic space and time coverage. The results suggest a significant added value of this approach for the modeling of transport modes requiring space and time matching that cannot be correctly modeled with the traditional discrete representation of the territory as well as for estimation of traffic loads in low hierarchy arcs of the network.This is already allowing work to be done with the current results as the basis for estimating the market potential for shared taxis and minibus express services, both of which are dependent on the availability of estimations of starting and ending points of trips with much better resolution than earlier available

The next steps of our developments consist of checking the traffic flow estimates obtained with traffic allocation models based on these matrices and compare them with regular traffic counts obtained with automatic sensors (assess variability of both streams)

We hope to be able to develop a measure of dispersion of traffic values on links that should be considered for planning purposes, depending on the hierarchical level and on the expected value of that traffic flow

3. Alternative transport modes simulation and optimization

The modeling of alternative transport modes tested in the study led to the development of optimization and simulation procedures required under spatial-temporal demand matching. Some of the optimization procedures include the estimation of the matching potential of single drivers in the LMA for the establishment of carpooling schemes; the estimation of the most profitable configuration of one-way car sharing depots (location and capacity) considering costs of balancing supply and demand of vehicles along the time and space; and the design of a express minibus system for commuting trips with the LMA (routes and schedules). Modeling some of the proposed services require simultaneous simulation and optimization procedures, as the shared taxis services, the potential of which is a function of the dynamic matching between supply and demand, where the taxi selection to perform a service should be optimized to ensure the efficiency of the system.

The development of all these procedures required a detailed network modeling and demand spatial-temporal characterization, which was obtained by the simulation model presented above.

Among the developed models we can highlight the shared taxi that presents interesting results in terms of implementation potential, showing significant savings for passengers (average 20% price reduction for share taxi riders). We can also conclude that:

- The concept of shared taxi can be operationalized for real time allocation of passengers to taxis
- A win-win-win (passengers-operators-society) situation can be achieved
- The business model seems very interesting and the simulation procedure can be very helpful for fine tuning of the parameters
- Current Lisbon taxi fleet is probably too large and suffers from low load factors. Shared taxi system should help improve business, mainly thanks to demand induced by the lower prices
- This system is still illegal under current legislation, this work is expected to produce results that would change that regulatory position

SOTUR:

This research project aims to open new ground on the field of land use and transportation integrated models, the scenario and policy design participatory process with stakeholders, and the development of strategic evaluation indicators of policies towards the main principles of sustainability.

We can group the main scientific achievements of the project in three main groups:

1. Land use and transportation integrated models (LUT)

Two different models were developed and validated for this projects based on agent based modeling: an application of the Urbanism model, developed by Paul Waddel research team, for the Lisbon Metropolitan Area, incorporating new procedures and definition of spatial resolution, and a new agent-based model that tried to integrate lifecycle and within household processes in a traditional LUT model. Both models were developed using the same base data which was obtained through diverse sources, but especially by a household survey that tried to characterize the underlying processes of house acquisition, residential satisfaction, and household dynamics.

In parallel, to allow the coherent use of inputs to the models and the share of results among the different researchers of the project and also to the main stakeholders, a Geodatabase portal was developed, which contained all the data available for the models' calibration and validation, apart from the visualization of the outputs of model for different urban development scenarios and implemented policies (illustrated in Figure 28)

The two models are currently under validation procedures. The tests performed show their ability to assess changes in the LMA macrodrivers and also land use and transportation policies.

2. Scenario and policy design participatory process with stakeholders:

The methodology followed developed three scenario narratives, each describing a possible future for Portugal and its implications for cities. An innovative element has been the involvement of stakeholders input in the construction of scenarios. These were obtained during two workshops held in Coimbra (January 25, 2010) and Porto (March 2nd, 2010) that involved participants from the Cities of Coimbra, Porto, and Lisbon and also national institutions. The main goal of the scenario development exercise was to demonstrate a process by which the effectiveness (or robustness) of different strategies aiming at promoting urban regeneration can be tested under a number of potential futures. Figure 3 below illustrates the methodology.

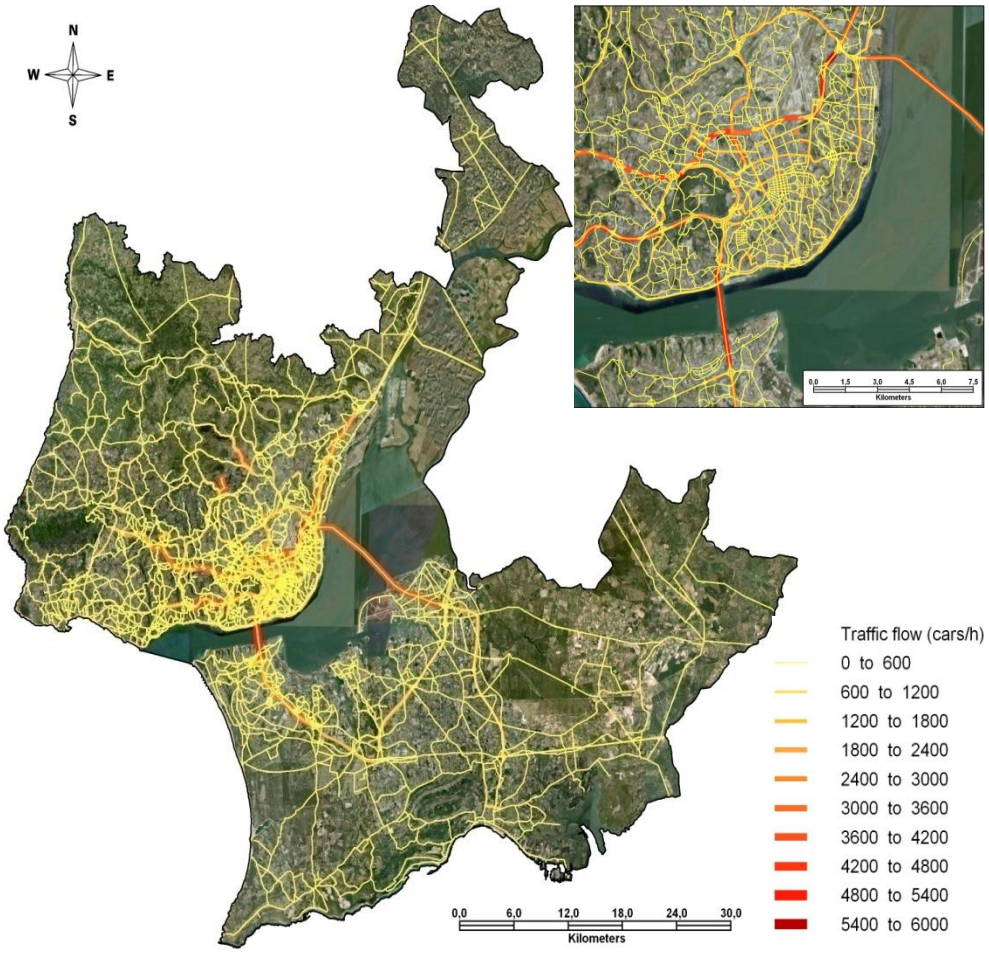


Figure 28 - Lisbon Metropolitan Area traffic flow representation

The scenarios presented illustrate three instances out of a wide range of potential futures, although scenarios do not attempt to forecast the future of Portugal, but rather serve as a basis to explore the robustness of policy options. The elaboration of the scenarios in the form of in-depth narratives aimed to illustrate one manner in which perhaps non-intuitive combinations of driving forces could occur (see Fig. 29). Stakeholders were also invited to choose policy measures that have been grouped and later tested with the modeling tools. The final results have been presented to stakeholders in a Lisbon conference (July 9, 2010) with very positive manifestations from stakeholders.

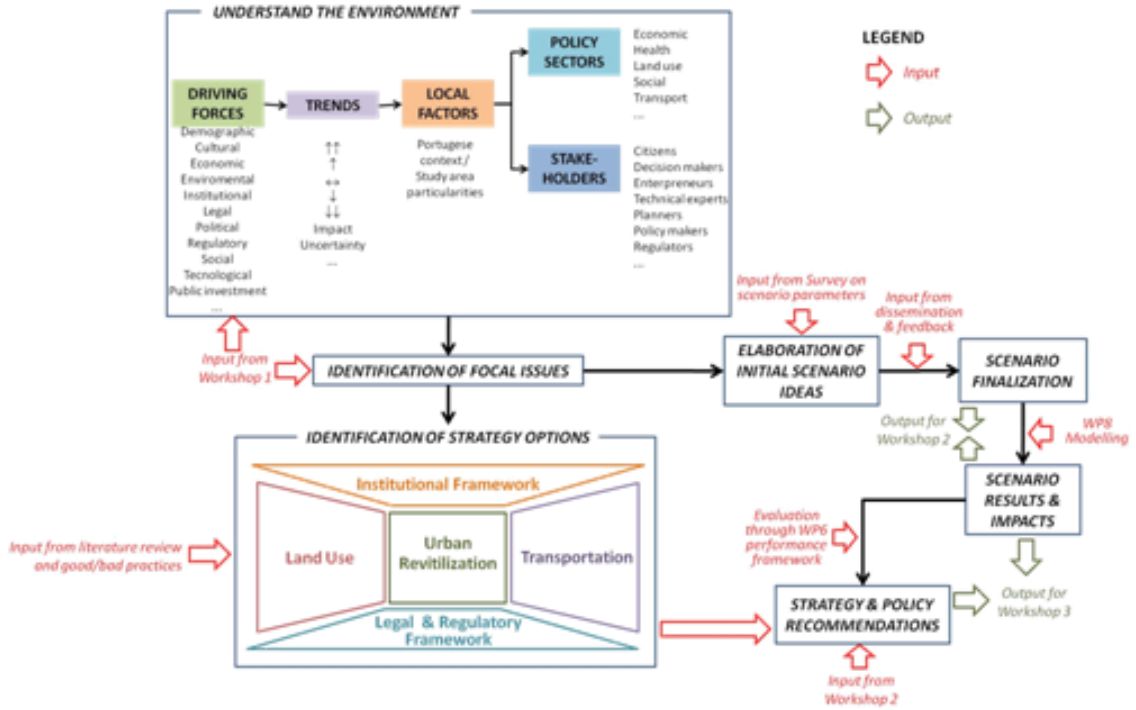


Figure 29 - Elaboration of Scenarios Illustrating non-intuitive combination of driving forces

The research has produced very significant impacts: the development of a set of articulated integrated land use and transport models to assess revitalization strategies, already referred; a scenario planning approach to test these strategies and assess their performance. A particular aspect is the engagement of stakeholders in three workshops along which the scenarios have been developed. This participatory approach is still rather unusual in Portugal and represents an effective demonstration of an important element of innovation in policy process.

3. Development of strategic evaluation indicators of policies towards the main principles of sustainability

This pillar of the project was halted until the fine development of the LUT models and the definition of the scenarios and policies to be tested. Nevertheless, there are already some results related to the assessment of the factors underlying residential satisfaction, and the initial development of the evaluation framework that will be used in the final stage of the project.

The assessment of residential satisfaction showed that the urban space quality (i.e. availability of common public spaces and quality infrastructures and equipment) is a key factor for attract people back to the city centre and promote revitalization.

Potential economic/social impact of the results achieved

Both projects presented within the urban systems sustainability may present significant economic and social impacts, as stated in their objectives. The outputs may be of vital importance to assess how some land use policies along with changes on the transportation services may significantly improve the overall efficiency of the urban system. The first can accomplish a significant reduction of the mobility requirements, while the second may increase the efficiency of transport supply (i.e.

smaller vehicle flows) derived from better organization of the services provided and a closer fit to the current travel requirements.

The developed tools (i.e. LUT model and alternative transport modes optimization and simulation models) may be used in the Lisbon Metropolitan Area context to assess the impacts of new configurations of the land use regulation and transportation system. The method is transferable to other metropolitan areas provided availability of data and simulation effort.

Some of the transportation options tested in the SCUSSE project are currently illegal under the Portuguese regulation of the transportation sector. This research may help to unlock and change the regulation into more flexible definition of regulated public transport services, which could a very relevant impact of this study.

Some companies of the transportation sector may be interested in pursuing the deployment of the proposed and designed transport alternatives, which would ensure significant impact on the society of the research developed in the SCUSSE project..

Role of non-academic partners

Non academic partners worked in both projects mainly as data providers and consulting entities, in the case of SOTUR, during the stakeholders' workshops.

Statement of a major stakeholder

The Instituto da Mobilidade e dos Transportes Terrestres (IMTT) has recently stated the interest on developing a pilot study and implementation test of shared taxis services in Lisbon, and the first exploratory meeting has already taken place. The deployment of this service with the support of the developed optimization and simulation solutions will allow testing the robustness of the developed modeling tools, and at the same time retrieve data to the simulation model to improve its ability to reproduce the real market behavior.

In the SOTUR project several institutions or public entities were part of the stakeholders' participatory workshops, helping the research team to define the possible urban development scenarios and policy measures to improve the urban system efficiency and promote urban revitalization. Some other stakeholders have stated their interest in adopting the scenario building methodology in the development of their strategic plans, namely EPUL and EMEL, an possibly build on the developed LUT models to use then to support decision making processes.

Main Researchers Involved

FCT/UC: António P. Antunes, Gonçalo Correia

IST/UTL: José Manuel Viegas, Luís Martinez, Rosário Macário, João Abreu, Silva, Gonçalo Santos (PhD student), Tomás Eiró (PhD student)

MIT: Christopher Zegras, Moshe Ben-Akiva, Joseph Ferreira, William Mitchell, Joseph Sussman

Companies Involved

Geotaxis, EasyBus

b) Integrated Transports and Energy Modeling - iTeam

Objectives & Motivation

The Integrated Energy and Transportation Activity Based Model, iTEAM, is focused on developing models of complex system as a function of interactions at the micro-level: each individual/household/firm is represented as an independent decision unit and has a behavior that affects any of the city's subsystems. This follows the established approach in behavioral econometrics, urban planning and transportation research where urban phenomena are analyzed in this bottom-up fashion (Almeida et al., 2009).

The iTEAM project covers both the data collection (for calibration of these agent based models) and the modeling itself, building on earlier projects, such as CityMotion, SCUSSE and SOTUR.

Main Scientific Achievements

1. Innovative Survey Technologies

iTEAM is the first urban modeling project to integrate several distinct innovative technologies. More importantly, it integrates them in a unified platform, allowing for seamless interactions between them. This platform, Greenhomes, is a Web2.0 server where users can participate and monitor their own data. This data may originate from 3 different sources: the online questionnaire – filled during registration and upon further request and availability; the smartphone survey - which comprises an application for Android OS that allows non-intrusive logging (GPS, Accelerometer, GSM and Wifi) and a web application. Together these two pieces of software help the user elaborate his activity travel diary; energy telemeter survey – this last data source consists of monitoring, for each household, the aggregated energy consumption by a 15 min. sample rate. The main industrial partner, ISA, provides the necessary state of the art technology.

Taken together, and with statistically significant sample sizes, those three technologies provide the necessary information to calibrate our agent based models.

Finally, still in the realm of data collection of mobility information, iTEAM also considers other external data, namely from the CityMotion and SOTUR projects. From CityMotion, digital traces such as taxi or bus trips are helping configuring the supply side as well as tuning furthers the demand side (e.g. number of taxi trips originating in a neighborhood).

Also in CityMotion, researchers have invested in web-mining and information retrieval of Points of Interest (POIs) from crowd sourced websites, such as Yahoo Local or Sapo mapas. An application of such data is in the determination of accessibility measures to activities as determined from POIs. Together with the public transit network and GPS taxi logs, the team is building accessibility measures for LMA (as in Figure 30 below).

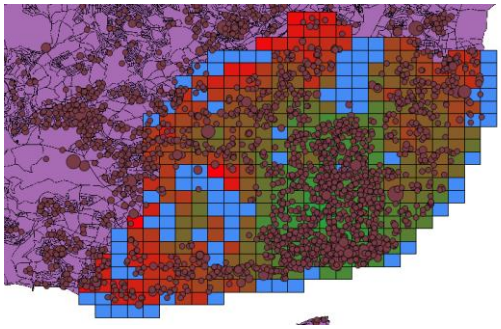


Figure 30 – Accessibility to POIs or activities (small circles) in Lisbon according taxi, bus and metro networks (blue means low accessibility; red means high accessibility)

In the same trend, but applied to Cambridge and Somerville (where the necessary training data is available), the team also developed a Machine Learning algorithm for automatically classifying POIs by NAICS categories (land use taxonomy). Such classification is vital for models such as job location choice. With our algorithm, researchers can obtain POIs directly from crowd sourced websites such as Yahoo Local or Yelp and classify them automatically. Until now, such data needed to be outsourced to specialized companies. Figures below contrast the job location estimations for the retail sector by applying NAICS classified Yahoo POIs (Fig. 31) against "ground truth" data from InfoUSA (Fig. 32).

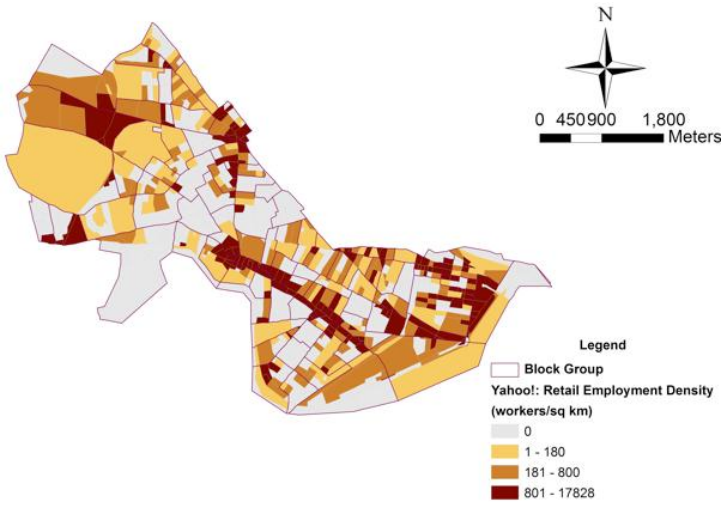


Figure 31 – Yahoo (automatic, crowd sourced) data

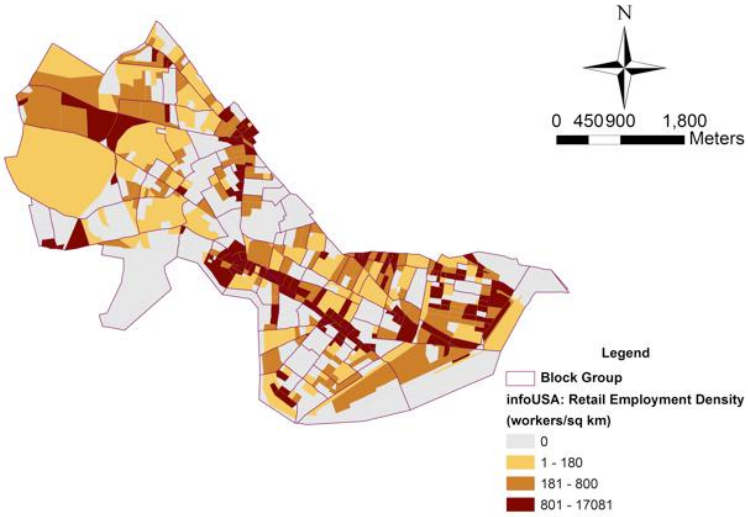


Figure 32 – InfoUSA (proprietary) data

From SOTUR, iTEAM is reusing earlier transportation surveys that took place under MIT Portugal Program.

2. Activity based models

iTEAM is the first project, among a very wide range of Urban Models (activity-based and trip-based), that integrates energy, transports and land use together. Thus, the core of iTEAM is the set of activity based agent models that describe the whole urban model. In practice, after calibration, such agents will become autonomous in the simulation. Of course, the quality of this system, and henceforth its ability to accurately support predictions and scenario studies, is directly dependent on two aspects:

Calibration from statistically significant and comprehensive data obtained from our data collection initiatives;

An individual/household/firm agent design that considers all fundamental activities and choices that are relevant to the urban model.

While processing traditional interview based survey data has become a routine task in urban planning and transports engineering, the same is not to be said about innovative data such as from smartphones or smartmeters. For the former, iTEAM has already built an algorithm for mode detection from GPS traces (Teixeira and Bento, 2010; Teixeira, 2010). In the following table, we show the confusion matrix when testing the algorithm (kappa statistic=0.91). A confusion matrix, represented in table 2, compares the ground truth with predictions.

Table 2 – Confusion matrix

	Car	Walk	Bus	Bicycle
Car	188	1	4	1
Walk	0	94	0	12
Bus	5	3	28	0
Bicycle	0	9	0	36

In parallel, iTEAM has an external partner, EPFL that collaborates in this topic, particularly focusing on extracting activities and routes from GPS traces.

In terms of the smartmeter data processing, work was done to infer appliance on/off state changes from aggregated electrical signals (Figueiredo et al, 2010; 2011) and building on this, the team is identifying patterns of in-home/out-of-home patterns. In Fig. 33, we show an example of the application of wavelets to separate the "baseload" side of the signal (e.g. freezer, refrigerator) from the remaining, non-stationary, signal (e.g. cooking).

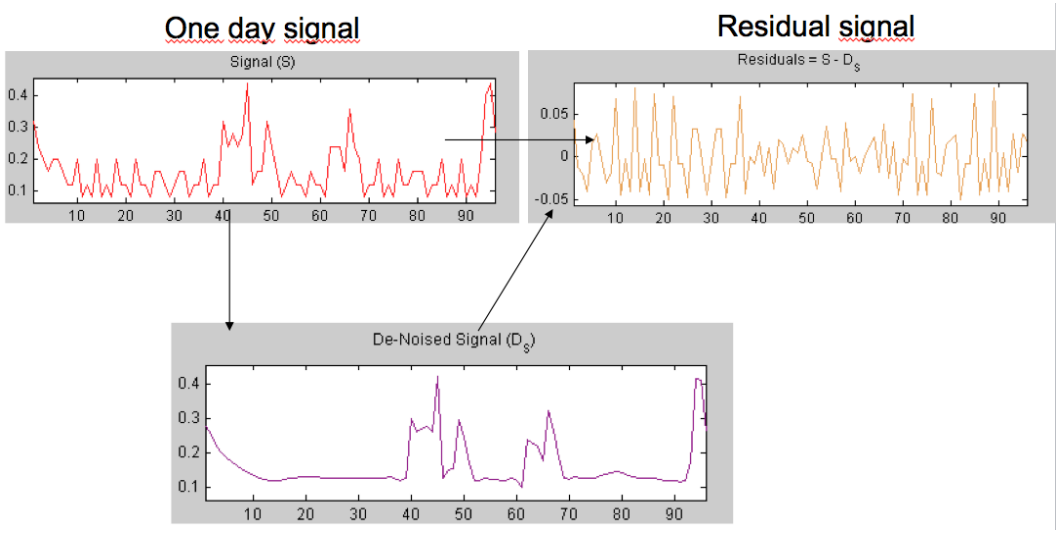


Figure 33- Disaggregating household electrical signal

Finally, regarding agent models themselves, the choices considered include house location choice, job location choice, activity choices and activity planning, mode and route choice. Together with these, we also consider other models, namely regarding fertility, mortality, real estate and building construction to name a few.

Incoming from collaboration with SOTUR, all of these models are already in place, however they still need much deeper calibration and specification regarding activities (SOTUR still follows the classical four step, trip based model, as opposed to an activity based model) and data detail: there are no activity diaries as such neither any energy use information.

The core of the activity based models are currently under development at the MIT and IST sides and will be further implemented after we reach sufficient behavioral data from the running surveys (as referred in previous point).

As initially proposed, iTEAM builds on the first wave of MIT Portugal Program projects, and has a particular responsibility of becoming the unifying testbed of some of their contributions.

3. Urban Metabolism

The role of Urban Metabolism research in iTEAM is to lend a methodology for performance measurement in terms of materials and energy flows to add to the ones already developed under SOTUR. Such methodology allows the translation of activities into materials, waste production, stock variation and emissions (Niza et al, 2010).

In parallel, a different perspective is to apply Data Envelopment Analysis (DEA) to indentify factors that have high environmental impact. In practice, this is to find a number of environmental indicators and their dependencies with variables available in the model (e.g. population growth, oil prices, etc.).

Currently, the team advanced with a number of achievements (see figure 2):

- Detailed set of material types to describe product's composition - 28 categories of materials. Choice of material categories based on Eurostat MFA, recycling technologies and other classifications from MFA studies
- Categorization of material states - 4 categories of products. The identification of raw materials, intermediate products, final goods and waste is crucial to distribute among economic activities and to establish average lifetimes
- Expanding detail on lifespan - Building a database of average lifetimes. Application of distribution equations.
- Economic activities distribution - Distribution among sectors is done by assigning % to the products regarding their destination (>60 sectors) according to the structure of the Portuguese Economic Input Output Table

Regarding DEA, in the absence of data at the city level, the team is applying the technique to a country level analysis.

4. System Integration

System integration is, naturally, one of the main challenges of our project. There are many different components, developed by many different teams and under different disciplines. System Integration is organized into two lines, as represented in Fig. 34:

- Data Collection
- Urban Model

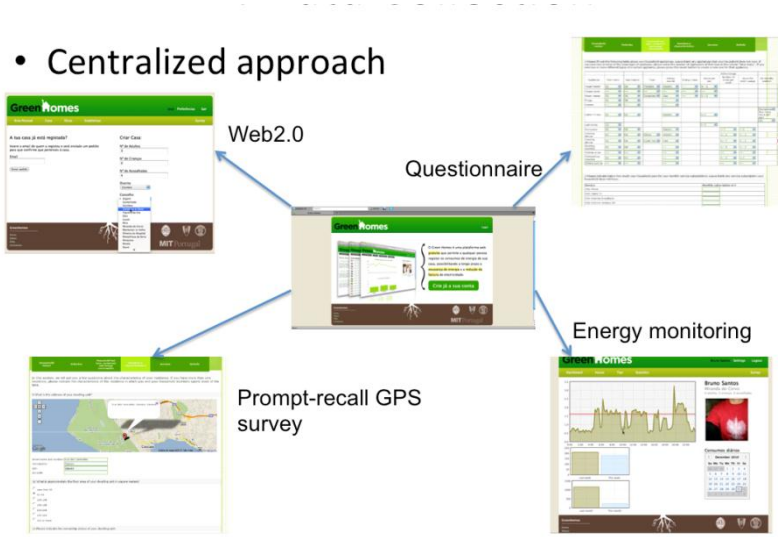


Figure 34 – Data collection integration

Data Collection is centralized in Greenhomes, as described before (see Figure 21). Regarding the Urban Model, we are using OPUS (Open Platform for Urban Simulation), which is extendable and open source. Its transports model is external so the team has already linked OPUS both with DynaMIT (Santos, 2010a; 2010b), show in Figure 35, as well as with Transcad (commercial software used in SOTUR).

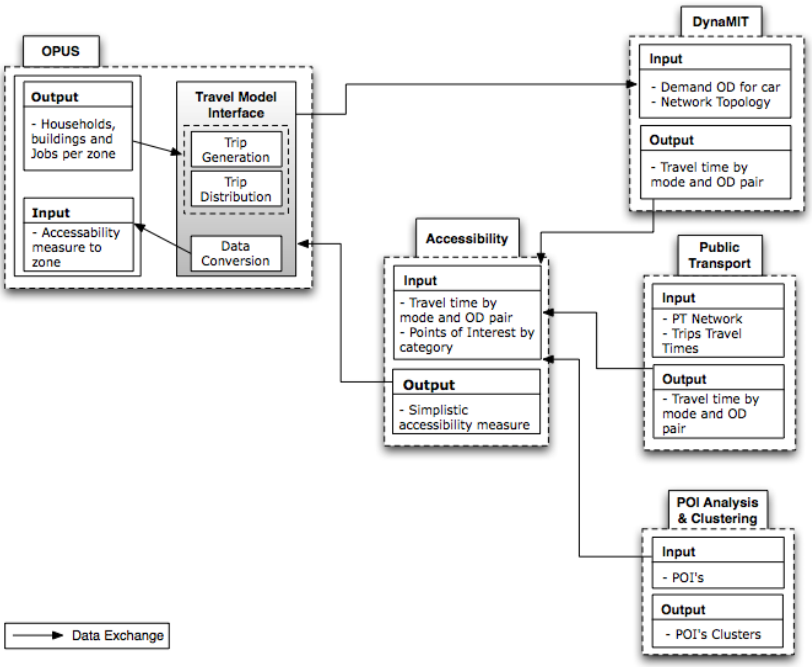


Figure 35 – OPUS and DynaMIT

In practice, the remaining components to add (to OPUS) will focus on adapting its behavior models to the activity based perspective as well as including Urban Metabolism and DEA modeling algorithms.

5. Collaboration Outreach

Led by MIT, iTEAM's vision has been the beacon light that is gathering a community of prestigious researchers throughout the world in what have been called the "iTEAM Workshops". These are invitation-only meetings that have the primary aim of setting up collaborations towards this projects' goals. They are unarguably ambitious but with great impact for our cities.

The first workshop was in Lisbon (close to WCTR2010), the second one was in Washington DC (close to TRB2011), the third one will be in Singapore, and the fourth in Washington DC (TRB2012). The group has members from KTH Stockholm, EPFL, Imperial College London, MIT, FCTUC, IST, Univ. Tokyo, Univ. Toronto, TNO Netherlands, ETH Zurich, UPC Barcelona, NUS Singapore, to name a few. The current challenge is to establish synergies between projects related to iTEAM that are running in all these institutions (e.g. Sustaincities, Future Cities, Future Urban Mobility, etc.).

Finally, aside from the running collaboration with EPFL, a far than less important collaboration is starting in March 2011 with MIT-Singapore project Future Urban Mobility (FM) whereas the running sub-project on smartphone data collection will be jointly developed with a team from NTU

(Singapore), with the goals of porting the software to other platforms (e.g. iPhone, Symbian OS) as well as running and sharing the data collection campaign in Portugal and Singapore.

Potential economic/social impact of the results achieved

The iTEAM project will produce a tool that is arguably relevant for decision support in policy decisions. It is also generating a number of innovative software tools, around the greenhomes platform. These can be applied/exported to any other country in the world that intends to apply activity based modeling.

Role of non-academic partners

ISA is the non-academic partner in iTEAM. Their role has been on supporting the development and research on the smart meters and energy signal processing. During year 3, the expectation is to involve other partners both in the data collection software and hardware side as well as in the modeling side.

Main Researchers Involved

FCT/UC: Francisco Câmara Pereira, Ana Almeida
FE/UP: Teresa Galvão, Ana Camanho, Carlos Bento
IST/UTL: João Abreu, Samuel Niza, Leonardo Rosado

Companies Involved

Intelligent Sensing Anywhere, S. A.

1.3.5 Developing Systems for Smart Vehicles

The automotive industry, among many others, is keen on increasing the use of integrated systems in their vehicles with the aim of saving weight, increasing the number of functions and reducing both the component and assembly costs. Within this horizon, it seeks to develop smart devices and materials for automotive interiors that incorporate sensor and actuator capabilities for both conventional and new functions in terms of: safety, comfort, performance, aesthetic and information processing.

In the design of novel integrated systems for smart interiors, a research team has been developing functional prototypes with integrated optical fiber sensors in polymeric foils, using standard industrial fabrication processes. An automated system for the integration of optical fiber sensors in line with the industrial manufacturing of polymeric foils has been achieved, as well as the application of the developed sensing foils to different fields besides the automotive one. Finally, a model to evaluate the cost of the integration process with full cost break-down and sensitivity analysis has been created. The consortium comprises members from three Universities together with four industrial partners. The three major industrial partners are well established automotive suppliers in complementary areas for automotive interiors: artificial leathers and soft tissues (TMG), technical molded components (Iber-Oleff) and seat related components (Sunviauto). In addition, a company that specialized in sensoring technologies (FiberSensing) is also part of the group.

In the intelligent in-vehicle safety systems, is highlighted the development of an initial computer model for about 500 meters of a non-urban highway and 80 cars driven, using Agents in a MultiAgent-Based program named AnyLogic. This is being scaled up by using the outputs of this sort of models in traffic programs, like AIMSUN 6.1 under different scenarios. Both researches should bring substantial changes to safety and materials in cars, and establish Portugal as a high technology country in that area.

Here we provide two examples of the research developed: a) Adapting the Vehicle dynamic parameters to the driving Environment and Driver capabilities, and b) Integrated Systems for Smart Interiors, which are described below.

a) Adapting the Vehicle dynamic parameters to the driving Environment and Driver capabilities

Objectives & Motivation

The main aim of this study is to contribute to the improvement of road safety through the application of Intelligent in-Vehicle Safety Systems. This research project officially started in September 2009 with MIT being involved only since November 2010. Its main objective is to recommend a system to adjust the vehicle's dynamic attributes to the driver's state and driving circumstances, which will ultimately grow into a technological device. Four initial objectives have been identified:

- to list drivers' (permanent and temporary) limitations and driving circumstances which have an impact on road accident involvement;
- to develop a procedure to identify which aspects of risk perception and vehicle control could be affected by each of the limiting factors;
- to specify information or vehicle dynamics adjustments for those limitations. If amendment for one or more limitations is not possible or does not substantially reduce the probability and severity of accidents, to identify a list of restrictions of the driving task in one or more dimensions (e.g. speed, longitudinal and lateral acceleration, and distance to the vehicle ahead); and
- to develop a business model for the commercial deployment of an on-board device with these functionalities.

Main Scientific Achievements

Potential economic/social impact of the results achieved

As a long-term project, the proposed technological device offers significant potential for urban and non-urban road safety both in developed and developing countries.

Indeed, there has been a growing recognition that road traffic deaths and injuries are a global problem as they impose huge economic costs in societies, let alone the human tragedy. Perception of risk and disruption are also associated with road accidents both on highways and urban roads impacting mobility patterns and therefore, the competiveness of regions and countries.

While established road safety effort (including cost-effective road safety engineering, educational, enforcement and publicity measures) are still needed, the major challenges now are to seek further significant reductions both in the industrialized and less developed nations.

This project argues that driver behavior (by far the single most frequent factor behind road accidents) has to be conditioned by technology. In other words, the driving license should be treated more like a judo belt, with different colors indicating different levels of skill in handling difficult situations. Over the course of the lifetime, depending on medical condition, level of fatigue, on actual driving style and the vehicle conditions, the "color" of a driving license should change in real-time, sometimes upwards, sometimes downwards.

Indeed, this study seeks to employ an innovative approach to road safety by designing and building safety into vehicles and by focusing on the multi-dimensional variability of driving ability. It aims at conditioning driving performance continuously and automatically through the development of an electronic in-vehicle safety system that adjusts the dynamic attributes of the vehicle and the degrees of freedom allowed in driving to balance between the current competencies of the driver and the challenges posed by the vehicle and the surrounding conditions.

Role of non-academic partners

Over the course of the 20th century, technology was extensively implemented in many areas of the road transport systems to improve mobility, efficiency and comfort. Safety, however, was frequently perceived as an important result of road vehicle technology deployment but it is seldom recognized as a primary value. In the past few years though, in Europe, United States and Asia, there has been a change of paradigm with the industry contributing to develop technology which supports the driving task increasing safety. Being very recent approach efforts are often scattered and not always successful.

The industry has been perceived as very interested in collaborating with academic partners for mutual benefit. In fact, Ford US is interested in supporting the SAVED project and different lines are being analyzed for its concretization (see Statement of a major stakeholder).

Statement of a major stakeholder

FORD US is currently the most promising non-academic stakeholder for the SAVED project, as stated in this declaration. SAVED2, which was a 2009 MIT-Portugal research proposal, aimed at not only expand the scope of its twin SAVED project but also to boost the then Consortium, including by involving the car industry. The SAVED2 research proposal was well classified but not recommended for funding. Alternatives to collaborate with Ford are being sought.

Main Researchers Involved

IST/UTL: José Manuel Viegas, Silvia Shrubsall, Luis Picado Santos, Ana Paiva, João Dias
U. Minho: Jorge Santos
MIT: Nancy Leveson and Qi Hommes

Ford Research &
Advanced Engineering
MD3137, RIC /Room3135B
2101 Village Road
Dearborn MI 48121
November 13, 2009

To: WHOM IT MAY CONCERN

Subject: SAVED2 Proposal

The SAVED2* project proposal by Doctor Sílvia Shrubsall and Professor José Viegas at CESUR (Research Centre for Urban and Regional Systems) at Instituto Superior Técnico and Professor Nancy Leveson at MIT, in the USA, is under review by myself and my colleagues at Ford Motor Company from the standpoint of its industrial relevance with respect to both vehicular safety and security systems.

This proposal explores a number of important and as yet unanswered questions and hence we are in the process seeking directional support for this project within Ford Motor Company. We are also considering offering some generic real-world requirements & system specifications associated with our security systems (such as central locking systems) as these could perhaps be used in the proposed SAVED 2 project work.

At Ford Motor Company, we have a formal process to follow before we can sign a letter of support or express and intent to do so. This process requires us to present our draft letter to the members of the operating committee of the Chief Technology Officer of Ford Motor Company and to get their formal approval. The next meeting of the operating committee is on Thursday, Nov. 19, 2009 and should the outcome be in the affirmative, I will send out a formal letter of support very soon after this date.

Sincerely,

K. Venkatesh Prasad

K. Venkatesh Prasad, Ph. D.,
Group & Technical Leader, Infotronics Technologies, Ford Motor Company.
kprasad@ford.com / +1.313.317.9048

Companies Involved

INiR, Tranquilidade, PRP

b) Integrated Systems for Smart Interiors

Objectives & Motivation

Over the last decades, engineering has significantly contributed to the increase of daily life's safety and comfort. Smart technologies comprise a new interdisciplinary research field, focusing on issues such as safety and integrity. One of the current focuses of the engineering community is the development of a new generation of high-performance mechanical systems that have integrated sensing, diagnostics and control capabilities, while continuing to perform their intended functions.

The high-level objective of this research is the development of integrated systems for smart interiors in automobiles, an entirely new generation of high-performance mechanical systems, interfaces between humans and electronic and mechanical devices, installed inside cars.

Different tasks have been addressed to accomplish its objectives: from the study of textile and composite materials with sensing capabilities, to embedding optical fiber sensors into flexible carriers, to interfaces between humans and electronic mechanical devices and the development of a new SMART car seat.

Main Scientific Achievements

Within the different scientific developments accomplished so far, the following can be highlighted:

1. Development of Textile & Composite Materials with Sensing Capabilities

The integration of optical fiber sensors in different materials has been performed with good results. As illustrated in Fig. 36 In particular, the following intermediary successful stages can be emphasized:

- selecting the best suitable flexible carriers materials for embedding optical fibers and optical sensors.
- performance evaluation of the integrated flexible carriers plus fibers (full mechanical and thermal characterization and their interaction with fibers when subjected to changes in the environmental conditions).
- suitability to measure vibrations, temperatures and displacements with optical fiber sensors.
- obtain an industrial process to best embed the optical fibers with carriers (e.g., the industrial process cookbook), in order to achieve big scale and automated fabrication.
- obtaining the static and dynamic responses of embedded sensors.

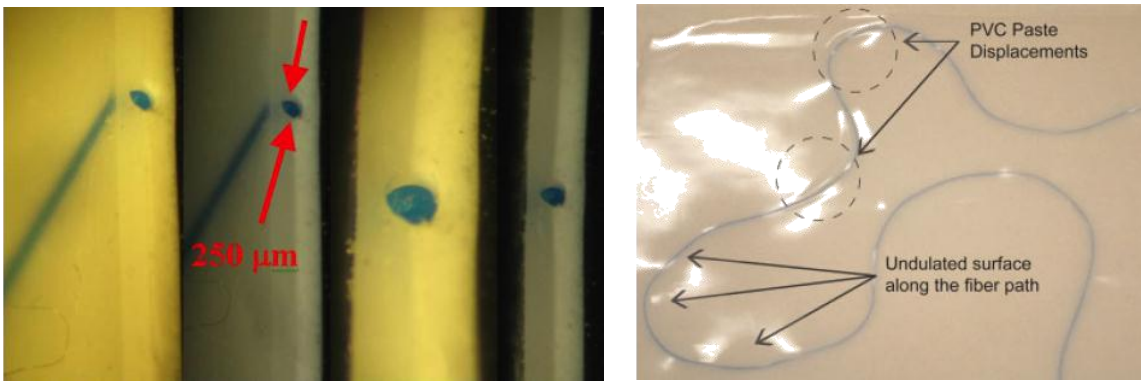


Figure 36 - . integration of optical fiber sensors

The study of solutions for the improvement of human-machine interfaces, in terms of user satisfaction and manufacturing cost has been carried out. In particular, the following intermediary stages can be highlighted:

1. model the user satisfaction through a DAP pyramidal structure (D=satisfaction dimensions, A=interface attributes, P=interface engineering parameter), as represented in Fig. 37;
2. engineering parameters identification through interface decomposition and analysis;
3. interface attributes identification through an extensive interviews method;
4. links identification between the interfaces attributes and engineering parameters through a neural network method.

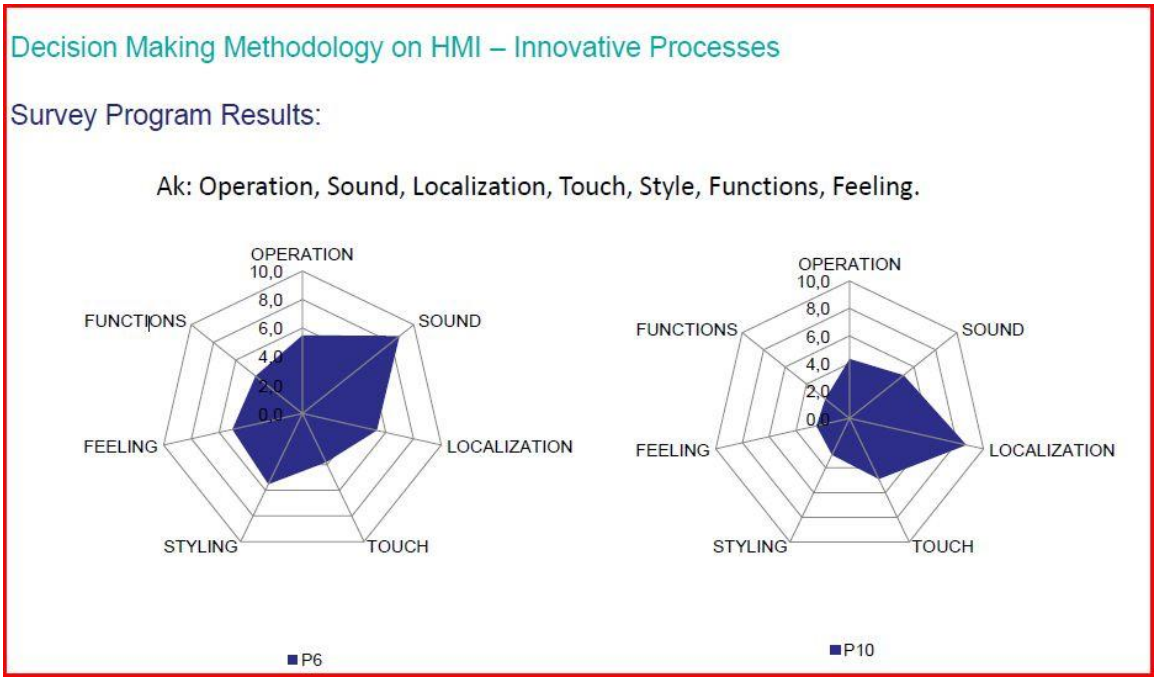


Figure 37 - Human Machine Interaction on Sensitivity Functions Approach: Case of Non-Visual Senses

The development of a methodology to, contribute to attaining the expected kinesthetic feeling of an in-car interface bush buttons, has been studied. In particular, the following intermediary stages have been carried out:

- identification of the main non-visual senses and define a methodology to capture the expected feeling regarding these senses;
- identification of the engineering parameters involved on the kinesthetic sense analysis;
- model of the kinesthetic sense.

4. Influence of Variability on Assembly Systems

The study of solutions for reducing (several sources) variability in an assembly system, since it affects the performance of the system (reduction on capacity and increasing variability in the output rate) has been undertaken. The following intermediary stages have been carried out:

- Problem Definition and System Boundaries Research on Assembly Systems;
- Types of Assembly Systems found at Affiliated Company;
- Endogenous Factors of Influence: Workers Performance Variability;
- Research on Human Factors;
- Data Collection of Workers Variability.

Potential economic/social impact of the results achieved

Both economic and social impacts are decisive. The main social impact: after integrating flexible carriers with optical fiber sensors, it's expected that their usage in automobiles will increase the safety of passengers. As far as economic impact is concerned, it is possible to say that the creation of a whole new scale economy for the automotive industry is being undertaken, by gaining productivity on the assembly lines and reducing the product development time and resources.

Role of non-academic partners

Fibersensing: fabricating the optical fiber sensors based on Fiber Bragg Gratings (FBGs).

Textil Manuel Gonçalves (TMG): development of PVC technology and big scale integration with optical fiber sensors, thus, reducing the unitary price per square meter of polymeric foil.

Iber-Oleff: Accordingly with the research plan, several human resources from the company were allocated to this research and several prototypes were manufactured in order to perform research.

Statement of a major stakeholder

The Automotive Industry is well known for constantly seeking breakthrough innovations and improvement opportunities. It has often been the driver for technical and social revolutions.

In recent years, the "automobile concept" as such has been under intense debate, due to the emerging "smart-integrative" approaches that swept across design centers in almost all the OEM's. Key word is now "integration". From the point of view of TMG Automotive, the possibility to embed sensors in traditional polymeric foils for automotive interior trims is an extremely attractive concept, adding relevant value to the product.

The Smart Interiors project addressed this need, by introducing a sensing network on the automobile chassis that could be used for structural monitoring. Using optical fiber based sensors in polymeric foils, as was done on this project, is a novelty, especially due to its industrial manufacturing process approach.

The outcome of this project was very positive in terms of the technological content brought to the Company.

Isabel Gonçalves Folhadela Furtado, TMG Automotive CEO

Main Researchers Involved

FE/UP: Francisco Pires, Pedro Camanho, António Torres Marques, António Carneiro de Araújo
IST/UTL: António Ribeiro, Elsa Henriques, Filipe Cunha, Mihail Fontul, Marta da Silva Carvalho
U.Minho: Higino Correia, João Paulo Carmo, Paulo Mateus Mendes

Companies Involved

TMG Automotive, Sunviauto, Fibersensing, Iber-Olef

2 Overview of All Research Projects Funded Through Open Competitions

2.1 Sustainable Energy and Transportation Systems

The development of sustainable energy and transportation systems addresses the global challenge of providing critical services to increasingly urban populations under significant resource constraints. The topics of the Research Calls were intended to provide solutions to this challenge by promoting cross-disciplinary research that supports the strategic direction of the MIT Portugal Program.

The Research Calls were intended to support a diverse range of research projects that address the many challenges of developing sustainable urban and regional futures. These may have included focused research projects contributing to specific technologies and strategies (such as vehicle-to-grid) as well as large, integrated initiatives serving the needs of multiple stakeholders and complex governmental and business alliances (such as Green Islands).

Value in the results of this research includes both convergence toward the practical development of energy and resource efficient urban futures as well as integration of distinct technologies toward well defined research priorities. The portfolio of research supported within the Sustainable Energy and Transportation Systems Application Area was intended to lead toward implementable scenarios of urban and regional systems that support and enhance the various pathways toward a sustainable society.

The following table provides a description of the projects that were awarded financing in this context as a result of the 2008 and 2009 Research calls. This is followed by a set of factsheets characterizing each of the projects.

Project Reference	Project Title	Main PT Researchers	Main MIT Researchers	Universities/Schools	Associated Laboratories	Industry Partner
MIT-Pt/SES-GI/0008/2008	Power demand estimation and power system impacts resulting of fleet penetration of electric/plug-in vehicles	Carla Silva, Tiago Farias, Christos Ioakimidis, João Peças Lopes, Manuel Matos	John B. Heywood	IST/UTL	IDMEC, ISR, INESC-Porto	GALP, EDP, APVE
MIT-Pt/TS-ITS/0036/2008	SAVED - System for Adapting the Vehicle dynamic parameters to the driving Environment and Driver capabilities	José Viegas, Luis Picado Santos, Jorge Santos, Ana Paiva, João Dias	Nancy Leveson and Qi Hommes	IST/UTL, FCT/UC, U Minho		INiR, Tranquilidade, PRP
MIT-Pt/SES-SUES/0037/2008	Net Zero Energy School - Reaching the community	Carlos Silva, Luísa Schmidt, Ana Horta, Augusta Correia, Carlos Pina dos Santos, Margarida Rebelo, Marluci Menezes, Luís Matias	collaboration done through students visits to MIT	IST/UTL, ICS	ISR, LNEC	QUERCUS, GALP
MIT-Pt/SES-SUES/0041/2008	iTEAM - integrated Transportation and Energy Activity-based Model	Francisco Pereira, Ana Almeida, João Abreu, Samuel Niza, Leonardo Rosado, Teresa Galvão, Ana Camanho, Carlos Bento	Moshe Ben-Akiva, Chris Zegras and John Fernandez, Marta Gonzalez	FCT/UC, IST/UTL, FE/UP		ISA, S. A.
MIT-Pt/TS-AAS/0046/2008	AIRDEV - Business Models for Airport Development and Management	Rosário Macário, Jorge Pinho de Sousa, Jorge Reis Silva	Amedeo Odoni, Cynthia Barnhardt, Richard de Neufville	IST/UTL, FCT/UC, UBI		INAC, Alstom
MIT-Pt/TS-ITS/0059/2008	MISC - Massive Information Scavenging with Intelligent Transportation Systems	João Barros, Jorge Pinho de Sousa, João Paulo Cunha, Michel Ferreira	Muriel Medard, Dina Katabi, Minji Kim	FE/UP, FC/UP, UA	IT, IEETA	Biodevices, BAE, MacLaren Electronics, Petratex, STCP
MIT/SET/0014/ 2009	BioTrans - Capturing Uncertainty in Biofuels for Transportation. Resolving Environmental Performance and Enabling Improved Use	Fausto Freire, Carlos Henggeler Antunes	Randolph Kirchain		ADAI-LAETA, INESC-Coimbra	Prio Biocombustíveis, Prio Advanced Fuels
MIT/SET/0018/ 2009	Energy Box - development and implementation of a demand-responsive energy management system	Carlos Henggeler Antunes, Armando Mónica de Oliveira	Richard Larson (the Co-Applicant), Daniel Livengood (PhD candidate)	UC	INESC-Coimbra	ISA, S. A.
MIT/SET/0023/ 2009	EXPRESS - EXploration of Portugal's high speed Rail and Economic development Strategy Solutions	João Abreu, Luís Picado Santos, Filipe Moura	Joseph Sussman (the Co-Applicant), Dana Rhodes, Adam Ross, Sevara Melibaeva (student), Travis Dunn (student)	IST/UTL, FCT/UC	CESUR	RAVE

Power demand estimation and power system impacts resulting of fleet penetration of electric /plug-in vehicles

FCT CODE: MIT-Pt/SES-GI/0008/2008

Starting Date: 1 April 2009 **Expected Completion Date:** 1 April 2012

Principal Investigator: Carla Silva, IST/UTL **MIT Collaborator**: John B. Heywood (Sloan Automotive Laboratory)

Institutions/Research Centers involved: IDMEC/IST; INESC-Porto; IN+/IST; MIT

Companies involved: GALP; EDP; APVE

FCT Funding: 193.776,00€

Main Scientific Achievements:

1.Characterization of the electric power systems and grid model development:

The electric power grid of Island of Flores, Island of S. Miguel and representative networks from Portugal mainland were fully characterized. For steady state analysis network topologies, generation system and load were represented. In addition, for dynamic behaviour analysis, dynamic models for all the generators were detailed. Firstly, steady state analyses were conducted for the characterized islanded systems and Portugal mainland distribution networks. Grid branch congestion and voltage drops were evaluated for daily operating scenarios and specific charging schemes were identified, including smart charging ones, which involve hierarchical control structures based on the monitoring of network voltage drops. Secondly, dynamic simulation analyses were conducted for the islanded system, in order to assess the increased potential to integrate additional intermittent renewable energy sources, when electric vehicles are present in the electricity grids. Frequency oscillations were then evaluated for the tested scenarios, due to the fact that frequency is the limiting factor for intermittent sources in weak grids as it is necessary to comply with the EN50160 standard. Scenarios where electric vehicles are regarded as conventional loads, as responsive loads and as vehicle-to-grid devices were tested. Results from steady state analyses indicate that dumb charging strategies may be detrimental for grid operating conditions even with low integration values of electric vehicles. Conversely, when smart charging strategies are adopted, then the networks can easily accommodate large penetration of electric vehicles and their availability to be charged following external set-points potentiates their use for provision of other ancillary services. The provision of primary frequency control, ancillary service, in islanded systems proved to be very effective with little effort requested to the electric vehicles. Typically, with small reductions of consumption levels electric vehicles helped to improve the power system resilience, which allows extra integration of intermittent renewable energy sources.

2.Forecasting/backcasting tool to evaluate CO_2 and energy evolution of road transport sector:

An Excel spreadsheet tool was created based on historic data inputs (e.g., number of vehicles per 1000 inhabitants, fleet turnover rate, new vehicle sales rate, gasoline/diesel share, mobility patterns (annual distance travelled per vehicle), alternative energy pathways (biofuel percentage of mixture in conventional fuels, electricity generation mix evolution) and alternative vehicle technology penetration rate (including EV and PHEV). The model was applied to Portugal mainland. Six scenarios were drawn (BAU, liquid fuels low diesel share, liquid fuels high diesel share, policy oriented, electricity powered, hydrogen powered). As a result PHEV, EV and fuel cell vehicles can have the potential to reduce energy consumption up to 9% and CO_2 emissions up to 19% in a fleet full life cycle perspective. A Monte Carlo approach was used for scenario uncertainty.

3.Cost-benefit analysis of introduction of EV/PHEV from the user point of view:

Full characterization of technology costs, over 2010-2050, by using learning curves as a function of the units sold (for each component, e.g. ICE, battery, electrical motor, ECU, fuel cell, exhaust aftertreatment, stop-start). Total ownership costs (TOC) over time for Portugal as a function of fixed and operational costs (e.g. acquisition price, circulation tax, maintenance, fuel prices). It is concluded that the TOC for the several alternative vehicles (different powertrains) will converge over time.

System for Adapting the Vehicle dynamic parameters to the driving Environment and Driver capabilities (SAVED)

FCT CODE: MIT-Pt//TS-ITS/0036/2008
Starting Date: 1st September 2009 **Expected Completion Date:** 31s August 2012
Principal Investigator: José Viegas, IST/UTL **MIT Collaborators**:
Institutions/Research Centers involved: *Instituto Superior Técnico*, *Massachusetts Institute of Technology and Universidade do Minho*
Companies involved:
FCT Funding: 192.979,00€
Main Scientific Achievements:

SAVED seeks to employ innovative methods to provide a lasting significant improvement to road safety by developing the concept and specifications for a system that adjusts the road vehicle's dynamic attributes to the driver's state (permanent and short-term limitations) and driving circumstances. The project started in Sept 09 with the involvement of MIT from November ´10. Research has been split into four major lines and initial accomplishments of each of the four working groups are:

1. ***Driver behavior definition and risk assessment group (IST1)*** developed an agent-based simulation model including a mix of safe drivers, i.e. drivers who adequately adjust their driving style to the driving conditions, and hazardous drivers, i.e. drivers who have poor sightseeing, tiredness and speeding predisposition and therefore increase the probability of accidents, and the proportions may be controlled by the user, with variable consequences on the rate of accidents. In another step of the model, a Transition was designed to convert (a controllable proportion of) Hazardous Drivers to Safer Drivers, by making the vehicle limit the drivers' degrees of driving freedom. For example, it can automatically limit the maximum speed allowed. At the same time, a comprehensive inventory, classification, analysis and selection of Human Factors are ongoing.
2. ***Infrastructure and traffic management group (IST2)*** is focusing on the role of infrastructure and traffic management such as Active Traffic Management (ATM) on traffic safety. The study is proceeding on using the traffic simulation software AIMSUN 6.1 to model case-study situations based on real data.
3. ***Integrating safety into intelligent driver controls group (MIT)*** chose to apply Professor Nancy Leveson's System Theoretic Process Analysis (STPA) method to the adaptive cruise control (ACC) systems. ACC employs a radar system to detect the distance between the car a driver is operating and the car in the front. Depending on the driver's input, the ACC system can help maintain a safe distance between the two cars. However, given the complexity of the system and the integration with the driver, many potential hazardous operation modes can happen. Therefore, it is imperative that safety be integrated into the system during the design phase such that the system complies with all safety constraints. The steps prescribed by STPA did lead to the identification of many potential unsafe scenarios as well as the preliminary analysis of their causes by examining the process models and control structure interactions. Developments of design requirements that can eliminate potential hazards in the system from early on are being analyzed.
4. ***Simulation in laboratory group*** **(UMinho)** will prepare simulation environments to be tested in laboratory and preliminary analyses are expected to occur over the next year. This simulation environment will incorporate the signals from the sensors, a complex video capture and display system, and the necessary integrative software.

NETZERO ENERGY SCHOOL. Reaching the Community

FCT CODE: MIT-Pt/SES-SUES/0037/2008
Starting Date: 1-6-2009 **Expected Completion Date:** 31-5-2012
Principal Investigator: Carlos Silva, IST/UTL **MIT Collaborator**:
Institutions/Research Centers involved: IST,ICS, LNEC
Companies involved: Quercus
FCT Funding: 199.646,00€
Main Scientific Achievements:

Socio characterization of energy concepts and perspectives of the school community (students, professors and staff)

A detailed survey to the school community enabled to characterize how the school community understands and perceives energy concepts: the difference conceptions between boys and girls, between different economic classes, the differences between students and teachers.

This characterization is fundamental do design a set of experiments to be developed in the school with students and teachers to teach them how to make the most energy efficient use of the facilities of the school. It allows to determine whether the school community will be more motivated to change behaviour due to environmental reasons or economical ones; or what are the misconceptions regarding energy use that is necessary to deconstruct and replace by new concepts (for example students find that computers demand more energy than fridges and freezers); or to define what type of activities they prefer to be engaged in order to learn new concepts.

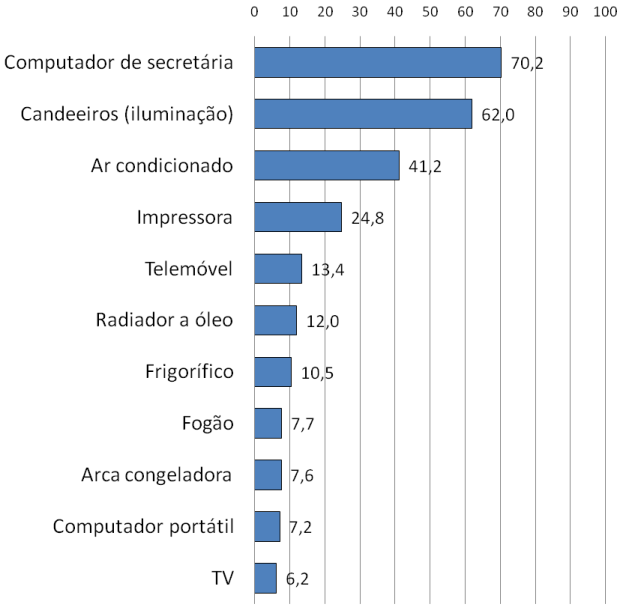


Figure 1: Students perspective on the appliances with higher consumption in the school

Development of measuring system for residential energy consumption monitoring

An important goal of this project is to measure the spill-over-effect that learning energy efficiency practices in the school will have at the residential level. To do this, a set of families from the school community will be monitored in terms of energy consumption. This required the definition of a measuring system and the development of a procedure to approach the families, install the equipment, monitor the energy consumption and evaluate the results. Thus, a testbed experiment was developed in Oeiras (NEGAWATT initiative), where 15 families were monitored over one year. This experiment allowed the team to fine tune the best set of equipment to be used in the residential monitoring experiment in the school community, to test different communication approaches with the families and to develop a set of tools to evaluate the spill-over-effect results.

Integrated Transportation and Energy Activity-based Model (iTEAM)

FCT CODE: MIT-Pt/SES-SUES/0041/2008

Starting Date: April 1st, 2009 **Expected Completion Date:** April 30th, 2012

Principal Investigator: Francisco da Câmara Pereira, FCT/UC **MIT Collaborators**: Moshe Ben-Akiva, Chris Zegras and John Fernandez

Institutions/Research Centers involved: FCT/UC, IST/UTL, FE/UP

Companies involved: ISA, S.A.

FCT Funding: 210.281,00€ **MIT Funding**: $90.873,00USD

Main Scientific Achievements: *(please focus on the 2-3 main scientific achievements of your work)*

Innovative Survey Technologies

iTEAM integrates individual survey data collection in a unified platform, Greenhomes, a Web2.0 server where users can participate and monitor their own data. This data comes from 3 different sources:

- the online questionnaire;
- the smartphone Android OS app for logging (GPS, Accelerometer, GSM and Wifi);
- energy smartmeters for monitoring the aggregated energy consumption of households.

Besides these individual survey initiatives, in iTEAM we apply machine learning and information retrieval techniques to extract activity information from online resources, such as Yahoo Local or Sapo Mapas building on earlier work from team.

Activity based models

iTEAMs individual/household/firm agent design considers all fundamental activities and choices that are relevant to the urban model, namely house location choice, job location choice, activity choices and activity planning, mode and route choice. Together with these, we also consider other models, namely regarding fertility, mortality, real estate and building construction to name a few.

Besides the traditional survey statistical treatment to calibrate these models, we also apply pattern recognition to infer transport modes from GPS logs, and time series analysis to infer activity from in-home energy meters. Such information is used to support the activity diary surveys and increase considerably the precision and resolution of data.

Urban Metabolism

Urban Metabolism allows the translation of activities into materials, waste production, stock variation and emissions. In parallel, a different perspective is to apply Data Envelopment Analysis (DEA) to indentify factors that have high environmental impact. In practice, this is to find a number of environmental indicators and their dependencies with variables available in the model (e.g. population growth, oil prices, etc.).

The explicit integration of Urban Metabolism in an urban model such as OPUS (which is the basis of iTEAM) is currently unprecedented. The team will extend this open platform with algorithms for automatic generation of control sums for waste production, material stock, emissions and energy flows given the activities/trips generated during the simulation.

Business Models for Airport Development and Management (AIRDEV)

FCT CODE: MIT-Pt/TS-AAS/0046/2008

Starting Date: **Expected Completion Date:**

Principal Investigator: Rosário Macário, IST/UTL **MIT Collaborators**: Amedeo Odoni, Cynthia Barnhardt, Richard de Neufville

Institutions/Research Centers involved: FEUP, UBI

Companies involved: INAC, Alstom,

FCT Funding: 183.144,00€ **MIT Funding**: $262.509,00USD

Main Scientific Achievements:

All project outcomes are at an intermediate stage of development. The main achievement of AirDev relates to the adoption of Business Model concept to the infrastructure. Consequence of this innovative approach the project is expected to obtain the following intermediate achievements.

AIRPORT PERFORMANCE AND DEVELOPMENT

An **airport performance analysis** covering operational, financial and economic performance. This analysis provides an anchor to this project as the subsequent studies developed addresses the typology of airports defined herewith. Performance analysis will be developed along the following methods;

- Non-parametric index number approaches to measure the total factor productivity (TFP);
- Parametric (econometric) analyses such as Stochastic Frontier Analysis (SFA); and
- Non-parametric linear programming approaches as Data Envelopment Analysis (DEA).

A clarification of the airport city concept and a structured approach on **how to develop an airport,** considering marketing tools and the relation of the airport with the hinterland supported by an analytical model based on Value Network Analysis.

AIRPORT CAPACITY

A set of concepts, guidelines, algorithmic and **decision support tools**, structured around a methodology to describing, designing and evaluating airport **capacity expansions**

AIRPORT BUSINESS MODEL

Analysis and depiction of the key elements for the development of an **airport business model** according to its different vocations. A **system dynamics approach to airport profitability** as been developed to identify the variables supporting the business model.

AIRPORT OWNERSHIP, FUNDING AND FINANCING

Development of financing and funding options for the different alternative business models, providing an **evaluation on the best options between ownership, funding and financing;**

Development of new construction for **airport charges**, introducing a more fair relation between different types of air transport services, enhancing commercial value of airport slots

Publications:

Journal articles = 1; Book = 1; Book chapters = 4; Conference papers = 11

Academic Dissertations:

PhD (finished) = 1; PhD (on going) = 4; MSc (finished) 4 ; MSc (on going) = 2

Massive Information Scavenging with Intelligent Transportation Systems (MISC)

FCT CODE: MIT-Pt/TS-ITS/0059/2008

Starting Date: 01-07-2009 **Expected Completion Date:** 30-06-2012

Principal Investigator: João Barros, FE/UP **MIT Collaborator**: Muriel Medard

Institutions/Research Centers involved: FE/UP, FC/UP, UA, IT

Companies involved: Biodevices, STCP, Petratex, McLaren Electronics, PT Inovação, BAE Systems

FCT Funding: 199.979 € **Other Funding**: 100.000 €

Main Scientific Achievements:

The goal of the MISC project is to create urban scanner for improving safety in transportation systems. This is achieved by creating a vehicular sensor network that monitors multiple sensors including bio-physical sensors and correlating them in real-time with specific geographical locations.

A main scientific achievement was the development of a broad theoretical foundation in the area of vehicular ad-hoc communications, namely the development of secure network coding protocols that are resilient to Byzantine attacks [1, 4]. This is achieved by employing algebraic watchdogs [3, 7] that are able to distinguish between transmission errors and malicious nodes. These secure and resilient protocols [2, 8, 9] are of great importance to vehicular networks [5], since they may carry critical and sensitive data.

Another scientific achievement was the development of a prototype that provided the first iteration to the urban scanner. This prototype combines the VitalJacket that measures the heart wave, with the OBDlink that reads sensor data from the vehicle and GPS location. These data streams were aggregated over many trips before being processed and analysed afterwards. This prototype is already very close to the final system, with just the communications module missing. The obtained data showed that there is a correlation between acceleration/deceleration and the variation of the driver's heart rate, hence showing an emotional response to driving related events [6].

In order increase the MISC deployment, vehicles that have CarPCs with DSRC radios can send data to the central server through the vehicular network, while vehicles without CarPCs can use Android-based smartphones to send data through the 3G network. These elements are currently being finalised so that STCP buses integrated in the MISC urban scanner in early Q2-2011.

[1] L. Lima, F. Zhao, J. Barros, M. Medard, R. Koetter, T. Kalker, and K.Han. *On Counteracting Byzantine Attacks in Network Coded Peer-to-Peer Networks*, IEEE Journal Sel. Areas in Comm., 2010.

[2] G. Maierbacher, J. Barros and M. Medard, *Practical Source-Network Decoding*, IEEE International Symposium on Wireless Communication Systems (ISWCS'09), Siena, Italy, September 2009

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[4] L. Lima, J. Barros, R. Koetter, *Byzantine Attacks against Network Coding in Peer to Peer Distributed Storage*, IEEE Intl. Symposium on Information Theory, Seoul, Korea, June/July, 2009.

[5] L. Lima, D. Ferreira and J. Barros, *Topology Matters in Network Coding*, Springer Telecommunication Systems Journal, Special Issue on Future Internet Architectures, 2010.

[6] J. Rodrigues, F. Vieira, T. Vinhoza and J. Barros, *A Non-Intrusive Multi-Sensor System for Characterizing Driver Behavior*, IEEE Symp. Int. Transportation Systems, Madeira, Portugal 2010.

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Capturing Uncertainty in Biofuels for Transportation: Resolving Environmental Performance and Enabling Improved Use

FCT CODE: MIT-Pt/SET/0014/2009

Starting Date: 18 Oct 2010 **Expected Completion Date:** Oct. 17, 2013

Principal Investigator: Fausto Freire **MIT Collaborators**: Randolph Kirchain, Elsa Olivetti

Institutions/Research Centers involved: ADAI-LAETA, INESC Coimbra and MIT MSL

Companies involved: Prio Biocombustíveis SA and Prio Advanced Fuels (both part of the Martifer Group)

FCT Funding: 198.758,00 €

Objectives and Main Scientific Contributions to be expected:

The project will develop innovative methodologies for the implementation of biofuels systems for sustainable transportation in Portugal, by developing an integrated life cycle technology, economic, and environmental assessment, explicitly incorporating uncertainty. The project focuses on systems producing a major crop traded on the global market and explores the use of next generation biofuels and feedstocks that could be sourced domestically, which could provide a business opportunity for Portuguese companies. The project has the following **specific objectives**:

- Characterize the uncertainty in selected bio-derived fuel feedstock sources, including their quality and environmental performance.
- Develop a consequential life cycle inventory (LCI) modelling framework of biofuel systems, in which consideration of land use change (LUC) and/or indirect land-use change (ILUC) is crucial for a comprehensive sustainability assessment.
- Develop decision-support tools that explicitly incorporate the uncertainty of the quality performance function and environmental performance to guide blending decisions.
- Assess the environmental value of biofuel alternatives based on the complementary use of Multi-Criteria Decision Analysis (MCDA) and Life Cycle Assessment (LCA).
- Combine LCA and blending algorithms using MCDA towards novel engineering systems methodologies through case studies that compare fuels for transportation on metrics of environmental performance.

Expected results:

- Characterization of the uncertainty in feedstock quality and sustainability assessment of bioenergy systems.
- LCI models of some of the most relevant biofuel systems for transportation, encompassing indirect effects of land use change.
- New insights about modeling options in LCA, for example on the choice between attributional and consequential modeling.
- Methodological contributions for the state-of-the-art in LC uncertainty analysis and the main procedures to reduce and/or manage this uncertainty.
- Innovative applications of MCDA methodologies to LCA, taking into account technical, economic and social criteria.
- Decision-support models that explicitly treat quality uncertainty to support blending decisions in fuel production.
- A methodology to assign sustainability ratings to bioenergy system alternatives.
- Case studies that combine the insight gained from the LCA, MCDA and blending algorithms to test the sensitivity of and illustrate strengths and limitations of the methodologies.

Energy Box - development and implementation of a demand-responsive energy management system

FCT CODE: MIT/SET/0018/2009

Starting Date: 18 Oct 2010 **Expected Completion Date:** 17 Oct 2013

Principal Investigator: Carlos Henggeler Antunes **MIT Collaborators**: Richard Larson, Daniel Livengood

Institutions/Research Centers involved: INESC Coimbra; IPCDVS, University of Coimbra

Companies involved: ISA – Intelligent Sensing Anywhere, S.A.

FCT Funding: € 195.836,00 **Other Funding**: -

Objectives and Main Scientific Contributions to be expected: The implementation of demand-sensitive pricing schemes is a proven strategy for an industry to provide more service within capacity constraints of the current service system infrastructure, thus postponing or avoiding huge capital expenses. The ongoing transformation of electric grids into "smart grids" provides the basis to implement demand-sensitive pricing aimed at using the electric power infrastructure more efficiently. This creates benefits for the end-users (lowering their electricity bill without degrading comfort levels), the operators (managing the peak and flattening the aggregate demand curve, which may permit to meet forecasted demand growth with the current portfolio of generation sources) and the environment (avoiding building new generation units). In this context of migration to smart grids demand-sensitive pricing of electricity will become the standard pricing mechanism. Therefore, it is necessary to make the most of short-term price signals, comfort requirements and user preferences to induce changes in electricity-consuming behavior. In this context, the aim of this project is to further develop and implement in practice the concept of Energy Box (Livengood and Larson, 2009) as a 24/7 background processor to manage in an intelligent manner - responding to price signals, comfort requirements, etc. - one's home or small business electrical energy use. The Energy Box is thus an energy management system consisting of a hardware device and algorithms coordinating in an autonomous manner the management of electricity use, storage and selling back to the grid for the typical small consumer of electricity in the residential and services / industrial sectors. This is an automated energy management system that mimics the individual consumer's decision-making process under the same conditions (of the grid, in-door comfort and air quality, occupancy patterns, weather, etc.). The Energy Box will exploit the flexibility that consumers generally have in the timing of their electricity usage to induce changes in their electricity-consuming patterns through time-varying electricity pricing to achieve a total system optimal control. This becomes feasible with the "smart grid" infrastructure, including two-way communication and short-interval meter reading, complemented with sensor networks. This project aims further to develop algorithms, based on OR techniques for decision support, to produce a learning, adaptive version of the Energy Box that has the capability to address both usability and user-engagement issues. Usability is perceived as going beyond having a good human-machine interface and includes requiring minimal information input or intervention from the user while causing minimal or no disruption to the user's activity or work processes. An innovative stance will be to include researchers on cognitive psychology to study issues regarding the dissemination and degree of use, perceived as the level of enthusiasm with which the user deploys and uses the Energy Box including the willingness to leave decisions to switch on/off electric appliances providing the energy services with a certain level of comfort to a device (although this is parameterized with input information). It is expected to develop, in association with a company with expertise in this domain, a prototype (hardware and software) capable of controlling a space-conditioning facility in the home or small office. The groundwork laid down for the Energy Box will be the starting point of this project. These competences will be expanded with the expertise on the design of energy efficiency measures, load control and management, electric vehicles and consumer behavior. The association with ISA, which possesses a relevant technical and scientific knowledge in this field, provides the technological basis to develop a hardware/software prototype aimed at performing in-situ experiments, which can lay down the foundations for a possible future mass deployment of the Energy Box.

EXploration of Portugal's high speed Rail and Economic development Strategy Solutions (EXPRESS)

FCT CODE: MIT-Pt/**SET/0023/2009**

Starting Date: 1/9/2010 **Expected Completion Date:** 31/8/2013

Principal Investigator: João de Abreu e Silva **MIT Collaborators**: Joseph Sussman (MIT PI), Donna Rhodes

Institutions/Research Centers involved: Centro de Sistemas Urbanos e Regionais (CESUR/IST/UTL), Centro de Investigação em Engenharia Civil (CIEC/FCT/UC)

Companies involved: RAVE

FCT Funding: 192.255 € **Other Funding**: 2.311€ (from RAVE)

Objectives and Main Scientific Contributions to be expected:

The EXRESS research project aims to study several aspects of the High Speed Rail (HSR) deployment in Portugal. They include:

- Financial crowding-out effects: We will examine the hypothesis that substantial capital investments and ongoing operating expenses needed for HSR will "crowd out" funds and credit available for other transportation needs. Of particular concern is that funding for urban transportation may be crowded out, causing HSR stations to be less accessible, holding down demand. We will develop and evaluate alternative unimodal and/or multimodal strategy and finance approaches for addressing this crowding-out effect.
- Urban/regional form and megalopolis creation: HSR will have profound impacts on the cities it serves and on the broader region within which it operates. We will study the impact of various deployment approaches on local urban form. For example, the use of HSR for daily commuter trips into Lisbon or Oporto can change the structure of these cities substantially. We will also consider the potential for creation of a Portuguese megalopolis in the Lisbon-Oporto corridor. Also the HSR urban/regional impacts will have implications in the levels of demand attracted by the HSR services, which suggests the existence of a two-way relationship between service demand and spatial impacts of HSR.
- Demand uncertainties and competition / coordination with other modes: HSR deployment will create competition and require cooperation with other modes of travel, including urban transportation, existing conventional rail, and air. We will explore innovative demand forecasting approaches that consider dynamic multi-modal interactions as well as uncertainties in demand forecasts.
- Configuration of freight services on HSR: Using HSR for freight service has the potential to improve the efficiency and sustainability of freight movements while orienting Portugal as an intercontinental freight hub. For example, shipments to the west coast ports of Portugal, such as Sines, could be transported by HSR into the economic heart of the Iberian Peninsula. On the other hand, freight may hinder the ability of the HSR system to provide other expected economic benefits and complicate coordination with other modes. We will explore all of these tradeoffs.

These individual strategic deployment challenges are inter-related, and we will evaluate them in combination. For example, configuration of freight services will affect urban form and megalopolis formation; "crowding out" of funds for urban transportation will affect cooperation with other modes; and so on. To understand the integrated performance of various approaches, we will perform a comprehensive evaluation using multi-criteria analysis, stakeholder analysis, and scenario planning.

2.2 Materials & Design Inspired Products

Materials and Design Inspired Products is a research area of the MIT-Portugal Program targeting products and associated services resulting from the integration of science and technology (including advanced modeling tools) into competitive solutions and new developments for niche markets in the mobility industries (e.g., automotive and aeronautics) and health sector (medical devices), and for other opportunities that arise from the efforts of entrepreneurs and graduates involved in the Program.

The Research Calls in this area were intended to follow an Engineering Systems approach integrating different aspects of the product development chain with social science and management issues.

Relevant knowledge development in the framework of the product development chain requires different stages to be addressed, namely: concept/idea development, modeling, prototyping and evaluation, manufacturing, and supply chain management, using an engineering systems approach, i.e., considering the adequate management and social contexts. In fact, a major objective of this Call, was to foster integrated analysis and novel solutions for problems comprising more than one of those stages performed by multidisciplinary groups.

The following table provides a description of the projects that were awarded financing in this context as a result of the 2008 and 2009 Research calls. This is followed by a set of fact sheets characterizing each of the projects.

Table 4– Research projects in the area of Engineering Design and Advanced Manufacturing

Project Reference	Project Title	Main PT Researchers	Main MIT Researchers	Universities/Schools	Associated Laboratories	Industry Partner
MIT-Pt/EDAM-EMD/0007/2008	New Technological Solutions for Smart Cardiovascular Medical Devices	Luis Rocha, António Pontes, Júlio Viana, João Tavares, João Carmo, Joaquim Mendes, José Silva, Alexandra Rodrigues	Brian Wardle, PhD student	U Minho, FE/UP, IST/UTL	IPC, Algoritmi, ICS, INESC-P, IDMEC-P, INEGI, ICEMS	Hospital S. João
MIT-Pt/EDAM-SI/0025/2008	Development of Integrated Systems for Smart Interiors	Francisco Pires, António Ribeiro, Elsa Henriques, Higino Correia	R Roth, Qui Holmes, T Wierzbicki	FE/UP, IST/UTL, U Minho		Iber-Oleff, TMG, FiberSensing, Sunviauto
MIT-Pt/EDAM-SMS/0030/2008	Assessment and Development of Integrated Systems for Electric Vehicles	Jorge Martins, Adriano Carvalho, Carla Silva, Gonçalo Gonçalves, João Afonso, José Claro, José Esteves, José Duarte, Júlio Viana, Francisco Brito, João Fernandes	R. Roth	U MInho, FE/UP, IST/UTL		Simoldes, Efacec, Inteli, CEIIA
MIT-Pt/EDAM-IASC/0033/2008	Lean, agile, resilient and green supply chain management	Virgílio Machado, Rui Valente, António Pires, Nuno Costa, Susana Azevedo	Deborah Nightingale	FCT/UNL, IDNT, UBI	UNIDEMI	Volkswagen Autoeuropa, Delphi, Delta, Edia
MIT-Pt/BS-HHMS/0042/2008	DACHOR - Multibody Dynamics and Control of Hybrid Active Orthoses	Miguel Silva, Jorge Martins, Paulo Flores, Luis Ferreira da Silva	Dava Newman, Hugh Herr and Diana Young	IST, U Minho		Plux
MIT/MCA/0066/ 2009	Economic and Environmental Sustainability of Electric Vehicle Systems	Luis Dias, Fausto Freire, Aníbal Traça de Almeida	Randolph Kirchain, Jeremy Gregory		INESC-C (Economics), ADAI, ISRC	General Motors, Critical Move, EVIberia, EDP Distribuição

New Technological Solutions for Smart Cardiovascular Medical Devices

FCT CODE: MIT-Pt/EDAM-EMD/0007/2008

Starting Date: 01-08-2009 **Expected Completion Date:** 31-07-2012

Principal Investigator: Luis Rocha, U Minho **MIT Collaborators**: Brian Wardle (MPC and MEMS@MIT)

Institutions/Research Centers involved: FE/UP, IST/UTL

Companies involved: Hospital S. João

FCT Funding: 185.772,00€

Main Scientific Achievements: **(please focus on the 2-3 main scientific achievements of your work)**

1. *Definition and characterization of the fabrication process for the new technology to build the flexible pressure sensor:*

Two different approaches are used to manufacture the flexible PDMS films. On one side, molds are fabricated using SU-8, a photoresist resin with excellent lithographic and optical characteristics. On the other side, acrylic molds are produced by CNC milling. This technique presents some advantages relatively to SU-8 molding, such as lower costs and faster production times, but it is associated with poorer dimensional control. The electric components (capacitor electrodes and inductor) are based on aligned carbon nanotubes, as shown in. Chemical vapor deposition (CVD) is used to growth forests or "carpets" of vertically-aligned CNTs. A silicon substrate with patterned Fe/Al2O3 catalyst is placed on a horizontal quartz tube furnace at atmospheric pressure at 750 ºC for the CNTs growth. This method has the advantage of allowing the growth of high purity, high yield and vertically aligned CNTs. Next, the CNTs are embedded into the polymer matrix (PDMS). Finally, the PDMS membranes are bonded using uncured PDMS adhesive techniques.

2. *Definition of the sensor specifications and sensor model.*

The main specifications for the transduction element (pressure sensor) have been defined. For aortic aneurysm pressure measurement the sensor should have a dynamic range between 20mmHg and 250mmHz, a 1mmHg resolution and an absolute accuracy below 5mmHg. Other characteristics related to the materials and placement of the sensor are under study. Both analytical and FEM models have been created as a tool to design the sensor on the technology being developed.

3. *First prototype using COTS (components out of the shelf) to test the measurement wireless system approach.*

The sensors and the external reader exchange information and energy by inductive-coupling as depicted. A distinctive difference between this work and previous systems is the measurement method. While previous approaches are based in the measurement of the circuit's impedance using a network analyzer, our measurement approach is based on the direct analysis of the LC resonant oscillation response. A first prototype was already built and the measurements validate the proposed approach. A second prototype that uses an improved twin configuration for the elimination of harmonics is being tested. Simulations demonstrate that the measurement of more than one sensor is also feasible.

4. *Definition of new methodology for the development of medical devices.*

Concept selection is often the point of no return in the design process. It is vital that the best initial concepts are selected, as they determine the direction of the design embodiment stage. It is often said in the literature that nearly 60 to 80% of the cost is committed at this stage. After this stage has been passed, the design process will diverge towards a detailed solution, the system-level design. We are proposing a process of concept selection based on the medical device's expected clinical and economical effectiveness. The assessment in such an early stage is not expected to be very accurate, but it can reduce product development cost and help reducing uncertainty regarding the success of the new product. It can also be beneficial in the sense that will integrate in the product development process users and will compel a reflection over existing solutions, both products and procedures.

Development of Integrated Systems for Smart Interiors

FCT CODE: MIT-Pt/EDAM-SI/0025/2008

Starting Date: **Expected Completion Date:**

Principal Investigator: Francisco Pires, FE/UP **MIT Collaborators**: R Roth, Qui Holmes, T Wierzbicki

Institutions/Research Centers involved: IST/UTL, U Minho

Companies involved: TMG Automotive, Fibersensing, Sunviauto, Iber-Oleff

FCT Funding: 198.167,00€ **Other Funding**: 241.960,00€

Main Scientific Achievements:

The main scientific developments, accomplished so far, are:

1 – Development of Textile & Composite Materials with Sensing Capabilities

The integration of optical fiber sensors in PVC has been performed both in Laboratory and in industrial environment. In particular, the following developments have been accomplished:

- selecting the best suitable flexible carriers materials for embedding optical fibers and sensors.
- a performance evaluation of the integrated flexible carriers plus fibers (full mechanical and thermal characterization and their interaction with fibers when subjected to changes in the environmental conditions).
- the suitability to measure vibrations, temperatures and displacements with optical fiber sensors.
- the determination of the industrial process o best embedded the optical fibers with carriers (e.g., the industrial process cookbook), in order to achieve big scale and automated fabrication.
- obtaining the static and dynamic responses of embedded sensors.

2 – Decision Making Methodology on Human Machine Interaction Innovative Processes

The study of solutions for the improvement of human-machine interfaces, in terms of user satisfaction and manufacturing cost has been carried out. The following stages can be highlighted:

- model the user satisfaction through a DAP pyramidal structure (D=satisfaction dimensions, A=interface attributes, P=interface engineering parameter);
- engineering parameters identification through interface decomposition and analysis;
- interface attributes identification through an extensive interviews method;
- links identification between the interfaces attributes and engineering parameters through a neural network method.

3 – Human Machine Interaction on Sensitivity Functions Approach: Case of Non-Visual Senses

The development of a methodology, which will contribute to attaining the expected kinesthetic feeling of an in-car interface bush buttons, has been studied through the:

- identification of the main non-visual senses and define a methodology to capture the expected feeling regarding these senses;
- identification of the engineering parameters involved on the kinesthetic sense analysis;
- development of a model of the kinesthetic sense.

4 – Influence of Variability on Assembly Systems

The study of solutions for reducing (several sources) variability in an assembly system through:

- Problem Definition and System Boundaries Research on Assembly Systems;
- Types of Assembly Systems found at Affiliated Company;
- Endogenous Factors of Influence: Workers Performance Variability;
- Research on Human Factors;
- Data Collection of Workers Variability.

Assessment and Development of Integrated Systems for Electric Vehicles (MOBI-MIT Portugal Program)

FCT CODE: MIT-Pt/EDAM-SMS/0030/2008

Starting Date: April 1st , 2009 **Expected Completion Date:** March 31st , 2012

Principal Investigator: Jorge Martins, U Minho **MIT Collaborators**:

Institutions/Research Centers involved: U. Minho, FEUP, IST

Companies involved: CEIIA, INTELI, SIMOLDES, EFACEC

FCT Funding: 341 565 € **Other Funding**:

Main Scientific Achievements:

This project aims at assessing the new paradigms of Electric Vehicle (EV) use and developing fully operational prototype systems to be incorporated into electric vehicles. some notable scientific highlights of the project are presented in continuation:

1. **EV Simulation and Data gathering:**

A unique database on electric/hybrid vehicles and systems (motors, batteries, etc) has been built. This Database has now more than 650 entries spanning from the early days of the EV, in the nineteenth century, up to the models and concept cars that have been released in the 2011 auto shows; This information enabled a thorough assessment of the state of the art of EV market and associated technologies. A survey based on the data collected has been published, while a mass-market book on EVs is now under preparation. In addition, tools for evaluating the impact of using several electric mobility solutions were also developed by the project. These include Range Extender engine simulation, Life Cycle Analysis, and simulation of real driving cycles (based on data collected during field work).

2. **Battery charging and power management**

A smart charging system is now at an advanced stage of development. Its main advantage in comparison with conventional systems is that it incorporates PFC (power factor correction) and induces sinusoidal energy consumption with a very low THD (total harmonic distortion). It allows for slow charging, fast charging (still under development) and has Vehicle-to-Grid (V2G) capability. This and the other powertrain systems, are to be tested in an EV test bench being built by the project as well as in test mules. The bench will allow the replication of real driving cycles, with the inclusion of vehicle inertia through a flywheel system and the replication of road slopes and drag through a computer-controlled motor/generator.

An efficient Battery Management System (BMS) is also being developed. The goal of this system is to ensure proper cell balancing and monitor the State of Health (SoH) and State of Charge (SoC) of the battery pack. The control of this system is based on a battery model built on theoretical models and fine-tuned around experimental data sets. The model emulates battery performance variation with SoC, transient power peaks and temperature fluctuation. This will also allow the accurate simulation of battery cell behaviour during vehicle drive cycles.

3. **Range extender prototype**

A range extender (RE) prototype for Electric Vehicles is being built. It enables on-board recharging whenever the battery SoC is low. It has two operation modes. The ECO mode, which is the default one, starts whenever the SoC drops below a certain level (e.g. 30%) and allows for a very high energy efficiency, at the expense of a modest power output (15kW). The BOOST mode, which provides extra power (40kW) at a lower efficiency, is only triggered whenever the SoC drops below a critical level (10%). This will happen in situations where the power demand is high and the ECO mode is insufficient for sustaining the SoC.

Lean, agile, resilient and green supply chain management (LARG_SCM)

FCT CODE: MIT-Pt/EDAM-IASC/0033/2008
Starting Date: 01-06-2009 **Expected Completion Date:** 31-05-2012
Principal Investigator: Virgílio Cruz-Machado, FCT/UNL **MIT Collaborators**: Lean Advancement Initiative
Institutions/Research Centers involved: FCT/UNL (UNIDEMI, UNINOVA), UBI (NECE), IPS, IPP
Companies involved: Volkswagen Autoeuropa, Delphi, Delta, EDIA
FCT Funding: 191.724,00€
Main Scientific Achievements:

A lean company means nearly zero inventories; a resilient company must have enough inventories to react to the effects of disruptions that may occur in a supply chain. These concepts seem to be contradictory. However, it would be ideal to have both systems working together in a company. The main objective of LARGe_SCM project is to develop a deep understanding of interrelationships (conflicts and trade-offs) across lean, agile, resilient and green manufacturing paradigms, in the auto industry sector. The research has been centred on the investigation of the conditions to increase company resilience, without affecting (or significantly reducing) the maintenance of a lean and sustainable manufacturing environment.

A number of models and methodologies have been developed, namely:

1. A conceptual model providing the links between Lean, Agile, Resilience and Green paradigms and the supply chain performance is being developed. This model assists in the identification of synergies and divergences between the paradigms.
2. To investigate the relation between supply chain performance and paradigms attributes, a conceptual model was proposed with the main relations between key performance indicators and supply chain attributes.
3. An innovative approach, using a BSC approach as a management tool for Lean and Green supply chain performance evaluation, was developed; as result Lean and Green measures were derived.
4. A model to help supply chain managers to monitor and control the influence of a set of Lean and Green practices on supply chain performance was developed and tested. The most important green practices were identified and performance measures were designed to evaluate the influence of green practices on supply chain performance.
5. A model for a better understanding of the agile and resilient paradigms influence on supply chain performance and competitiveness was proposed.
6. The development of an ANP model is being used to design a LARGe_SCM information system; it allows an analysis of the cross-linkage between the different paradigms practices and performance metrics and the framework of the differences and synergies of the four paradigms.

Multibody Dynamics and Control of Hybrid Active Orthoses (DACHOR)

FCT CODE: MIT-Pt/BS-HHMS/0042/2008

Starting Date:

Expected Completion Date:

Principal Investigator: Miguel Tavares da Silva, IST/UTL

MIT Collaborators: Dava Newman, Hugh Herr and Diana Young

Institutions/Research Centers involved: U Minho

Companies involved: Plux

FCT Funding: 192.620,00€

Other Funding:

Main Scientific Achievements:

1. *Development of advanced computational models for the integrated design of the hybrid Ankle-Foot Orthosis (AFO):*

Computational models were developed, using a multibody formulation with fully Cartesian coordinates, to provide insight to the development of the physical prototypes. These models included the development of an architecture for the control of a partial multibody model of the human ankle joint by providing the proper set of muscle activations to a group of Hill-type muscle actuators; the development of a novel Hill-type muscle actuator with an integrated three compartment fatigue model that allows including muscular fatigue in the simulation and analysis of human movements; and the development of a comprehensive foot model for the simulation of the foot-ground iteration using a non-linear continuous contact force model with viscous friction.

2. *Construction of a physical prototype of the functional mechanical actuation (FMA) solution that includes the construction of a series elastic actuator (SEA) regulated by impedance control (IC):*

A physical prototype of a FMA AFO in being presently constructed and assembled considering the biomechanical requirements of an individual with a body mass of 70kg. The breakthrough in the design is the ability to provide the necessary power not only during controlled plantar flexion after heel contact, but also during high torque propulsion from heel-off to toe-off. A powerful reduced size SEA works as an ideal force actuator allowing for the direct implementation of impedance controllers for the ankle joint angle. The control architecture is driven by a state machine that adapts the stiffness and damping values of the impedance law, according to the current gait state.

3. *Construction of a physical prototype of a 4 channel functional electrical stimulator (FES) unit:*

A physical prototype of a FES unit was designed and constructed for the stimulation of four independent skeletal muscles. The unit has 4 asynchronous channels that deliver programmed electrical pulses, modulated in amplitude and time, to each one of the selected muscles. It is an embedded system, with custom electronics and open software, in order to allow testing of different action potential profiles. The system communicates with an external real-time controller through a serial bus, allowing the model identification and the closed loop control of the muscle contractile dynamics and the consequent control of the ankle-joint angle. The devised FES unit had recently the approval of the ethical committee and is presently being tested in non-pathological subjects for parameter identification of the muscle-device integrated dynamics.

4. *Advanced computer methods for acquisition and analysis of pathological and non-pathological human gait patterns:*

A comprehensive protocol and a graphical user interface (GUI) for gait analysis were developed for subject instrumentation and laboratory setup, which enable the study of the time-distance, kinematic, kinetic and electromyographic parameters of gait. The referred GUI is user-friendly, suggesting its future use in clinic and in physical rehabilitation environments.

Economic and Environmental Sustainability of Electric Vehicle Systems

FCT CODE: MIT-Pt/MCA/0066/2009

Starting Date: Oct. 18, 2010 **Expected Completion Date:** Oct. 18, 2013

Principal Investigator: LC Dias **MIT Collaborators**: R Kirchain, J Gregory, R Roth

Institutions/Research Centers involved: INESC Coimbra, ADAI-LAETA, ISR, and MIT MSL

Companies involved: Critical Move, EVIberia, EDP Distribuição

FCT Funding: 198.780,00€

Objectives and Main Scientific Contributions to be expected:

The primary outcome from this work will be strategies for developing economically and environmentally sustainable Electric Vehicle (EV) systems. It aims at contributing to answer the following questions:

- What are the conditions under which the EV system produces a net environmental benefit and is economically competitive relative to existing vehicle systems?
- What is the uncertainty associated with these conditions and how can knowledge of that uncertainty be leveraged in strategic decisions around the development of EV systems?

Conditions are based on vehicle characteristics, type of use, contextual characteristics (including utility grid mix), and technology transition characteristics.

One task of this project concerns the economic and environmental analysis of EVs, aiming at providing:

- economic and environmental assessments of EV fleets using scenarios that vary technologies and context;
- methodological guidance on the application of dynamic fleet-based Life Cycle Assessment using a hybrid approach;
- methodological guidance on the integration of life cycle costing, process-based cost modelling, cost learning curves, and technological forecasting in the economic assessment of future technologies;
- insight on leveraging uncertainty in the life cycle cost and environmental assessment process to streamline data collection efforts and improve decision-making;

A parallel task concerns economic and environmental analysis of power generation, with the following goals:

- to improve understanding of current energy technologies and future energy options of the electricity sectors based on environmental and economic aspects;
- to select the most relevant future renewable electricity systems for Portugal;
- to perform a comparative attributional and consequential modeling of the selected systems and to assess and discuss the differences in the results;
- to identify the major sources of variability and uncertainty in the sustainability assessment of electricity systems and procedures to reduce this uncertainty.

Building on these results, a multi-criteria and multi-stakeholder analysis will shed light on:

- which contexts of usage are the most interesting for each vehicle engineering option;
- which contexts of usage are attractive for a wide range of engineering options;
- which vehicle and power generation options are most suited to each context of usage;
- which vehicle and power generation options are attractive for a wide range of contexts of usage.

More information: http://www.uc.pt/en/efs/research/EESEVS

2.3 Stem Cell Engineering for Regenerative Medicine

Regenerative Medicine aims at improving the length and quality of life by restoring, maintaining, or enhancing tissue and organ function, by merging of different fields including stem cell research, biomaterials development and tissue engineering. 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 implants and biohybrid organs to replace tissue function. Stem cells in particular have the ability to selfrenew and to differentiate into cells that are found throughout the body. The possibility of using stem cells and their differentiated progenitors to treat numerous degenerative disorders has stimulated great interest in developing safe transplantable sources of stem cells able to repopulate damaged tissues.

The research in the cutting-edge area of Stem Cell Engineering for Regenerative Medicine within the MIT-Portugal Program addresses stem cell-based therapies and tissue engineering for treatment of hematological diseases, neurodegenerative diseases, bone, skin and cartilage disorders, vascularization of ischemic tissues and urinary tract repair.

To build a robust research portfolio, the Research Call was looking for cross-cutting research projects in Stem Cell Engineering for Regenerative Medicine targeting to: i) improve the basic understanding on the fundamental processes which control stem cell activity and their differentiation; ii) enhance technologies involved in isolation of stem cells from adult tissues, expansion of those cells in vitro, differentiation and transplantation protocols; iii) develop novel biomaterials and surfaces able to elicit specific reactions to cells, supporting cell growth and differentiation and organizing cells into tissues; and iv) design specific motifs at different length scales to improve functionality of tissue engineered constructs.

Within this call for research projects, proposals supporting and enhancing the Stem Cell Engineering for Regenerative Medicine cross-cutting project were be accepted, using the following Human Stem Cell model systems: hematopoietic stem/progenitor, mesenchymal stem, embryonic stem, induced pluripotent stem and vascular progenitor cells.

The following table provides a description of the projects that were awarded financing in this context as a result of the 2008 and 2009 Research calls. This is followed by a set of fact sheets characterizing each of the projects.

Table 5 – Research projects in the area of bioengineering systems

Project Reference	Project Title	Main PT Researchers	Main MIT Researchers	Universities/Schools	Associated Laboratories	Industry Partner
MIT-Pt/BS-CTRM/0051/2008	Smart small-scale devices: systems for controlled delivery of bioactive molecules, cell expansion and for sensing cell environment	Ana Aguiar-Ricardo, Cláudia Lobato Silva, Teresa Casimiro, Margarida Diogo	Linda Griffith, Paula Hammond	FCT/UNL, IST/UTL	REQUIMTE, IBB	Hovione, ECBio
MIT-Pt/BS-BB/0082/2008	Bridging Systems and Synthetic Biology for the development of Improved Microbial Cell Factories	Eugénio Ferreira, Isabel Rocha, Miguel Rocha, Filipe Mergulhão, Rui Oliveira	Bruce Tidor	U Minho, FE/UP	CEB, CCTC, IBET	Biotrend, SA; Biotempo, Lda
MIT-Pt/BS-BB/0014/2008	Structural and functional study of the proteins mediating electron transfer between microorganisms and solid substrates with relevance for bio-energy production	Ricardo Louro, Claudio Soares, Yan Astier, Carlos Salgueiro	Dianne Newman	FCT/UNL	ITQB	EDP Inovação
MIT/ECE/0047/ 2009	Micro/nano design of functional stem cell-instructive materials for bone tissue regeneration	Manuela Estima, João Moreira	Ali Khademhosseini, Robert Langer (Co-PIs)	U Minho	IBB, CNBC	Stematters

Smart small-scale devices: systems for controlled delivery of bioactive molecules, cell expansion and for sensing cell environment

FCT CODE: MIT-Pt/BS-CTRM70051/2008

Starting Date: 01/04/2009 **Expected Completion Date:** 31/03/2012

Principal Investigator: Ana Aguiar-Ricardo, FCT/UNL **MIT Collaborators**: Paula T Hammond and Linda G Griffith

Institutions/Research Centers involved: REQUIMTE/FCT/UNL, IBB/IST/UTL, IPOFG, MIT

Companies involved: Hovione and ECBio

FCT Funding: € 199.712,00

Main Scientific Achievements:

The project is focused on the development of hydrogel-based smart small-scale systems using a green methodology: i) for *in vivo* drug delivery (smart microporous particles); ii) for *ex vivo* cell expansion (3D matrices or scaffolds) and iii) for monitorization of cell environment (bioactive beads).

i) Porous microparticles for *in-vivo* drug delivery

A new Supercritical-Assisted Atomization (SAA) apparatus was assembled and optimized for the production of biocompatible powder microcarriers for pulmonary drug delivery. Chitosan microparticles of relatively controlled size (4.3 μm) and distribution (span =2.3) were produced at mild operating conditions that are compatible with the stability of thermolabile compounds. The SAA process will enable the micronization of polymeric excipients not only with classical drugs but also with proteins and enzymes together with stabilizing agents.

Mesoporous microbeads can be easily obtained by radical polymerization of biocompatible glycerol dimethacrylate (GDMA) in $scCO_2$. Small mass density microparticles (ρ= 0.19-0.37 $g.cm^{-3}$) with controlled size (1-3 μm) and homogeneous morphology were obtained. The (S)-ibuprofen loading (up to 120 $mg.g^{-1}$) and release profile from the PGDMA microbeads is highly promising which makes them potential drug delivery vehicles (*J Supercrit Fluids* 55 (2010) 333-339).

ii) 3D porous structures for *ex vivo* cell expansion

Blended scaffolds of chitosan (CHT) and polyvinyl alcohol (PVA) in different percentages (30 % (w/v)) were prepared by freeze-drying method and cross-linked with methylenebisacrylamide (MBA) followed by $scCO_2$ cleaning. The scaffolds showed to be stable up to two weeks in lysozyme solution (2 μg/ml) and in RPMI-1640 medium, a cell culture medium for L929 fibroblasts cells growth demonstrating that these 3D structures could be suitable for mammalian cell culture. In the dry state, materials exhibited high porosity (90%) and a medium pore size around 30 μm. The swelling behavior at different pHs (pH 5 and 7) demonstrated the high water uptake capacity of these 3D materials (around 1000% at pH 7 and 2000% at pH 5, relatively to the initial dry scaffold weight). This high swelling ability is fundamental to improve the cells diffusion into the porous structure and to allow stem cell proliferation, especially if we apply perfusion operation to these scaffolds.

iii) Bioactive beads for monitorization of cell environment

Biocompatible and thermoresponsive poly (*N*-isopropylacrylamide) (PNIPAAm) microbeads with well-defined morphology were successfully prepared using a green synthesis approach by polymerization in $scCO_2$. The mechanical properties of these beads were systematically modified by using different cross-linking species (J Supercrit Fluids 2010,doi:10.1016/j.supflu.2010.10.039). Furthermore, NIPAAm was also copolymerized with other monomers, namely methacrylic acid (MAA), to render both pH and temperature responsive PNIPAAm-PMAA microbeads and allow further functionalization. A layer-by-layer polymer assembly strategy has been studied for both creating cell-interactive surface coatings and incorporating fluorogenic substrates for proteases on the microbeads. The interaction of different polymers with PNIPAAm beads has an impact on their morphology and thermoresponsive behavior, as it was demonstrated for the complexation of tannic acid (TA). The reversible hydrogen bonding between TA and PNIPAAm beads allowed the preparation of microgels which morphology and temperature response depended on pH and TA content (Macromolecules 44 (2011) 612-621).

Micro/nano design of functional stem cell-instructive materials for bone tissue regeneration

FCT CODE: MIT/ECE/0047/2009

Starting Date: 01/06/2010 **Expected Completion Date: 31/05/2013**

Principal Investigator: Manuela E. Gomes **MIT Collaborators**: Bob Langer and Ali Khademhosseini

Institutions/Research Centers involved: University of Minho (UM) - 3B's Research Group - Biomaterials, Biodegradables and Biomimetics (3B´s/UM); University of Coimbra - Centre for Neuroscience and Cell Biology (CNBC/UC)

Companies involved: Stemmatters (STM)

FCT Funding: 199.800,00€

Objectives and Main Scientific Contributions to be expected:

Bone tissue engineering may provide a solution for many patients suffering from a number of clinical scenarios, with a significant impact on society. To date, most approaches have relied on postimplantation neovascularization from the host, but for thick and metabolically demanding organs, like bone, relaying on blood vessels ingrowth is clearly insufficient to meet the implant's demand for oxygen and nutrients. The vascularization of bone implants and consequently its success relies on the combination of tailored physical cues with integrated biochemical pathways and appropriate cell types. Recently, adipose derived stem cells (ASC) are recognized as an appealing cell source due to its high availability and since it can be harvested from humans through liposuction, which is considered a safe and minimally invasive surgical procedure. Moreover, these cells have already shown the ability to differentiate into endothelial and osteoblastic lineages. Nevertheless, stem cells require appropriate physical and biochemical instructive environments to develop into target phenotypes.

In this project, we aim to develop functional constructs for bone tissue engineering through the incorporation of instructive molecules within ASC-laden hydrogels to direct their differentiation into osteogenic and endothelial lineages. Furthermore, we aim to merge the engineered hydrogels with microengineering approaches to spatially organize the resulting cell types into therapeutically viable tissue constructs. Through this unique approach we expect to overcome some of the most common limitations of bone tissue engineering such as the inability to generate 3D constructs with biomimetic tissue microarchitecture and vasculature. We expect that the proposed project will generate micro/nano-engineered natural hydrogels with the ability to direct ASC behaviour, through nano/micro design features combined with the controlled release of biological molecules, to generate highly functional engineered bone tissue substitutes.

With this project we envision to engineer innovative scaffold biocompatible materials, including a new generation of micro-biomaterials for functional human tissue-like substitutes, using microfabrication technologies combined with targeted controlled-release delivery systems for stem cells.

Bridging Systems and Synthetic Biology for the development of improved microbial cell factories

FCT CODE: MIT-Pt/BS-BB/0082/2008
Starting Date: April 1 2009 **Expected Completion Date:** March 31 2012
Principal Investigator: Eugénio Ferreira, U Minho **MIT Collaborators**: Bruce Tidor
Institutions/Research Centers involved: Universidade do Minho, Universidade do Porto, Instituto de Biologia Experimental e Tecnológica
Companies involved: Biotempo and Biotrend
FCT Funding: 199 977 €
Main Scientific Achievements:

- Construction of an integrated regulatory and metabolic genome-scale model of the bacterium *Escherichia coli*. The model was built from literature data (collected semi-automatically with developed literature mining tools); integration of data from available public data sources and genome analysis and will be used in the course of this and other projects as a platform for metabolic engineering design.

- Development and publication of OptFlux, an open-source user-friendly software tool that aims at being the reference tool in metabolic engineering applications (available at www.optflux.org).

- Implementation and validation of algorithms for the identification of metabolic engineering targets using integrated regulatory and metabolic models. These algorithms have been implemented in OptFlux.

- Identification of metabolic engineering targets (genes to be deleted from *E. coli*) for the overproduction of amino-acids in *E. coli*.

- Implementation of an advanced laboratory method for the analysis of a wide range of metabolites in *E. coli* with GC-MS.

Main publications:

Carneiro, S.; Villas-Boas, S.; Ferreira, E.C.; Rocha, I. Metabolic footprint analysis of recombinant *Escherichia coli* strains during fed-batch fermentations. Molecular BioSystems (accepted), 2010.

Lourenço, A.; Carneiro, S.; Rocha, M.; Ferreira, E.C.; Rocha, I. Challenges in integrating *E. coli* molecular biology data. Briefings in Bioinformatics (accepted), 2010 (a)

Rocha, I., Maia, P., Evangelista, P., Vilaça, P., Soares, S., Pinto, J.P., Nielsen, J., Patil, K.R., Ferreira, E.C., Rocha, M. OptFlux: an open-source software platform for *in silico* metabolic engineering. BMC Systems Biology 4:45, 2010.

Vilaça, P.; Rocha, I.; Rocha, M. A computational tool for the simulation and optimization of microbial strains accounting integrated metabolic/ regulatory information. Biosystems (accepted) 2010

Structural and functional study of the proteins mediating electron transfer between microorganisms and solid substrates with relevance for bio-energy production

FCT CODE: MIT-Pt/BS-BB/0014/2008

Starting Date: 1 June 2009 **Expected Completion Date: 3**1 May 2012

Principal Investigator: Ricardo O. Louro, ITQB-UNL **MIT Collaborator**: Dianne K. Newman

Institutions/Research Centers involved: ITQB-UNL; FCT-UNL; MIT

Companies involved: EDP Inovação

FCT Funding: 192 144,00€ **Other Funding**:

Main Scientific Achievements:

The project focuses on the characterization of biological electron transfer chains that mediate the transfer of electrons between an extracellular solids and the metabolism of sediment bacteria that can be cultivated in devices called microbial fuel cells to generate electricity. The main focus is on organisms that perform metal based anoxygenic photosynthesis.

We have purified and characterized FoxE, a diheme cytochrome identified as the putative metal oxidase of *Rhodobacter SW2*.

A crystal structure of this key protein was obtained in collaboration with the laboratory of Dr Carlos Frazão at ITQB-UNL and an oral presentation of this work was delivered at the National Congress of Biochemistry in December 2010. Two papers are being prepared.

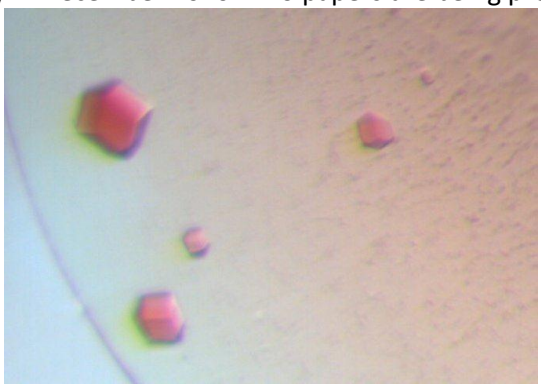

Figure 1. Well formed crystals of FoxE with approximately 100 μm ready for data collection.

We have purified and made the biochemical characterization of PioC, a Hipip that mediates the electron transfer between the iron oxidase of *Rhodopseudomonas palustris* and its photosynthetic centre.

This work is being conducted in collaboration with Prof Carlos Salgueiro at the FCT-UNL and was presented as a poster at the National Congress of Biochemistry in December 2010.

Our US collaborator, who has moved to Caltech, has found that this biological electron transfer chain of Rhodopseudomonas palustris has redundancies and another Hipip can functionally replace PioC. We are currently expressing and purifying this protein to determine the structure of PioC and of the second Hipip by NMR methods. This will allow us to identify the structural bases for the functional redundancy. This work was presented as a poster at the Gordon Graduate Research Seminar in California in February 2011.

The methodological developments associated with the realization of this work were selected for invited lectures at two international conferences in 2010:

- World Congress of Industrial Biotechnology 2010, Dalian, China, July 2010
- Joint EUROMAR 2010 and 17th ISMAR Conference, Florence, Italy, July 2010

2.4 Fundamentals of Engineering Systems

Engineering systems is an emerging field that integrates engineering, management and social sciences to achieve the best possible understanding, design, and implementation of highly complex, technology-based systems. The Research Call sought research proposals in the following interdisciplinary approaches and methodological areas:

- Design and Implementation:
- Uncertainty and Dynamics:
- Networks and Flows:
- Interface of Humans and Technology:

The Research Call was directed to research teams that wanted to contribute to this new field by simultaneously: 1) developing new engineering systems methodologies, which may evolve from an innovative combination of two or more methodologies; 2) tackling-issues pertaining to complex socio-technical systems in a specific domain/context; and 3) achieving a deeper understanding of fundamental engineering systems concepts.

The following table provides a description of the projects that were awarded financing in this context as a result of the 2008 and 2009 Research Calls. This is followed by a set of fact sheets characterizing each of the projects.

Table 6 – Research projects in fundamentals of engineering systems

Project Reference	Project Title	Main PT Researchers	Main MIT Researchers	Universities/Schools	Associated Laboratories	Industry Partner
MIT/FSE/0064/ 2009	FIRE-ENGINE - Flexible Design of Forest Fire Management Systems	João Claro, José Cardoso Pereira, José Calvão Borges, Paulo Fernandes, Tiago Oliveira	Richard de Neufville	FE/UP, ISA/UTL, UTAD	INESC-Porto	Portucel Florestal, S.A.

Flexible Design of Forest Fire Management Systems (FIRE-ENGINE)

FCT CODE: MIT/FSE/0064/2009

Starting Date: 2010/09/01 **Expected Completion Date: 2013/08/31**

Principal Investigator: João Claro **MIT Collaborators**: Richard de Neufville

Institutions/Research Centers involved: MIT ESD, INESC Porto, ISA, UTAD

Companies involved: Portucel Florestal

FCT Funding: ~200k EUR (PT) + ~390k USD (MIT) **Other Funding**: ~130k EUR (Portucel Florestal)

Objectives and Main Scientific Contributions to be expected:

Forest fires are a major threat to forest, environment, and prosperity of communities. Portugal has struggled with severe consequences of fires, has one of the worse fire management performances in Europe, and needs substantial improvements in policy, management and technology. A national plan approved by the Portuguese government in 2006 was an important first step in this direction. But concerns with fire management efficiency are not specific to Portugal, and their origin can be traced back to insufficiencies in the design of the management systems, in particular at three levels:

- Lack of a systems perspective considering appropriate combinations of management alternatives, and interactions between environmental, technological, social, cultural, economic, and management factors. Previous work has focused on fire dynamics, and has not integrated aspects such as the social dynamics associated with countryside depopulation and consequent fuel accumulation.

- Little or no attention to critical uncertainties that the systems face, from climate change, economic conditions, and technology and operations performance. Previous studies are largely deterministic.

- Correspondingly, no significant attempts to tackle complex dynamics that may result in policy resistance behaviors, emerging as distant unintended impacts of apparently appropriate decisions.

The research team has identified feasible first steps to create an integrated approach to the problem of identifying appropriate policies for fire management. The object of the project is the development of unique advances to the state of the art in the design of these systems, in three areas:

1. Data gathering and model construction. The project will include fieldwork to analyze historic fire data, document field operations, and develop an ethnographic study of system stakeholders. The fieldwork will be incorporated in a screening model to characterize fire risk in a landscape in space and time, and a system dynamics model to describe the interaction between stakeholders and forest. Team members have successfully developed the latter line of work in other contexts.

2. Methodological innovation. The project will explore the innovative combination of system dynamics with optimization and flexible design, opening new possibilities for analysis, such as policy optimization, valuation of flexibility in dynamic systems, and system dynamics under uncertainty. Team members have led the work in flexible design, and authored the first book in this field.

3. Policy contribution. Selected case studies will be developed with the leadership of Portucel Florestal SA, the largest Portuguese private forest landowner and producer, and a recognized partner in the national fire management system, seeking to fine-tune the way that the results of the project can be used to help companies and authorities improve operations and policy. Team members have a close relationship with Portucel, and unique access and experience in this domain.

The research team brings together experts in engineering systems, and forest and fire management, with a relevant network of international and national experts, in the public and private sector. Based on previous collaboration over a period of 18 months, the Portuguese and MIT PIs, together with Portucel, are confident that they can accomplish the project, and develop scientifically sound approaches to increase fire management efficiency. Intensive workshops will be held about every 6 months, so that the individual efforts can be integrated into an effective overall system and procedure, which can be used effectively by Portuguese forest companies and public authorities.

The research team is highly motivated to collaborate in the development of a science-based approach to start addressing a decisive issue for the future of Portugal, and by the prospect of entering a research area where important developments can be envisioned for the next decade.

3 Institutional Development

The MIT Portugal Program has facilitated the development of a national network of universities, research laboratories, and companies working together on common challenges: fostering innovative post-graduate programs that offer world-class training and future employment opportunities; establishing and expanding relationships between Portuguese and European companies and institutions of higher education working together to create value in the global market; and addressing key issues in strategic business areas that represent Portugal's future in new products and services. Since 2006, the network has grown to include 8 Portuguese academic institutions offering PhD degrees in association, 28 Portuguese research institutions and laboratories involved in research and development through MIT Portugal, and 59 program affiliates (companies, associations, national laboratories or hospitals).

Within the network, participants have shared and pursued common interests, namely the establishment of joint PhD degrees, the development of an advanced industrial sector in each area, and the breeding of a new generation of leaders and entrepreneurs. In evaluating the institutional development attainments of the MIT Portugal network, one can point to the following achievements:

- Produced a new generation of internationally competitive PhD and Masters students;
- Generated new faculty positions at multiple universities, who are conducting research and developing new educational models (see below);
- Shared "best practices" in education, including: course notes, e-learning, student evaluation procedures, evaluation of the teaching staff, identification and undertaking measures to fill the gap of scant human resources, co-supervision of research; and mid-term evaluation of the individual student research projects;
- Established shared resources, such as lab facilities, faculty, and staff.
- Constantly updated and shared information, through the permanent update of the common webpage.
- Financed collaborative research projects that bring together companies and universities, inspired in part by the innovation and entrepreneurship ecosystem at MIT.

These achievements were possible because the MIT Portugal Program is organized as a Community of Practice (CoP), according to the definition given by Hildreth and Kindle (Hildreth,Paul M and Kindle, Chris "Knowledge Networks: Innovation Through Communities of Practice, Idea Group Pub, London, 2004):

"The network of relationships that develop in a CoP, the inner motivation that drives them, and the knowledge they produce lead to the creation of an environment that is rich in creativity and innovation."

This conclusion is further illustrated by the following statements from the leaders of two MIT Portugal Program Focus Areas:

"The MIT-Portugal Program has significantly contributed to the change of the Portuguese Universities culture and their modernization. For the first time, PhD programs are jointly offered by Portuguese universities, contributing to establishing a network of research and advanced higher education in scientific areas of knowledge and aiming to educate of a new generation of leaders in engineering technical innovation. This is expected to be the basis for the creation of Graduate Schools in dynamic and research-oriented Portuguese Universities. The new by-laws of Instituto Superior Técnico (IST) allow the possibility to create new transversal academic and research units for the development of multidisciplinary or emergent areas, bringing together faculty and researchers from different departments and research units with dual or joint appointments. The MIT's Engineering Systems Division, which coordinates at MIT the MIT Portugal Program, is an example of this type of structure, which promotes the synergies among these faculty and researchers with different backgrounds. This new structure is expected to contribute for the reforming of the Portuguese university system and for the advancement of engineering, science, technology and management in Portugal."

Joaquim Sampaio Cabral, President of IST Statutory Assembly, 2009 and Co-leader of Bioengineering Systems Focus Area

"MIT Portugal Program is exposing the School of Engineering of University of Minho to a demanding but exciting network, contributing to an important internal reform developed in parallel with the European Bologna Process and a new legal framework in the Portuguese high education system. The MIT experience and the active engagement in the MIT Portugal Program network were also extremely relevant for the new curricula of our education programs (mainly at the graduate level). The two on-going PhD programs in cooperation with MIT and other Portuguese universities are being an excellent opportunity to improve and challenge our faculty in order to strengthen our internationally recognition. All these experiences and the chance to have a close contact with MIT organization, as a model to promote muitidisciplinary approaches, creative environments and an effective research coupled education, inspired some innovative rules recently adopted in our new by-laws. The result is a better established link between research and education and an internal organization with higher flexibility to accommodate our involvement in knowledge networks."

António M. Cunha, as Dean of Engineering, 2009 on the contribution of MIT-Portugal to modernize the UMinho School of Engineering

3.1 Attracting New Doctoral Researchers: Building Capacity in Portuguese Institutions

A crucial factor in Portuguese institutional development has been the creation of post-doctoral research contracts as well as job contracts for new faculty and research hires, in the Portuguese Universities and Research Centers. Below is a list of all the researchers hired, followed by profiles of a sampling of these vital additions to the human capacity in Portuguese higher education made possible through the program.

Table 7 – Assistant and Associate Professorships awarded through the MIT Portugal Program

Institution	Area	Name	Type of Research Contract (5 years)	Starting Date	% Time
CNC/UC	BES	Ricardo Pires das Neves	Assistant Professorship	Mar'10	100
FC/UL	SES	Guilherme Carrilho da Graça	Assistant Professorship	Jul'07	60
FCT-ITQB/UNL	BES	Luísa Vasconcelos	Assistant Professorship	Jan'08	100
		Ana Margarida Palma Teixeira	Assistant Professorship	Mar'09	100
		Vasco Bonifácio	Assistant Professorship	Jul'08	100
		José da Silva Lopes	Assistant Professorship	Jul'10	100
FE/UP	EDAM	Francisco Pires	Associate Professorship	Jul'07	100
		Jean Pol Piquard	Associate Professorship	Sep'08	60
		José Carlos Aguiar	Associate Professorship	Sep'08	60
		António Araújo	Assistant Professorship	Mar'10	100
	SES	Vítor Leal	Assistant Professorship	Sep'07	100
		Rita Mafalda Sousa	Assistant Professorship	Sep'08	30
		António Augusto Martins	Assistant Professorship	Feb'10	30
IST/UTL	BES	Frederico Ferreira	Assistant Professorship	Feb'09	100
		Cláudia Lobato Silva	Assistant Professorship	Jul'07-Jun'08	100
		Miguel Teixeira	Assistant Professorship	Jul'07-Jun'08	100
	EDAM	Mihail Fontul	Assistant Professorship	Nov'07	100
	ES	Carlos Silva	Assistant Professorship	Jun'08	100
	SES	Miguel Águas	Assistant Professorship	07	50
		Jorge Vasconcelos	Associate Professorship	07	40
UMinho	BES	Lígia Rodrigues	Assistant Professorship	Jul'07	100
		Isabel Rocha	Assistant Professorship	Jul'07	100
		Manuela Estima	Assistant Professorship	Sep'07	100
	EDAM	Pedro Santos	Assistant Professorship	Jul'07-Jun'08	100
		Eduardo Beira	Associate Professorship	Oct'08	100
		Luís Rocha	Associate Professorship	Mar'08	100
		Satyabrata Ghosh	Assistant Professorship	Nov'08	100

Name: Ricardo Neves Pires das Neves

Focus Area: Bioengineering - Stem Cells and Tissue Engineering

Host Institution: Centre for Neurosciences and Cell Biology

Starting Date: 01-03-2010

Teaching Responsibilities:
Until now I haven't been involved in any teaching activities.

Research Interest:
I am trying to develop new engineering platforms for stem cell fate modulation. I am currently involved in the following project:
Principal Investigator: PTDC/SAU-ENB/113696/2009 - Generation of cord blood-derived Induced Pluripotent Stem cells using a non-viral approach and their differentiation into cardiomyocytes- iPSCardio. (25%)

Two more project proposals are being evaluated:
Principal Investigator: PTDC/CTM-NAN/120552/2010 (35%)
Principal Investigator: PTDC/SAU-BMA/122111/2010 (35%)

Supervising Activity:
I am supervising Ana Francisca Lima – Master student in Molecular and Cell Biology, University of Coimbra.

Publications:
Vazão H, Pires das Neves R, Grãos M, Ferreira L. (2011) "Towards the characterization and maturation of smooth muscle cells derived from human embryonic stem cells" PLoS One (accepted in Press).

To join the MIT-Portugal Program was a big challenge for me. I did all my background in basic science in the University of Oxford (England) and when I heard about this program I thought it would be a great opportunity to change into a more translational type of research within the Bioengineering platform. It is my firm belief that more multidisciplinary teams are needed to face the emergent challenges in cellular reprogramming and the development of new cellular therapies in regenerative medicine. Portugal needs people able to integrate knowledge in Bioengineering with cell and molecular biology in order to solve very complex problems in regenerative medicine. My expertise in transcription, chromatin and metabolism will be very important tools in this area. Joining the MIT-Portugal program was a very important step in my career which is starting now to generate good outputs. It has been only a year since I moved back to Portugal and I have been able to capture competitive funding. I have written several grants more and wait with optimism that some more funding will come soon. I hope in the near future to contribute with some teaching responsibilities within the MIT-Portugal Program.

Name: Maria Luisa Vasconcelos

Focus Area: Bioengineering – Neuroscience

Host Institution: Instituto Gulbenkian de Ciência

Starting Date: January, 2008

Teaching Responsibilities:
Neuroscience Module; Bio-Engineering Systems Doctoral Program; 2 weeks.

Research Interest: I am the Principal Investigator in the projects described below.
We are interested in the nature of defined neural circuits: how activation of circuits elicits specific behaviors.
Female receptivity
Genetic studies have elucidated how Drosophila male courtship behavior is specified and its circuit components are being dissected at a surprising speed. The circuit of female behavior on the other hand has been largely uncharacterized. We are using a behavioral protocol that allows us to selectively inactivate subsets of neurons in the adult flies only. We screen for neurons involved in female receptivity.
Across species stress odor response
Stressed Drosophila melanogaster release an aversive odorant that elicits a robust avoidance response in test flies. Our data indicate that stress odour avoidance is not common to all Drosophilids. This behavioural difference between melanogaster and some of its sister-species provides a powerful framework, amenable to genetic, developmental and anatomical dissection, to investigate how evolution has shaped distinct responses to an environmental cue.

Supervising Activity:
Dennis Herrmann, Ph.D. student, developing the thesis “Functional Architecture of the Neural System Controlling Female Reproductive Behavior in Drosophila melanogaster”;
Nuno Martins, Master student, developed the thesis “Different Behaviors Elicited by CO2 in Fruit Fly Larvae”.

MIT Visits:
Visited the MIT once in 2009 for 2 days to discuss the courses of the Bioengineering program.

Publications:
Ruta V, Datta SR, Vasconcelos ML, Freeland, J. Axel R. (2010). A dimorphic pheromone responsive circuit in Drosophila from sensory input to descending Output. Nature 468: 686-690.

MIT-Portugal has allowed me to be in contact with researchers in my area both from MIT and other institutes in Portugal that I would have not met otherwise. While organizing the Neuroscience module I met Dr. Elly Nedivi, Dr. Martha Constantine-Paton, Dr. Peter So and Dr. Robert Gould from MIT and Dr. Tiago Outeiro, Dr. Rodrigo Cunha, Dra. Patrícia Figueiredo Dr. Pedro Almeida from IMM, CNC, IST and IBEB respectively.

Name: Ana Teixeira

Focus Area: Bioengineering

Host Institution: ITQB-UNL

Starting Date: March 2009

Teaching Responsibilities:

Bioprocess Engineering Module (FCT-UNL, Oct 2010)

Lecture: Microbioreactors and scale-down – 1 h

Research Interest:

(1) PTDC/EBB-BIO/100491/2008 - Using functional genomics to improve mammalian cells for virus based biopharmaceuticals manufacture – Team member (10%)

(2) PTDC/EBB-EBI/102266/2008 - Novel Cell Factories for the production of secreted complex bioproducts: a syntetic biology approach for improved product stoichiometries – Team member (10%)

(3) PTDC/EBB-EBI/102750/2008 - 2D fluorometry: a powerful tool to improve mammalian cell process development – Principal Investigator (50%)

(4) PTDC/EBB-EBI/103359/2008 - BACULOME-Engineering cellular energetics for improvement of bioprocesses: metabolic modeling for enhanced vaccines production – Team member (10%)

(5) MIT-Pt/BS-BB/0082/2008 - Bridging Systems and Synthetic Biology for the development of Improved Microbial Cell Factories – Team member (10%)

(6) PTDC/SAU-NEU/098747/2008 - Preconditioning triggered by Carbon monoxide: new strategies to prevent brain damage due to hypoxia-ischemia and reperfusion – Team member (5%)

Supervising Activity:

PhD student Fabiana Fernandes, within the MIT-Portugal program - co-supervision with Dr. Paula Alves (ITQB-UNL/IBET) and Prof. Kristala Prather (MIT).

PhD thesis: Development of a novel insect cell line for the production of complex multimeric proteins, combining recombinase mediated cassette exchange technology and synthetic genetic circuits.

MIT Visits:

2009 - Participation in iTeams course and visit to Prof. Kristala Prather's lab, 3 months

2010 - Visit to Prof. Kristala Prather's Lab and Prof. Danny Wang's Lab, 1 week

It was a very enriching experience, since in addition to the scientific component, during the participation in iTeams, I developed a better sensitivity for aspects related with technology-to-market transfer and general business concepts, complementary to my research interests.

Publications:

Teixeira AP, Duarte TM, Oliveira R, Carrondo MJT, Alves PM. High-throughput analysis of animal cell cultures using two-dimensional fluorometry, J Biotechnology 2011, 151:255-260

Teixeira AP, Duarte TM, Carrondo MJTC, Alves PM. Synchronous fluorescence spectroscopy as a novel tool to enable PAT applications in bioprocesses, *Biotechnol Bioeng 2011, in press*

Carinhas N, Bernal V, **Teixeira AP**, Carrondo MJT, Alves PM, Oliveira R. Hybrid metabolic flux analysis: combining stoichiometric and statistical constraints to model the formation of complex recombinant products. *BMC Systems Biology 2011, in press*

*Amaral AI, **Teixeira AP**, Sonnewald U, Alves PM.* Estimation of intracellular fluxes in cerebellar neurons after hypoglycemia: importance of the pyruvate recycling pathway and glutamine oxidation. *J Neuroscience Research 2011, in press*

As above mentioned, it was in overall, very enriching to have witnessed and participated in the dynamic environment of MIT, specifically the excellence of research practiced and the focus on finding ways to bring that research for the benefit of society. This has certainly impacted my scientific perspective and as a consequence the way I envisage the development of my future career.

Name: Vasco Daniel Bigas Bonifácio

Focus Area: Bio-Engineering Systems

Host Institution: Faculdade de Ciências e Tecnologia/Universidade Nova de Lisboa (FCT/UNL)

Starting Date: 01.07.2008

Teaching Responsibilities: No teaching responsibilities were atributed in the context of the MIT Portugal Program. Other teaching activities were developed at the Chemistry Department of FCT/UNL: Chemistry IA (TP) 35h in 2009/2010. Chemistry IA/IB (TP+Lab.) 44h in 2010/2011.

Research Interest:

Green chemistry (alternative solvents), Molecular electronics (molecular nanowires and sensors), Drug delivery, and Sustainable energy (hydrogen storage). Currently his actual research is focused in the synthesis of complex polymer architectures using supercritical carbon dioxide (e.g. dendrimers and nanovesicles), and in the development of biomaterials for drug and gene delivery and cell and tissue engineering. The following projects are undergoing:

- Just in time dendrimers. PTDC/CTM/099452/2008. Principal Investigator (30%).
- Smart small-scale devices: systems for controlled delivery of bioactive molecules, cell expansion and for sensing cell environment. MIT-Pt/BS-CTRM/0051/2008. Investigator (50%).
- Development of molecular recognition-based materials using supercritical fluid technology. Application to chromatography, catalysis and extraction. PTDC/QUI-QUI/102460/2008. Investigator (15%).
- CHEM4ALL – ICT tools for teaching chemistry to blinds and visually impaired students. RIPD/APD/109547/2009. Investigator (15%).

Supervising Activity:

MSc Thesis: Development of 2-oxazoline-based hydrogels and porous polyester microparticles in supercritical CO2, Rita Restani, 2009 (co-supervisor). Green synthesis of 2-oxazoline-based polymers with antimicrobial activity using scCO2, Vanessa Correia, 2009 (co-supervisor). Development of biocompatible crosslinked polymeric scaffolds, Ana Lopes, 2010 (supervisor).

PhD Thesis: Green synthesis of functional polymer microdevices, Rita Restani, 2010-2014 (co-supervisor).

MIT Visits:

One visit is being scheduled for a 4 months stay at Prof. Paula Hammond's laboratory. The final task of the project "Just in time dendrimers" will be made in this period in collaboration with the MIT host lab (study of biocompatible and biodegradable dendrimer LBL-based films for therapeutic coatings).

Publications:

- R. B. Restani, V. G. Correia, V. D. B. Bonifácio*, A. Aguiar-Ricardo*, J. Supercrit. Fluid. 2010, 55, 333-339 (IF: 2.639).
- C. Ribeiro*, P. Brogueira, G. Lavareda, C. N. Carvalho, A. Amaral, L. Santos, J. Morgado, U. Scherf, V. D. B. Bonifácio*, Bionsen. Bioelectron. 2010, 26, 1662-1665 (IF: 5.429).
- V. D. B. Bonifácio*, J. Morgado, U. Scherf, Synlett, 2010, 9, 1333-1336 (IF: 2.718). This article was highlighted by Prof. Timothy M. Swager (MIT) in Thieme Synfacts: Sticky caps for polymers, Synfacts, 2010, 8, 895.

The MIT Portugal Program gave me the opportunity to develop my own original research through national and international collaborations at the highest scientific level.

Name: José António da Silva Lopes

Focus Area: Bio-Engineering Systems

Host Institution: Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa (FCT/UNL)

Starting Date: 30/07/2010

Teaching Responsibilities:

Participation in Bioengineering Systems curriculum development issues regarding syllabus adjustments and schedule rearrangements.

Member of the Education Committee.

Research Interest:

-**Research on the Impact of Co-Joint Doctoral Degrees in Portuguese Higher Education Institutions** (15%): the main goal is to determine if a doctoral joint-degree with a focus on systems thinking and innovation, could enhance not only a more efficient networking process between different institutions but also to create added-value to a traditional Portuguese doctoral program, in order to improve the regular educational processes, teaching delivery and impact outside the University.

-**Management of the Educational and Scientific Program** (80%):

* main responsible for all the administration affairs between the institutions, concerning the Doctoral Program and the Advanced Studies Course;

* main responsible for the implementation of the communication procedures between the students and Faculty (both PT and MIT);

*leader of the educational program evaluation and assessment (student and faculty surveys, follow-up actions in order to improve the Program);

*coordinator of the laboratory rotations courses and of the PhD Projects allocation process;

*coordinator of the calendar and yearly schedule planning and logistics, syllabus coordination, communication issues with MIT Coordination Office, doctoral program guidelines and non-Portuguese students integration;

*regular participation in the student selection process committee.

-**Bio-Energy** (5%): just in early-stages of the project definition, but the main objective is to look for alternative processes, based on Supercritical Fluid Technology, in order to optimize bio-diesel production.

Supervising Activity:

-None at the present moment

MIT Visits:

2 Visits, each for 5 days for educational management issues with the Coordination Office at MIT

-Although they were 2 short visits, I found out the experience truly important as I had the chance to interact with MIT counterparts in several issues regarding the implementation of this innovative doctoral program, as well as to discuss several matters in the education and research fields that this program in Bioengineering focus on. It was also important to contact with a very different educational environment, when compared to the Portuguese one.

Publications:

- None at the present moment

Name: Francisco Manuel Andrade Pires

Focus Area: Engineering Design and Advanced Manufacturing

Host Institution: Faculty of Engineering of Porto University

Starting Date: 17/07/2007

Teaching Responsibilities:

- Optimized Integration of Materials and Structures (OIMS) of TME and LTI programs. Estimated total of 119 hours dedicated (30 hours classes preparation, 20 hours lectured classes, 10 hours attended classes, 9 hours mentoring, 50 hours assignments evaluation).
- Advanced Technology Seminars (ATS) of TME and LTI programs. Estimated total of 104 hours dedicated (15 hours classes preparation, 10 hours lectured classes, 20 hours attended classes, 9 hours mentoring, 50 hours assignments evaluation).

Research Interest:

My research interests include: Computational Modelling of the Behaviour of Materials and Structures and Optimized Development of products. I am the Principal Investigator of two research projects:

- "Development of Smart Automotive Interiors" and reference MIT-Pt/EDAM-SI/0025/2008. This project, from the academic side, involves 3 Portuguese Universities together with MIT and includes four Portuguese companies (TMG automotive, Iber-Oleff, Sunviauto, FiberSensing). I have 25% of time allocated to this project.
- "New Materials and Solutions for Next Generation Seats: From TGV to Regional Trains". This project involves Sunviauto, which is a Portuguese company. I have 25% of time allocated to this project.

Supervising Activity:

I am currently supervising two PhD thesis:

- Anton Sabaleuski, PhD topic "New Materials and Solutions for Next Generation Seats: From TGV to Regional Trains", Doctoral program in LTI, Faculty of Engineering of Porto University. PhD Started in September of 2009.
- Filipe Miguel Ferreira Nascimento, PhD topic "Smart Seat Design", Doctoral program in LTI, Faculty of Engineering of Porto University. PhD Started in September of 2009.

and one TME thesis:

- Deborah Perrotta de Andrade, TME Topic "Study of Polymeric Aerosols", Technology Management Enterprise, Faculty of Engineering of Porto University, Started in 2010.

MIT Visits:

I have made three visits to MIT with a total time of 42 days:

- from 26-July-2008 to 9-August-2008. I was hosted by ICL (Impact and Crashworthiness Lab);
- from 01-February-2008 to 11-February-2008. I was hosted by MSL (Materials System Lab);
- from 19-July-2010 to 3-August-2010. I was hosted by ICL (Impact and Crashworthiness Lab).

My experience at MIT was excellent: I could broaden my horizons in terms of research topics and their practical implementation. Therefore, I would recommend a visit to MIT for everybody involved in the program.

Publications:

Two papers currently being prepared for submission.

The contact with several MIT researchers encouraged me to work on new research fields, which are related to my area of research, that have enormous potential.

Name: Jean Pol Piquard

Focus Area: EDAM – Engineering Design and Advanced Manufacturing

Host Institution: FE-UP

Starting Date: 12.09.2008

Teaching Responsibilities:

ITM – Integrating Technology and Management: coaching and evaluation (4 phases) of the term project. Number of hours dedicated: approximately 90 hours between classes attendance, coaching time, projects revision and evaluation shared with my colleagues of the ITM course.
PDD – Product Design and Development: Seminar on "Market Intelligence through Competition's Analysis. Number of hours dedicated: 1,5 hours delivery + preparation.

Research Interest:

As Liaison Professor I focus on 4 applied research and development subjects that, until now, have occupied at least 50% of my time:

- **Identification Process of Research Subjects** with potential for, on one side, sustaining PhD thesis and, on the other, motivating the Research Affiliate financial commitment meaning outlining potential Return on Investment.
- **Alignment Process** between **Faculties priorities**, **PhD thesis requirements** and **Research Affiliates objectives** in terms of results and deliverables.
- **EDAM Environment clear Characterisation within the Global Challenges** for sustaining the key objective of ***"Rethinking Product Design and Manufacturing for a changing world"***
- **Research Affiliates** (International Companies) **and Industrial Affiliates** (Portuguese SME) **Contract Agreements development** particularly in the field of **Financing model** (fee, expenses, investments, intellectual property retribution), **Intellectual Properties** mutual protections and **Industrial Projects planning, management and control**.

Supervising Activity:

For the **AUTOCLASS Project** ("Automatic Classification and Quality Control for Car Tyres") with **the Research Affiliate Continental Mabor**, I assume the Project Coordination at the Steering Committee level jointly with the CEO of Continental Mabor reporting directly to the Continental AG Central Steering Group. The Project involves 3 PhD theses and, for the time being, 6 Portuguese Faculties and 3 MIT Faculties.

MIT Visits:

Not realized yet.

Publications:

Not in my objectives as Liaison professor

My position as Liaison Professor allows me to capitalize on my double experience and career as Executive in various companies at the International level and as Professor of Strategy and International Marketing which give me an acute perception of the existing challenges for satisfying the multi-requirements of High Level Education, Technology Investigation and Development and Companies Satisfaction in a Global Environment which requires disruptive innovation.
The first tangible results are the Conclusion of the Agreement with Continental Mabor as Research Affiliate and the initiation within the circle of FE-UP Faculties linked to the EDAM Program of a much more Industry oriented approach in the development of the PhD theses subjects, internships planning and monitoring, deliverables definition and project scheduling with clear tasks definition.
4 Projects of the level of challenge of the AUTOCLASS one are under development.
The Internationalization of the EDAM Program fits very well in the further development of my career and maintains the level of challenges I appreciate when taking into account the complexity of the implementation of a Research Affiliate network and sustaining a high quality level recruitment for LTI and TME.

Name: António Araújo

Focus Area: EDAM

Host Institution: FEUP

Starting Date: 01/03/2010

Teaching Responsibilities:

Product Design and Development (PDD) of LTI and TME programs. Estimated total of 116.5 hours dedicated (8 hours classes preparation, 1.5 hours lectured classes, 30 hours attended classes, 8 hours mentoring, 66 hours assignments evaluation, 3 hours final presentation)

Engineering & Manufacturing Systems (EMS) of LTI and TME programs – Preparing to teach in 2011-1012 (attending 2009-2010 and 2010-2011 lectures). Attended total of 15 hours of classes in 2009-2010 and expected to attend total of 24 hours of classes in 2010-2011.

Research Interest:

Electric Vehicles
Product Design and Development

Supervising Activity:

Nothing at the moment but there is some activity on this point being prepared.

MIT Visits:

1 visit from 01-May-2010 to 14-May-2010. It was a general visit to MIT, I had meetings with people in many labs at MIT. I was hosted by MSL (Materials System Lab)

The experience was excellent. I could feel the dynamics of that place, and see some of the good stuff they are doing. It is clear for me, after only 2 weeks over there, some of the simple things they are doing so well and some of the things we are doing not so well here in Portugal. But I found it hard to explain it to people back in Portugal. Therefore I would recommend a visit to MIT for everybody involved in the program (both teachers and students).

Publications:

Nothing at the moment (but I've been with MIT-Portugal for a short time)

It was a great change for me because my previous work experiences were in industry (12 years) and abroad (other EU countries). The experience was so far positive, but it is too soon conclude how MIT-Portugal impacted in my career since I've been here only since 1 year.

Name: Vítor Manuel da Silva Leal

Focus Area: Sustainable Energy Systems

Host Institution: Faculty of Engineering of the University of Porto

Starting Date: 01.09.2007

Teaching Responsibilities: Since 2007 Vítor Leal has been teaching in the following Programs: PDSSE - Doctoral program in Sustainable Energy Systems (MIT-Portugal) | DEASSE - Diploma of Advanced Studies in Sustainable Energy Systems (MIT-Portugal) | MIEM- Master in Mechanical Engineering (FEUP, undergrad). The courses lectured are:

Energy Planning: PDSSE & DEASSE, averaging 4h/week during 1st term; | Energy Demand-Side Management: PDSSE & DEASSE, averaging 5h/week during 2nd term| Energy in Buildings: PDSSE & DEASSE, averaging 4h/week during 2nd term; Lectured to both FEUP, UTL and FCUL students | Heat Transfer: MIEM, 4 to 6 h/week during 1st term.

Climatization / HVAC design: MIEM, 2 to 6 h/week during 1st term | Dissertation: MIEM, 1 to 3 h/week during first and second terms.

The total lecturing hours per week varied between 9.5 h/week and 13.5 h/week depending on semester and year.

Research Interest: Vítor Leal is interested in the areas of Energy in Buildings and Energy Planning in city, regional or national perspectives. His main recent projects were:

- **Passive Approach to Climatization – FCT PTDC/ENR/73657/2006 (2007-2009), "A passive approach to HVAC design based on the new regulations for energy in buildings", working 25% of the time as team member.**
- **SELECT GLAZINGS: FCT PTDC/ENR/72597/2006 (2009-2011), "Integrated selection of glazing and shading devices for services buildings in Portugal, working 25% of the time as IP.**
- **Green Islands / Net Zero Energy Schools (2010 -2011) "Development and analysis of strategies for Net-Zero Energy Schools in the Azores". Working 25% of the time as team member.**
- **EU SmartCities – Project developed in the frame of the FP7 project "THINK", coordinated by the European Universitary Institute, aimed at advising EU on energy sectorial policies. FEUP lead the subproject of identifying and advising strategies for the promotion of Smart Cities working 25% of the time as team member.**
- **CHP demand characterization – Project on demand from the Energy Agency of Porto to characterize the annual energy and peak power needs for heating and cooling in Porto downtown. Working 25% of the time as IP.**

Supervising Activity

- Ana Neves: "*Sustainable Energy Planning and Management at the Local Level*" – PhD in Sustainable Energy Systems of the MIT Portugal program, Faculty of Engineering of the University of Porto (since 2008; co-supervising with Prof. João Lourenço from IST-UTL)
- Gustavo Souza: "*Energy efficiency assessment methodologies and market mechanisms*" – PhD in Sustainable Energy Systems of the MIT Portugal program, Faculty of Engineering of the University of Porto (since 2008)
- Pedro Silva: "*Selection of glazing and shading devices for office buildings: criteria and integrated optimization*" – PhD in Sustainable Energy Systems of the MIT Portugal program, Faculty of Engineering of the University of Porto (since 2008; co-supervising with Prof. Marilyne Anderson from MIT/EPFL).
- Maria Kapsalaki: "*Carbon neutral buildings: design with climate and resource diversity*" – PhD in Sustainable Energy Systems of the MIT Portugal program, Faculty of Engineering of the University of Porto (since 2008; co-supervising with Prof. Matheos Santamouris from NKUA).
- Reza Fazeli: "*Design of Pathways for sustainable road transportation accounting for uncertainty*" - PhD in Sustainable Energy Systems of the MIT Portugal program, Faculty of Engineering of the University of Porto (since 2009; co-supervising with Prof. Pinho de Sousa from FEUP).
- ***Plus 3 pre-Bologna and 15 post-Bologna Mater thesis supervised between 2008 and 2011***

MIT Visits

Vítor Leal made two short academic visits to the MIT, both hosted by the Analysis Group for Regional Energy Alternatives (AGREA). The first took place in August 2007 for a period of one week, and the second in 2009 for

three days during the annual conference of the Alliance for Global Sustainability. Both served to know better the AGREA and to show the work and potentials existing the FEUP research units,as well as select contents for courses.

Although short, the experiences at the MIT allowed me to sense a very dynamic, open-minded yet focused and entrepreneurially-oriented attitude of both faculty and students.

Publications

- Fazeli, R., **Leal, V.,** Sousa, J.P.: A multi-criteria evaluation framework for alternative light-duty vehicles technologies, International Journal of Multi-criteria Decision Making, accepted for publication (2011)
- Souza, G., **Leal, V.,** Pina, A., Silva, C.:The relevance of the energy resource dynamics in the mid/long-term energy planning models, under revision for publication at Renewable Energy, 2011
- Neves, A., **Leal, V**.: Energy sustainability indicators for local energy planning: Review of current practices and derivation of a new framework, Sustainable Energy Reviews 14, July 2010. doi:10.1016/j.rser.2010.07.067

While the long-term results of my involvement in this Program are still unclear, the MIT Portugal Program already allowed me to gain access to a very dynamic network of interests and competences of both faculty and students which enabled me to re-center my research area to the growingly important Energy Planning Techniques and its applications.

Name: Rita Mafalda Dionísio de Sousa

Focus Area: Sustainable Energy Systems – Economics

Host Institution: FEUP

Starting Date: September 2008 **Dedication**: 30%

Teaching Responsibilities:

2008:
Course: Environmental and Natural Resources Economics
Advanced Program: PDSSE/EASSE
Hours: 4h/week
2009:
Course: Energy Economics
Advanced Program: PDSSE/EASSE
Hours: 4h/week
2010: Energy Economics
Advanced Program: PDSSE/EASSE
Hours: 4h/week

Research Interest:

Interests: Climate change economics. Emission and energy markets, emission prices, market linking and role of instruments as taxes and subsidies. Finance of the economic climate change system.

PhD Thesis (work in progress) "Carbon Prices and Linking of Carbon Markets", at the Faculty of Science and Technology - New University of Lisbon.

[Currently not included in other research projects]

Supervising Activity:

Technical support to the supervising of Filipe Lopes MSc Thesis: "Prevision of carbon prices in short and medium term", at the Integrated Masters in Electrotechnics and Computer Engineering, Energy Major, of the Engineering Faculty of Porto University.

Publications:

No publications yet

Name: António Augusto Areosa Martins

Focus Area: Sustainable Energy Systems - SES

Host Institution: Faculdade de Engenharia da Universidade do Porto

Starting Date: February 2010 **Dedication**: 30%

Teaching Responsibilities:

Teach the course of "Advanced Simulation of Thermal Systems" – ASTS, of the doctoral and advanced studies program of Sustainable Energy Systems (SES) of the MIT-Portugal program, with a total 4 hours weekly for 13 weeks (52 hours total).

Research Interest:

My research interests are in the areas of Transport Phenomena in Porous Media; Process Engineering; CFD and Simulation of Complex Fluids; Biofuels especially production, process development and their Sustainability Assessment; Lifecycle Assessment; Sustainability Assessment and Indicators for Processes and/or products, and Environmental and Human.

Currently, I participate in the following projects as a collaborator:

- **ECOPHARMABUILDING**: Eco-Innovation of Pharmaceutical Buildings Supporting in Sustainable LCA Tools, CIP ECO-INNOVATION (October 2009 – 2012). Total Financing: 100k€.
- **ELECTROELASTIC** (PTDC/EQU-FTT/113811/2009)–, FCT 2009 (2010-2013). Total Financing: 103 776 €.
- **Hemo-Networks** (PTDC/SAU-BEB/108728/2008), FCT (2009-2013). Total Financing: 66 819€.

I do not participate in any project as a PI.

Supervising Activity:

Co-Supervision of PhD student Alexandra Polzin: "Definition of Indicators and/or metrics systems for the evaluation of contribution of companies to Sustainable Development", Industrial and Management Engineering Doctoral program, FEUP, since March 2006.

MIT Visits:

No visits yet.

Publications:

No publications developed in the context of MIT-Portugal

MIT-Portugal gave me the opportunity of further developing my teaching skills. In particular it was the first time I have taught in English, and the teaching posed interesting challenges as the student's backgrounds were very diverse and the course was essentially practical. In the other hand, the research focus of SES program of MIT-Portugal at FEUP UP helped me in refocus and my research interests to the area of energy, in particular in development, implementation, analysis and sustainability of renewable energy systems, and the application of my expertise in simulation and transport phenomena in problems in other areas related to the program.

Name: Frederico Castelo Alves Ferreira

Focus Area: Bioengineering Systems

Host Institution: Department de Bio engineering, Instituto Superior Técnico (DEQ-IST); Institute for Biotechnology and Bioengineering (IBB)

Starting Date: 1st March 2009

Teaching Responsibilities:

1. "BioTeams – Innovation Teams", Advanced Course in Bio-Engineering Systems, PhD in Bioengineering, 2009-2010 (1 out 6 teams), 2010-2011 (2 out 7 teams) 6ECT at 18%. See "Bioteams survey report, 21 January 2010 for additional details"
2. "Green Technologies and Strategic decisions", MBiotec, MEBiol, MEQ 2009-2010, 6 ECT, 50%.
3. "Cell and Tissue Engineering", MEBiom , MEBiol , MBiotec , MBioNano, 2009-2010, 6ECT, 30%.
4. "Stem Cell Bioengineering", MBiotec, MEBiol, 2010-2011, 6ECT 30%.
5. "Biotechnology", MEQ 2009-2010, 2010-2011, 6ECT, 10%.

Note: Course 1 and 2 brings together technical and managerial contents using a hands-on approach; course 2 is a new optional course designed and launched last year. In the Course 3, 4 and 5, my participation was focused in specific teaching modules.

Research Interest:

Overall my research interests are: Stem cells, reactor and materials design, Bioseparations and catalysis, and Scale up/down and process integration.

The specific new topics embraced are:

A. Engineering human stem cells towards blood platelet production.

B. Tailoring materials for stem cells applications.

C. Jet Biofuel production.

These 3 specific research lines were selected to provide extremely challenging topics, but with high impact. The last 2 years have been spent to recruit the team and secure respective scholarships, perform the very first preliminary feasibility studies and devise research strategies. The results obtained were not published yet, but a patent is already been prepared for research line 3. The Specific research proposals were prepared and submitted applying for funding.

I also keep a parallel line of research "D. Difficult separation and hybrid processes" that links with previous work performed and specific know-how acquired and aims to provide support to other team members or institutions, eg Chiral Separations and Project with Hovione.

Supervising Activity:

Aligned with the research interests the following thesis are being supervised:

A. Engineering human stem cells towards platelet production.

1. Javad Hatami, PhD Student, PhD in Bioengineering (MIT Portugal Program) "Engineering human stem cells towards platelet production", SFRH/BD/61450/2009 (Individual FCT scholarship). Supervisor: Frederico Castelo Ferreira, co-Supervisor: Cláudia Lobato da Silva, Starting date: January 2010.

B. Tailoring materials for stem cells applications.

2. Raphaël Canadas, MSci student, Master in Bioengineering and Nanosystems, "Hybrid polymers for glucose responsive stem cell carriers" Supervisor: Frederico Castelo Ferreira, co-Supervisor: Cláudia Lobato da Silva, Starting date: Set 2010
3. Carla Moura, PhD Student, PhD in Bioengineering (MIT Portugal Program), "Developing Design and fabrication of zonal cartilage constructs", SFRH/BD/73970/2010 (Individual FCT scholarship), Supervision of Paulo Bártolo (CDRSP-IPL), co-supervisor: Frederico Castelo Ferreira, Starting date: April 2011
4. Miriam Sousa, PhD Student, PhD in Biotechnology, "Novel nanofiltration membranes: exploring

molecular size and functional interactions" SFRH/BD/73560/2010 (Individual FCT scholarship) Starting date: May 2011

C. Jet Biofuel production.

5. Nuno Faria, PhD Student, PhD in Bioengineering (MIT Portugal Program) "Biofuel TAKE-OFF - From yeast glycolipids to transesterification", SFRH/BD/33724/2009 (MIT Portugal Program Scholarship). Supervisor at Portugal: Frederico Castelo Ferreira, co-Supervisor at Portugal: César Fonseca, Supervisor at MIT: Bruce Tidor. Staring date: Set 2009

6. Isabela Gueiros, MSci student, Master in Biotechnology "Transesterification of glycolipids" Supervisor: Frederico Castelo Ferreira, co-Supervisor: Pedro Fernandes and César Fonseca, Starting date: Set 2010

D. Difficult separations and hybrid processes

7. Margarida Caras Altas "Kinetic enzymatic resolution of secundary alchools in water by microemulsion technologies" Supervisor Nuno Miguel Torres Lourenço, co-supervisor Frederico Castelo Ferreira. Concluded October 2010.

MIT Visits: I was a visiting scholar for about 3 months at MIT (7th September to 4th December 2009) under the MIT Portugal Program at Deshpande Center for Technological Innovation.

1. The objective of the visit was the participating in the Innovation Teams (i-Teams) program offered through the Deshpande Center for Technological Innovation (DCTI) and the Entrepreneurship Center (EC) at MIT, supporting following up teaching activity in the Bioteams.

2. Course designing and teaching skills. I did also have the opportunity to discuss and receive feedback on the design of an elective course "Green Technologies and strategic management", planned and lectured by Dr. Carlos Baleizão and myself at IST.

3. Exposure to the MIT Ecosystem. Several meeting were prepared and carried out to gain insights on the several MIT structural components of the entrepreneurship ecosystem. TLO, ILP, GSW, EC, DCTI, VMS, 100K organizers, entrepreneurs (see report "Short report: Frederico Ferreira's visit to MIT (Fall 2009)" 22nd January 2010.

The contacts mentioned allowed me to further contextualization of my role as facilitator between the MIT Portugal Program and the MIT Portugal Program industrial affiliates of the BioEngineering Systems area. (see report "Meetings with industrial affiliates (bioengineering area)", 8th May 2010.

Publications:

Sousa, M., Bras, A.R., Veiga, H. I. M., **Ferreira, F.C.**, Pinho, M. N., Correia, N.T., Dionisio, M. "Dynamical Characterization of a Cellulose Acetate Polysaccharide" J. Phys. Chem. B 114 (2010) 10939-1095

Sereewatthanawut, I., **Ferreira, F. C.**, Ghazali, N. F., Livingston, A. G. "Enantioseparation via EIC-OSN: Process Design and Improvement of Enantiomers Resolvability and Separation Performance" AIChE Journal 56 (4) (2010) 893-904

Research: The MIT Professorship position within IST-IBB allowed me to completely turn my areas of research to focus in to challenging, but high impact areas within the bioengineering area. My main research area is focused now on Stem cells research, new tailored materials and reactors configurations. On parallel, a new research idea was launched together with César Fonseca (LNEG) and with further planned support of Bruce Tidor at MIT on production of biofuel for aviation. These ideas will not be possible on my previous research positions and can only be developed within high expertise teams, allowing me to accelerate research and test new ideas. At the moment several students start the work on such fields, with promising results.

Teaching: The MIT Professorship position within IST-IBB allowed me to teach on the interface between technology and management, leveraging my scientific background and MBA. Additional topics have been lectured my fields of expertise. The interaction with students, both from a teaching and research point of view, has been extremely rewarding.

Administrative: Contact point for Portuguese companies, allowed me to interact with the innovation that is being carried out at enterprise level in Portugal and contribute to strength links between academia and industry**.**

Name: Cláudia Alexandra Martins Lobato da Silva

Focus Area: Bioengineering Systems

Host Institution: Instituto Superior Técnico (IST)

Starting Date: 04/07/2007-03/07/2008

Teaching Responsibilities:

Cell and Tissue Engineering – MIT-Portugal Advanced Studies Course, Bioengineering Systems

Cell and Tissue Engineering – Integrated Master on Biological Engineering , IST

Research Interest:

Human stem cell engineering towards the implementation of novel cellular therapies

- Expansion and differentiation of human stem cells, namely hematopoietic and mesenchymal stem cells
- Isolation and purification of stem cells
- Cellular Therapies with hematopoietic and mesenchymal stem cells
- Microscale platforms to study stem cell microenvironment
- Bioreactors for stem cell culture
- Kinetic modelling of stem cell behavior
- Metabolic profiling of stem cell cultures
- Bioreactors for animal cell culture for production of recombinant proteins

Projects: 2007 - 2009: "Isolation and Ex-vivo Expansion of Human Mesenchymal Stem Cells for the Prevention and Treatment of Graft-versus-host Disease", Portuguese Association Against Leukemia ("Associação Portuguesa Contra a Leucemia" (APCL))

Within the scope of this project, until now, 9 patients were submitted to ex-vivo expanded mesenchymal stem cell infusion to treat hematological disorders.

Supervising Activity:

David Braga Malta, "Derivation of Type II Pneumocytes from Murine Embryonic Stem Cells: Pre-Clinical Tests", Integrated Master Dissertation, Biological Engineering, Instituto Superior Técnico/Imperial College of London (co-supervision)

Pedro Miguel Andrade, "In Vitro Expansion of Human Mesenchymal Stem Cells in Stirred Culture Systems", Integrated Master Dissertation, Biological Engineering, Instituto Superior Técnico (co-supervision)

Francisco Ferreira dos Santos, "Expansion of Hematopoietic Stem Cells: Optimization of Co-Culture with Human Stroma", Integrated Master Dissertation, Biological Engineering, Instituto Superior Técnico (co-supervision)

Ana Margarida Fernandes, "Scale-Up of Mouse Embryonic Stem Cell Expansion in a Stirred Culture System", Master Dissertation in Biotechnology (Biochemical Engineering), Instituto Superior Técnico (co-supervision)

MIT Visits: September-October 2008

Publications:

Fernandes, A.M., Fernandes, T., Diogo, M., Lobato da Silva, C., Henrique, D., Cabral, J.M.S. "*Mouse Embryonic Stem Cell Expansion in a Microcarrier-Based Stirred Culture System*", Journal of Biotechnology, 132, 227-236 (2007)

At a very early stage in my career, I've had the chance to work with people like [MIT Institute Professor] Bob Langer and [Associate Professor] Sangeeta Bhatia. Without the MIT Portugal connection, I would never have had such an opportunity. It has been a very important step in my academic career.

Name: Miguel Nobre Parreira Cacho Teixeira

Focus Area: Bioengineering - Functional Genomics

Host Institution: Instituto Superior Técnico, Universidade Técnica de Lisboa

Starting Date: 01/07/2007 (till 30/06/2008)

Teaching Responsibilities:
Biosystems Science and Engineering – MIT/Portugal Biosystems Engineering PhD
Functional Genomics and Bioinformatics – MSc programs in Biological, Biomedical and Information Systems and Computer Engineering, IST
Genomics, Proteomics and Bioinformatics – PhD programs in Biotechnology and Environmental Engineering, IST

Research Interest: Multidrug/stress resistance in Saccharomyces cerevisiae as a model eukaryote or as a cell factory using functional genomics and systems biology approaches
PTDC/BIA-MIC/72577/2006: "Functional and biochemical analysis of the yeast multidrug resistance transporters Qdr2 and Aqr1". (PI)
PTDC/BIO/72063/2006: “Characterization and modeling of a specific transcriptional regulatory network required for multidrug resistance in yeast”. (PI)
PTDC/AGR-AAM/67858/2006: “Herbicide resistance in Arabidopsis thaliana: Role of plant multidrug resistance transporter” (15%).
PTDC/BIO/66151/2006: “PROBIOETHANOL - Proteomics and engineering of yeast ethanol tolerance for high-productivity bio-ethanol fermentation processes" (15%).
PTDC/SAU-FCF/71760/2006: “Imatinib Resistance and targets in Chronic Myeloid Leukaemia: post-genomic approaches using yeast as a model system” (5%).

Supervising Activity:
Tânia Cabrito, “Functional analysis of Saccharomyces cerevisiae and Arabidopsis thaliana multidrug resistance transporters involved in the resistance to the herbicide 2,4-D", MSc in Biological Engineering, Instituto Superior Técnico, 2007.
Luís Raposo, "Global analysis of the mechanisms of yeast resistance to stress induced by high concentrations of ethanol and glucose”, MSc in Biotecnology, Instituto Superior Técnico, 2007.

MIT Visits: None

Publications:
Teixeira M.C., Dias P.J., Simões T., Sá-Correia I. “Yeast adaptation to mancozeb involves the up-regulation of FLR1 under the coordinate control of Yap1, Rpn4, Pdr3 and Yrr1” Biochemical Biophysical Research Communications, 367: 249-255, 2008.
Monteiro P., Mendes N., Teixeira M.C., d´Orey S., Tenreiro S., Mira N.P., Pais H., Francisco A., Carvalho A., Lourenço A.R., Sá-Correia I., Oliveira A.L., Freitas A.T. "YEASTRACT-DISCOVERER: new tools to improve the analysis of transcriptional regulatory associations in Saccharomyces cerevisiae". Nucleic Acids Research. Database Issue, 36: D132-D136, 2008.
Teixeira M. C., Duque P., Sá-Correia I., “Environmental Genomics: mechanistic insights into toxicity and resistance to the herbicide 2,4-D”, Trends in Biotechnology, 25, 363-370, 2007.

The MIT-Portugal program opened the opportunity to start an academic career (as an invited assistant professor), providing the possibility to integrate a prestigious school such as IST and to facilitating my first steps as an independent researcher. It ended up opening the opportunity to obtain a more stable position as an assistant professor at IST only one year afterwards.

Name: Mihail Fontul

Focus Area: EDAM

Host Institution: IST

Starting Date: November 2007

Teaching Responsibilities:

TES (Technology Evaluation & Selection), LTI (EDAM PhD Program) & TME (EDAM Advanced Course Program), 2008-2010
DMG1 (Mechanical Drafting 1), Mechanical Engineering Undergraduate Course, 2006-2010
DMG2 (Mechanical Drafting 2), Mechanical Engineering Undergraduate Course, 2006-2010
PM (Mechanical Project), Mechanical Engineering Undergraduate Course, 2008
VR (Noise & Vibrations), Mechanical Engineering Undergraduate Course, 2006-2007
ME (Engineering Materials), Mechanical Engineering Undergraduate Course, 2009-2010
DP (Product Development), Mechanical Engineering Undergraduate Course, 2010

Research Interest:

PTDC/EME-PME/71488/2006, IDENTIFICAÇÃO E TRANSMISSIBILIDADE DE FORÇAS EM SISTEMAS COM MÚLTIPLOS GRAUS DE LIBERDADE (Multi Degree Of Freedom Force Transmissibility), 30%, researcher
PTDC/EME-PME/69904/2006, AMORTECIMENTO HISTERÉTICO COMO PARÂMETRO ENERGÉTICO DE DANO EM FADIGA DE MATERIAIS A MUITO ELEVADA FREQUÊNCIA (Hysteretic damping as an energy parameter in gigacycle fatigue), 25%, researcher
MIT-Pt/EDAM-SI/0025/2008, DEVELOPMENT OF INTEGRATED SYSTEMS FOR SMART INTERIORS, 10%, researcher

Supervising Activity:

DECISION MAKING METHODOLOGY ON HUMAN AND MACHINE INTERFACE INNOVATIVE PROCESSES, Jose Gaspar, PhD
HMI ON SENSITIVITY FUNCTIONS APPROACH: CASE OF NON-VISUAL SENSES, Ioannis Malliaros, PhD
TOWARDS HIGH STRENGTH - 3D CHITOSAN BASED PRODUCTS FOR BIOMEDICAL APPLICATIONS, Nuno Guitian, PhD
COST EFFECTIV INNOVATION, Jean-Loup Loyer, PhD
APLICAÇÃO DE TÉCNICAS DE TRANSMISSIBILIDADE E ACOPLAMENTO NA ANÁLISE ACÚSTICA DE UM VEÍCULO AUTOMÓVEL, Nuno Cota, MSc
METODOLOGIAS DE ENSAIO E ANÁLISE VIBRO-ACÚSTICA DE ESTRUTURAS: CASO ESTUDADO TÚNEL DE VENTO DO LABORATÓRIO AEROESPACIAL DO IST, Alice Sousa, MSc
AVALIAÇÃO DA CONDIÇÃO DA CAIXA REDUTORA E MOTOR DAS AERONAVES C-130 E P-3P, POR ANÁLISE DE VIBRAÇÕES, ATRAVÉS DO VIBRALOG ODYSSEY, Sara Cordeiro, MSc
ANÁLISE DE VIBRAÇÕES EM MATERIAIS DE CORTIÇA COM BORRACHA, Ivo Guelho, MSc

MIT Visits:

2 visits, each one week, in 2008 & 2009, ESD

I was at MIT working with Randy Kirchain and prepare the TES course and also some research projects. I have no else experience at MIT.

Publications:

I may say my career change a lot in the last 4 years. I learn to teach a different course than I used to have, I learn to work in a different research project than I used to do before. New concepts and new ideas make me be better prepared to face the problems I may find in the future. After all I believe I have the opportunity to grow-up in a different manner, to work on a different environment. I may say I'm more complete now.

Name: Carlos Augusto Santos Silva

Focus Area: Engineering Systems / Sustainable Energy Systems

Host Institution: Instituto Superior Técnico

Starting Date: June 19th 2008

Teaching Responsibilities:

Sustainable Energy Systems PhD and DFA programs:

- Introduction to Engineering (2hours / 1st semester)
- Energy Systems Modeling and Economics (2hours / 1st semester)
- Optimization of Energy Systems (2 hours/2nd semester)

Research Interest:

MIT Portugal Program Projects

- Green Island Project (40%) – Scientific coordination at IST

FCT – MIT Portugal Program projects

- NETZEROENERGYSCHOOL (10%) – Principal Investigator
- NODES (10%) - Researcher at IST
- PEERCHAIN (10%) Researcher at IST

Other FCT Projects

- OFFSHOREENERGY ROADMAPPING (15%) – Principal Investigator

Industrial Projects

- SMARTGALP (5%) – Researcher at IST
- FINERTEC (5%) – Principal Investigator

Supervising Activity:

PhD Supervision

- Miguel Covas : Holistic Strategies and Methodologies to Develop a Sustainable Data Center
- Nuno Santos: Energy Efficiency Strategies in Public Schools
- Rita Paleta: Remote Autonomous Energy Systems Design for Developing Countries

PhD Co-Supervision

- André Pina: Supply and demand dynamics in long- and medium-term energy systems modelling
- Kiti Suomalainen: Renewable energy resource dynamics in scenario generation for energy systems modelling
- Diana Neves: Energy sustainability in isolated regions

MsC Supervision:

- Inês Dias Ramalho: *Caminhos para a Sustentabilidade ? Avaliação de oportunidades no contexto sócio-económico para redução do Consumo Energético Residencial* (November 2009)
- Rita de Carvalho Paleta: *Análise do potencial técnico-económico de sistemas de produção local de energia em ambiente construído* (November 2009)
- Diogo Figueiredo: *Optimização da Produção de Colectores Solares: Caso de Estudo da WS Energia* (June 2010).

MsC Co-supervision:

- Marcos Leite Vieira: *Modelação e Simulação de Operações de Armazenagem (June 2009);*
- José Beirão: *Optimização de Contentores de Expedição* (November 2009).
- Tiago Caldeira:*Modelação, Simulação e Optimização da Logística de Recolha e Transporte de Resíduos de Biomassa para produção de Electricidade* (November 2009).
- João Raposo:*Optimização da Localização de Serviços Energéticos Utilitários* (June de 2010).
- Gonçalo Pereira: *Decision Analysis for Sustainable Energy Systems Design: The São Miguel - Azores Case Study* (October 2010).
- Vasco Esteves: *Optimização distribuída baseada em agentes biológicos de cadeias de abastecimento* (November 2010).

MIT Visits:

Long visit:

- October 2008-November 2008, ESD

Short Visits

- June 2009 for the ESD conference

The one month visit I made to MIT in Fall 2008 was very important for the development of my teaching activities at the MIT Portugal Program. During this month I had the opportunity to attend several classes from my MIT colleagues to learn how they teach their classes, a less formal and descriptive approach than the one we usually have in Portugal.

I also had the opportunity to discuss with several colleagues research opportunities and collaborations and visit their labs, in particular to prepare the research activities of the Green Islands Projects.

Publications:

[1] A. Pina, **C.A. Silva**, P. Ferrão. Developing an extended TIMES model to plan a sustainable energy system for S. Miguel (Azores). Submmited to *Energy Policy*.

[2] K. Suomalainen, **C.A. Silva**, P. Ferrão, S. COnnors. A method for including diurnal effects into synthetic wind speed data for energy systems planning: Validation in the Azores Islands. Submmited to *Renewable Energy*.

[3] M. Covas, **C.A. Silva**, L.C. Dias. A sustainable design approach for greener Data Centers. Submmited to European Journal of Operations Research

The biggest impact on my career has been the access to multiple networking opportunities in industrial and research events, where we can present and discuss results with key people in industry and academy and consequently develop projects in closed relationship with the Portuguese industry and with different research centers in other universities in Portugal through project participation and thesis co-supervision. The direct interaction with MIT is not so strong has I had foreseen, but nevertheless it has been very important for me to develop new teaching and communication skills and even to develop a more pro-active attitude towards the interaction with industry and the need to develop applied research.

Name: António Jorge Viegas de Vasconcelos

Focus Area: Sustainable Energy Systems

Host Institution: Instituto Superior Técnico, Universidade Técnica de Lisboa

Starting Date: 2007 **Dedication**: 40%

Teaching Responsibilities:

Seminar I and II

Research Interest:

All projects related to Sustainable Energy Systems at both design and implementation phases, in particular as regards the following aspects:

-introduction of market mechanisms, integration of proposed solutions into energy markets;

-alignment with EU energy and climate policy, development aid policy and other relevant policies;

-regulatory compliance;

-application of modern information and communication technologies to energy systems;

-multidisciplinary approaches;

-cooperation with hi-tech industries.

Supervising Activity:

Joana Abreu, "The human interaction side of demand response";

Filipa Amorim, "Evaluation of the Portuguese feed-in tariffs (FITs) design";

José Osório

Rita Paleta

MIT Visits:

2: 2008 and 2009; total time about one week

During these visits contacts with several researchers were done with twofold purpose:

- to better understand the ongoing research activity related to Sustainable Energy Systems at MIT in order to be able to suggest to MIT Portugal PhD students useful contacts;

- to explain policy, institutional and market related developments in the EU and in Portugal concerning Sustainable Energy Systems

Publications:

A paper on legacy costs pending

The contact with highly-motivated students and colleagues has provided numerous useful research ideas; participation in the design of several research projects has enabled the establishment of fruitful links between academia and industry.

Name: Lígia Raquel Marona Rodrigues

Focus Area: Bioengineering Systems

Host Institution: University of Minho

Starting Date: 1st August 2007

Teaching Responsibilities:

MIT-Portugal Bioengineering: Pre-Module Bioprocess Engineering, Modelling and Control (3h/yr); Bioengineering Systems – from Idea to Innovation (10h/yr); Lab Rotations (30h/yr)

Other classes outside MIT-Portugal Program: PhD Program in Chemical and Biological Engineering (Advanced Topics in Chemical and Biological Engineering I (5h/yr) and Advanced Topics in Chemical and Biological Engineering II (5h/yr)); MSc in Bioinformatics (Innovation and Entrepreneurship in Biotechnology and Bioinformatics (15h/yr)); MsC in Bioengineering (Integrated Labs (5h/yr) and Project in Bioengineering (30h/yr)); Integrated Master in Biological Engineering (Individual Project in Biological Engineering (72h/yr), Food Biotechnology (5h/yr) and Food Science and Engineering (30h/yr)); Integrated Master in Biomedical Engineering (Introduction to Biomedical Engineering (45h/yr))

Research Interest:

* Bridging systems and synthetic biology for the development of improved microbial cell factories. Funded by FCT under the scope of the MIT-Portugal Program – MIT-Pt/BS-BB/0082/2008. Since April 2009, duration 3 yrs. Role: Team Member (25%)
* Synbiobacther – Engineering "therapeutic" bacteria. Funded by FCT – PTDC/EBB-BIO/102863/2008. Since May 2010, duration 3 yrs. Role: PI (25%). Involves people from MIT
* The role of Gardnerella vaginalis in mixed species biofilms occurrence in bacterial vaginosis. Funded by FCT – PTDC/BIA-MIC/098228/2008. Since April 2010, duration 3 yrs. Role: Team Member (10%)

Supervising Activity: MIT-Portugal PhD students: Roberto Gallardo (Since Sep2009 Development of new strategies for the production of butanol); Other PhD students outside MIT-Portugal Program: Doctoral Program in Biomedical Engineering (Yunlei Zhang (Since Sep2010); António Machado (Since Jan2010)) Doctoral Program in Chemical and Biological Engineering (Sofia Meirinho (Since Sep2010); Sara Gonçalves (Since Sep2010); Jorge Padrão (Since Jan2010); Nair Sampaio (Since Aug2007, expected conclusion date Apr2011); Clarisse Nobre (Since Jan2007, expected conclusion date Apr2011); Duarte Torres (Dec2004-Mar2010); MsC students: Ongoing - 7; Finished since 2007 - 15

MIT Visits:

1st visit - Feb 2008-June 2008 – I-teams course; Kristala Prather & Bruce Tidor labs
2nd visit – May – 1 week – Kristala Prather lab

My experience at MIT was very useful for my professional career, especially the 1st visit since it was longer. During the 6-months that I was at MIT I had the opportunity to attend courses related with innovation and entrepreneurship which I have been teaching at the doctoral program since then (BioTeams). Also, I had the opportunity to meet several researchers that are working on the synthetic biology field which is the research field that I aim to develop at University of Minho. This stay was extremely relevant to strength my contact network and develop new collaborations and research ideas. The 2nd visit was a consequence of the 1st one since the aim was to write joint research project proposals and discuss ongoing research.

Publications:

Under the scope of the MIT-Portugal Program no papers have yet been developed although the results

from Gallardo's PhD work are being compiled. Also, a white paper on the BioTeams experience is being prepared.

MIT-Portugal has been extremely important for my professional career development, since it enabled me to strength my contact network and develop new research collaborations. Also, I had the opportunity to learn about the MIT culture regarding lecturing, research and innovation which I have been adopting in my professional activities.

Name: ISABEL Cristina de Almeida Pereira da ROCHA

Focus Area: Bioengineering

Host Institution: University of Minho

Starting Date: August 1st 2007

Teaching Responsibilities:

Advanced Studies Course (Bioengineering PhD Program):

- Computational Biosystems (teaching - 8 hours)
- BioTeams Project (Supervision and guidance of students – 14 hours)
- Leadership Module (Organization – 10 hours)

Master in Bioinformatics

- Director of the Master Program
- Advanced Bioinformatics and Systems Biology (supervision and teaching – 60 hours)

Research Interest:

Interests: Systems Biology and Metabolic Engineering. Bioprocess Optimization

Ongoing Projects:

-HeliSysBio - Molecular Systems Biology of Helicobacter pylori (FCT PTDC/EBB-EBI/104235/2008) (April 2010 – March 2013). Role: PI with 25% dedication

- SYSINBIO - "Systems Biology as a Driver for Industrial Biotechnology Improved Microbes". EU FP7 (Coordination Action) (December 2008-December 2011). Role: WorkPackage coordinator

-Bridging Systems and Synthetic Biology for the development of improved microbial cell factories (MIT-Pt/BS-BB/0082/2008) (May 2009-April 2012). Role: Team Member with 15% dedication

-SYNBIOBACTHER - Synthetic biology approaches to engineer "therapeutic" bacteria (FCT PTDC/EBB-BIO/102863/2008). Role: Team Member with 15% dedication

- AshByofactory - *Ashbya gossypii*: a systems metabolic engineered cell factory (FCT PTDC/EBB-EBI/101985/2008). Role: Team Member with 15% dedication

- ToMEGIM: Ferramentas Computacionais para Engenharia Metabólica usando Modelos Integrados de Escala Genómica. (PTDC/EIA-EIA/115176/2009). Role: Team Member with 15% dedication

- Reconstrução *in silico* de redes celulares de *Streptococcus pneumoniae* e avaliação do seu impacto na virulência. (PTDC/EBB-EBI/113824/2009). Role: Team Member with 15% dedication

Supervising Activity:

PhD thesis:

-"Development of Dynamic Multi-Layered Cell Models based on Cellular Automata."; PhD student Pedro Tiago Evangelista; PhD in Bioengineering (MIT-Portugal program). Co-Supervision with Miguel Rocha; Since September 2010

- "Metabolic Control Analysis as a Framework for Strain Optimization."; PhD student Paulo Jorge Lopes Maia da Silva; PhD in Bioengineering (MIT-Portugal program). Co-Supervision with Miguel Rocha; Since September 2010

- "Reconstruction of the Genome-scale Metabolic Network of *Kluyveromyces lactis*"; PhD student: Oscar Manuel Lima Dias; PhD in Chemical and Biological Engineering - University of Minho. Co-Supervision with Eugénio Ferreira; Since February 2009

- "*In vivo* metabolic pathway analysis of pathogenic bacteria to identify new drug targets". PhD student: Carla Andreia Freixo Portela; PhD in Chemical and Biological Engineering - University of Minho; Co-Supervision with Eugénio Ferreira and Silas Vilas-Boas (Univ. Auckland, New Zealand); Since March 2009

- "Systems analysis of metabolism in *Helicobacter pylori*"; PhD student: Daniela Matilde Marques Correia; PhD in Chemical and Biological Engineering - University of Minho; Co-Supervision with Maria João Vieira; Since February 2009

- "Novel modelling formalisms and simulation tools in Computational Biosystems"; PhD student: Carlos Daniel Moutinho Machado; PhD in Bioengineering (MIT-Portugal program); Co-supervision with Eugénio Ferreira; Since September 2008

- "Computational Tools for Data Integration and Regulatory Network Inference in Systems Biology", PhD

Student: José Pedro Basto Gouveia Pereira Pinto; PhD in Informatics - University of Minho; Co-supervision with M. Rocha; Since December 2007

- "From Genome-scale Models of Microorganisms to Process Control and Optimization - Application to Recombinant Protein Production". PhD student: Rafael Sousa Costa. PhD in Chemical and Biological Engineering (co-supervision with E. C. Ferreira) (started on January 2006).

Selected MSc Thesis:

- "Measurement and Control of Glucose Concentration in Mammalian Cultivations using Mid-IR Spectroscopy"; MSc student: Patrícia Raquel Pinheiro Pitrez Pereira; Integrated Master in Biological Engineering – University of Minho; Co-supervision with Mats Akesson, NovoNordisk, Inc, Denmark; September 2010.
- "Multi-Objective Evolutionary Algorithms for the *in silico* Optimization of Mutant Strains"; MSc student: Paulo Jorge Lopes Maia da Silva; MSc in Bioinfomatics – University of Minho; Co-supervision with Miguel Rocha, University of Minho, September 2010.
-"Identifying metabolic and regulatory signatures of type 2 diabetes by integration of gene expression data and genome-scale metabolic networks"; MSc student: Simão Pedro de Pinho Soares; MSc in Bioinfomatics – University of Minho; Co-supervision with Kiran Patil, Technical University of Denmark, September 2009.

MIT Visits:

February to May 2007 – visit to attend the MIT program i-teams and 2 other courses on innovation. The main objective was to plan the implementation of the Bio-Team project in Portugal
May 2008 – 5-day visit to promote existing collaborations with Professor Bruce Tidor's lab
September 2009 – 3-days visit to participate in the Leadership program of Professor Dava Newman also to help the implementation of a leadership program under the scope of the MIT-Portugal Program

My time at MIT, especially the 3-months period in 2007 gave me a unique opportunity to contact with state-of-the art educational methodologies and leading faculty in a unique, challenging and exciting environment.

Publications:

- Carneiro, S., Villas-Boas, S., Ferreira, E.C., **Rocha, I.** Metabolic footprint analysis of recombinant *Escherichia coli* strains during fed-batch fermentations. Molecular BioSystems, (In Press), 2011.
- Lourenço, A., Carneiro, S., Rocha, M., Ferreira, E.C., **Rocha, I.** Challenges in integrating *E. coli* molecular biology data. Briefings in Bioinformatics, (In Press), 2011.
- **Rocha, I.**, Maia, P., Evangelista, P., Vilaça, P., Soares, S., Pinto, J.P., Nielsen, J., Patil, K.R., Ferreira, E.C., Rocha, M. OptFlux: an open-source software platform for *in silico* metabolic engineering. BMC Systems Biology, 4(45), 1-12, 2010.

MIT-Portugal Program gave me the opportunity to be involved in a challenging PhD program with several top students in Bioengineering and also to contact with leading faculty from MIT. Also, I was involved in the organization of several modules, namely the BioTeams project, which gave me the opportunity to design and implement *de novo* educational programs. I think that helped me greatly in implementing another educational program, the Master Program in Bioinformatics in the University of Minho.
Also, many of the things I learnt and experienced about technology transfer and innovation back in 2007 at MIT have been very useful in my entrepreneurship activities, namely in launching a new spinoff in 2010 (SilicoLife) and in leading the Portuguese Association of Bioindustries (APBio) since 2009.

Name: Maria Manuela Estima Gomes

Focus Area: Bioengineering Systems

Host Institution: Univ. Minho/School of Engineering/3B's Research Group

Starting Date: July 2007

Teaching Responsibilities:

Doctoral Course Bioengineering Systems - Co-responsible for the Module on BioNanotechnology and Biomaterials module of the Bioengineering focus area, teaching classes on cells-materials interactions and scaffolds in Tissue Engineering and practical lessons on scaffolds development.
Participation (seminars) in the Module on cells and Tissue Engineering (2008/9, 2009/10 editions)
Supervision of Lab rotations

Research Interest:

Under the scope of the Program, my main research interests are related to the development of new scaffold materials, based on natural origin polymers such as gellan gum, chitosan and carrageenan, using micro/nano fabrication techniques, that can be used to direct the osteoblastic and endothelial differentiation of adipose stem cells, enabling to obtain vascularised bone tissue engineered constructs.
FCT Project - "Micro/nano design of functional stem cell-instructive materials for bone tissue regeneration", (MIT/ECE/0047/2009) Role: Principal Investigator (Co-PI: Ali Khademhosseini and Robert Langer).
Under this topic we have also recently submitted a proposal to NIH.

Supervising Activity:

MIT Portugal Program PhD students:
Daniela Coutinho, "*Micro/Nano-processing strategies as a tool to clarify the biological performance of degradable biomaterials for biomedical applications*", University of Minho (in collaboration with Ali Khademhosseini, MIT), 2007, ongoing
Silvia Mihailia: "*New Routes for Obtaining Vascularized Bone Tissue Engineering Constructs*", University of Minho (in collaboration with Ali Khademhosseini, MIT), 2009, ongoing
Other PhD students: 8

MIT Visits:

Short visits to several labs and meeting with group leaders in 2008 which allowed me to know and establish fruitful collaborations.

Publications:

Daniela F. Coutinho, H. Shin, S. Sant, J.T. Oliveira, **M.E. Gomes**, N. M. Neves, A.Khademhosseini, R.L. Reis' "Modified Gellan Gum hydrogels with tunable physical and mechanical properties", Biomaterials, 31(29): 7494-7502, 2010
Daniela F. Coutinho, S. Sant, M. Shakiba, B. Wang, **M.E. Gomes**, N.M. Neves, R. L. Reis, A. Khademhosseini, " Photocrosslinkable polyelectrolyte-complex capsules of chitosan and methacrylated gellan gum for micro-fabrication", 2011, Soft Matter, submitted
Silvia M.Mihaila, A.M. Frias, R.P. Pirraco, T. Rada, R.L. Reis, A. P. Marques and **M.E. Gomes**, "Adipose Tissue-Derived SSEA-4 Subpopulation Differentiation Towards the Endothelial Lineage", 2011, Stem Cells and Development, submitted.

MIT-Portugal Program gave me unique opportunities of establishing fruitful collaborations with other groups at MIT and other groups in Portugal, both in top research and educational programs, which had a great impact in the development of my research goals and educational skills.

Name: Pedro Miguel Santos

Focus Area: Microbial Functional Genomics

Host Institution: University of Minho

Starting Date: September 2008

Teaching Responsibilities:

- Structural Biochemistry (Geology-Biology degree, 6h/week)
- Biochemistry laboratory I (Biochemistry degree, 6h/week)
- Biological Molecules (Applied Biology degree, 2h/week)
- Multiplexed Proteomics (Advanced course, 80h)

Research Interest:

Interests:

-Bacterial biotransformation and biodegradation of recalcitrant and/or toxic compounds
-Microbial adaptation to environmental stress conditions
-Microbial pathogenesis
-Genomics and Proteomics

Projects:

BIOMYR –Towards the metabolic engineering of beta-myrcene pathway Pseudomonas sp. M1: functional genomics and structural biochemistry approaches
FCT- PTDC/EBB-BIO/104980/2008 (2010-2013)
Prime Contractor: CBMA/Universidade do Minho – **Pedro M Santos (PI)**
Partners: Fundação da Faculdade de Ciências (FFC/FC/UL), Instituto Tecnologia Química e Biológica (ITQB/UNL), Instituto superior Técnico (IST/UTL), Institute for Biotechnology and Bioengineering (IBB), Helmholtz Centre for Environmental Research

ROOT-INT- Role of a two-component regulatory system in the early interaction between Sinorhizobium meliloti and plant root hairs
FCT-PTDC/BIA-MIC/113733/2009 (2011-2014)
Prime Contractor: Instituto Superior Técnico – Leonilde Moreira
Partners: Instituto Gulbenkian para a Ciência (IGC), CBMA/Universidade do Minho – **Pedro M Santos**

Benthic Estuarine Barcode(BEstBarcode): Development and application of massively paralelized sequencing for monitoring of estuarine macrobenthic communities
FCT- PTDC/MAR/113435/2009 (2011-2014)
Prime Contractor: CBMA/Universidade do Minho – Filipe Costa
Team members: Ronaldo Sousa, Maria Ribeiro da Costa, Pedro Alexandre Fernades Teixeira Gomes, Sandra Caeiro, Mehrdad Hajibabaei, **Pedro M Santos**

Supervising Activity:

Catarina Rodrigues, PhD student
Pedro Miguel Soares-Castro, MSc student

MIT Visits: 0

Publications:

Santos P.M., Sá-Correia I. (2009) Adaptation to beta-myrcene catabolism in Pseudomonas sp. M1: an expression proteomics analysis. Proteomics 9:5101-11.

Teixeira M.C., **Santos P.M**., Rodrigues C, Sá-Correia I. (2009) Teaching Expression Proteomics: From the Wet-Lab to the Laptop. Biochem. Mol. Biol. Education 37:279–286.

Santos P.M., Simões T, Sá-Correia I. (2009) Insights into yeast adaptive response to the agricultural fungicide mancozeb: a toxicoproteomics approach. Proteomics 9:657-670.

Unfortunately, I was only in the MIT-Portugal program for one year. It was an option for me to leave the program since I almost did not have the opportunity to interact with MIT. This was mainly due to lack of funding to support collaborative work. Nonetheless, I believe that the program may be very advantageous for researchers with established contacts with MIT team.

Name: Luis Alexandre Machado da Rocha

Focus Area: EDAM

Host Institution: University of Minho

Starting Date: 01-03-2008

Teaching Responsibilities within MIT Portugal Program:

2008-2009: Integrating Technology and Management (LTI and TME) – 30 hours
Microfabrication and Microsystems (TME) – 15 hours
Biomedical Devices and Technologies (Bioengineering) – 6 hours

2009-2010: Integrating Technology and Management (LTI and TME) – 30 hours
Technology Advanced Seminars (LTI and TME) – 9 hours
Biomedical Devices and Technologies (Bioengineering) – 6 hours

2010-2011: Integrating Technology and Management (LTI and TME) – 30 hours
Technology Advanced Seminars (LTI and TME) – 9 hours
Biomedical Devices and Technologies (Bioengineering) – 6 hours

Research Interest:

- Oct. 2008 – July 2010 ***Principal Investigator from University of Minho – 25%***
  "AHRS - Attitude heading Reference System", QREN/1608, Industrial consortium funded by QREN, Portugal. Partners: Spin.Works, University of Minho, INESC Porto and Faculty of Engineering of the University of Porto. (Funding UMinho €88.564).
- Since Oct. 2007 ***Researcher (ongoing) – 10%***
  "QWiSNet - Quality of service in wireless sensor and actuator networks", PTDC/EEATEL/68625/2006, funded by Science and Technology Foundation, Portugal. University of Minho (Funding €86.090)
- Since Jan. 2009 ***Researcher (ongoing) – 10%***
  "MEMS Micro-Antennas for Wireless Biomedical Devices", PTDC/EEA-TEL/65286/2006, funded by Science and Technology Foundation, Portugal. University of Minho. (Funding €130.000)
- Since Aug. 2009 ***Principal Investigator (on-going) – 30%***
  "New technological solutions for smart cardiovascular medical devices", MIT-Pt/EDAM-EMD/0007/2008, funded by Science and Technology Foundation under the framework of the MIT-Portugal Program, Portugal. Partners: University of Minho, Faculty of Engineering of the University of Porto, Instituto Superior Técnico and Massachusetts Institute of Technology (USA). (Funding €185.772).
- Since Jun. 2010 ***Principal Investigator (on-going) – 25%***
  "SmartPolySense - Low-Cost Polymer Micromanufacturing Technologies for Smart Systems", PTDC/EEA-ELC/099834/2008, funded by Science and Technology, Portugal. University of Minho. (Funding €150.00)
- Since Jan. 2011 ***Principal Investigator from University of Minho– 20%***
  "TICE.Healthy - Physical Rehab" Industrial consortium with more than 28 participants from industry and academia. (Funding UMinho €177.449).

Supervising Activity:

Supervision of Master of Science (M.Sc.) Thesis:

- Vasco Ferraz, "Estudo, caracterização e teste de uma antena microfabricada" (*Analisys, characterization and test of a microfabricated antenna*). Faculty of Engineering of the University of Porto, DEEC. Thesis defended on June 2008.
- Diogo Filipe de Sousa Teixeira e Melo, "Sistema Integrado para leitura de um Acelerómetro MEMS de

Elevada Resolução." (*Integrated Capacitive Readout for a high resolution MEMS accelerometer*). Faculty of Engineering of the University of Porto, DEEC. Thesis defended on June 2010.

- Helder David Malheiro Silva, "Sistema de Monitorização da Postura em Tempo-Real sem Fios" (*Wireless real-time monitoring posture system*). University of Minho, DEI. Thesis defended on December 2010.
- Márcio Filipe Araújo Cerqueira, "*Design and processing integration of a 3D Thermal Accelerometer*". University of Minho, DEP. Thesis defended on December 2010.
- Bou Sing Hau, "*A Piezoresistive Detector Design for a High Sensitivity Pull-in Time Digital Accelerometer*". Delft University of Technology, The Netherlands. (on-going)
- Manuel António de Castro Faria, "Desenvolvimento de micro-sensor de temperatura em materiais piroeléctricos" (*Development of a temperature microsensor using piroelectric materials*). University of Minho, DEP. (on-going)

Supervision of Doctoral (Ph.D) Thesis:

- Rosana Alves Dias, "*Micro g MEMS Accelerometer Based on Time Measurement*", SFRH/BD/46030/2008. University of Minho - started April 2009. (on-going)
- Isa Santos, "*Technological, economic and social implications in the design of a stent graft*", SFRH/BD/42967/2008. Faculty of Engineering of the University of Porto - started February 2009. (on-going)
- Alexandra Sepulveda, "*Technologies for flexible sensors in the design of a smart stent graft*", SFRH/BD/42965/2008. University of Minho - started June 2009. (on-going)

MIT Visits:

1 – June 2008, 15 days: Getting to know the MIT partners of EDAM and new contacts on the microfabrication areas.
2 – March 2009 until June 2009 (Visiting Scholar): Working with Prof. Brian Wardle on flexible nanocomposites for microsensors fabrication.
3 – June 2010, 3 days: Meetings to deal with ongoing teaching and research activities.

The MIT experience was positive since it allowed me to establish new research collaborations that are being exploited in the framework of the MIT Portugal Program and can be helpful in the future. The MIT ecosystem is very interesting, namely the strong emphasis on entrepreneurship. MIT organization is in line with what I experienced in TUDelft during my Ph.D.

Publications:

L. Mol, **L.A. Rocha**, E.Cretu and R.F. Wolffenbuttel, "Squeezed film damping measurements on a parallel-plate MEMS in the free molecule regime" *J. Micromech. Microeng*. 19 (2009), 6 pages.
R. A. Dias, L. Mol, E. Cretu, R.F. Wolffenbuttel and **L. A. Rocha**, "Design of a time-based micro-g accelerometer", *IEEE Sensors* (2011), In-Press
L.A. Rocha, R. A. Dias, E. Cretu, L. Mol and R.F. Wolffenbuttel, "Auto-calibration of Capacitive MEMS Accelerometers based on Pull-In Voltage" Microsystems Technologies (2011), In-Press

Overall, the MIT Portugal Program experience is positive. In my case, the MIT Portugal Program and UMinho gave me the freedom to try to establish a research team on the areas of Microsystems and microfabrication using both silicon and polymer based technologies. This has been a hard effort that is being consolidated by several projects funded in these areas (on within the MIT Portugal Program). In addition, the MIT Portugal Program has given me experience on coordination and multi-institution collaboration. Through MIT Portugal Program I have significantly broaden my contact network (both students and faculty).

Name: Satyabrata Ghosh

Focus Area: Engineering Design and Advanced Manufacturing

Host Institution: University of Minho

Starting Date: Nov 03, 2008

Teaching Responsibilities:

I do not teach any course in MIT Portugal program.

EuroRheo Program : An European Master Degree program
Conventional Injection Molding: 44 Hours
Non-convention technology: 22 Hours

Research Interest:

Biodegradable polymers and composites, Structure –properties relationships, Melt Rheology of Polymers, Product development, Thermal analysis, Static and quasi-static mechanical properties of materials, Application engineering of biopolymers.

Project Advisor: MIT Portugal – 20 %

1. Towards High Strength - 3D Chitosan Based Products for Biomedical Applications
2. LIGHTDOOR – Lightweight automotive DOOR structure in advanced polymer composites

Research work by myself – 40 % time.

Supervising Activity:

I haven't supervised any MIT Portugal student so far.

Publications:

No publications yet in the MIT-Portugal context.

MIT Portugal program has a great impact on my professional career. The traditional PhD curriculum allows one to get a better understanding a narrow area of a particular discipline, and that can enhance a chance to step into academic career. On the other hand, MIT Portugal Program /MIT Portugal Program provide a credible engineering management envelope enabling real life social and engineering / technical / technological problems. Thus reduces the gap between university education and real life problems. Naturally, the candidates from MIT Portugal Program can efficiently and quickly handle the major technical/engineering challenges in major technical companies or on major technological platforms. Moreover, the candidates can develop individual business entity that would create new jobs, and new sources of revenue for the country.

3.2 Research Residences at MIT: Faculty/Research Exchange Program

As noted in the education section of the MIT Portugal 2006-2011 Final Report, a very successful feature of the MIT Portugal network has been the faculty/research exchange program. This program allows Portuguese faculty to spend a significant amount of time at MIT as Faculty Fellows (29 of them to date – see table below) - in order to work closely with their MIT colleagues, make or expand valuable professional networks (both academic and research), develop specific skills that are essential for them to teach new courses and modules that were developed collaboratively with MIT within the MIT Portugal Program, and to absorb the culture of MIT's rich academic and research environment. MIT Portugal Faculty Fellows have engaged with MIT colleagues in a range of pursuits – from nano-technology to malaria and neurodegenerative diseases to Design Lab and Innovation Teams.

In addition to those positions made directly possible through the program (see chart above), one of the most outstanding achievements of the MIT Portugal Program has been attracting high caliber young faculty and supporting their efforts to establish innovative teaching and research activities in Portugal. An excellent example of this is Lino Ferreira, who received the prestigious Crioestaminal Prize in 2008. Dr. Ferreira is an MI Portugal Program Bio-Engineering faculty member and Assistant Researcher affiliated with the Center for Neuroscience and Cell Biology (CNC) at the University of Coimbra, and Biocant (a biotechnology park) – as well as a former MIT postdoctoral fellow. The Crioestaminal Prize is awarded in recognition of the best biomedical basic research project carried out in Portugal each year, and Crioestaminal, S. A. is also an industrial affiliate of the MIT Portugal Program.

Faculty exchanges that permit Portuguese faculty to spend time at MIT working on a range of research challenges together with their MIT colleagues are critically important in building the human capacity and connections needed to make the program a success and have the expected impact. Two good examples of this type of exchange were Professors Joao Sousa and Joao Claro, who came to MIT during sabbatical stays specifically to be exposed to engineering systems approaches and practices. Another excellent example of successful faculty exchange is the eleven Portuguese faculty that have visited MIT to take part in the MIT Entrepreneurship Center's Innovation Teams course – in which students develop commercialization strategies for cutting-edge technologies – and to bring lessons learned back home to their respective Portuguese universities.

Table 8 - MIT PORTUGAL Faculty Felows

MIT PORTUGAL Faculty Fellows						
Researcher		**Dates of Visit**		**MIT Host**		
Name	**University**	**Start**	**End**	**Person**	**Focus Area**	**Subject of Research/visit**
Aguiar Oliveira, Ana Isabel Ricardo	New University of Lisbon	6/15/2007	12/10/2007	Paula Hammond	BioEngineering	Sabbatical: chem engineering
Alves, Paula	New University of Lisbon	7/1/2009	9/1/2009	Danny Wang	BioEngineering	iTeams/Danny Wang research lab
Bernardo, Carlos A. A.	University of Minho	4/26/2009	6/15/2009	Joel Clark	EDAM	Sabbatical: EDAM research interactions
Carvalho, Patricia	Technical University of Lisbon - IST	9/1/2008	8/30/2009	Subra Suresh	BioEngineering	Cell and molecular mechanics in human diseases
Claro, Joao	Porto	8/25/2008	12/19/2008	Richard DeNeufville	Engineering Systems	Building relationships with ESD faculty,furthering his understanding of EngSys for transfer to PT university context
da Silva, Claudia Lobato	Technical University of Lisbon - IST	Fall 2008		Dava Newman	BioEngineering	Stem cell research
Duarte, Jose	Technical University of Lisbon - IST	9/1/2009	6/1/2009	William Mitchell	Energy	Design Lab
Ferreira, Frederico	New University of Lisbon	9/7/2009	12/5/2009	Cooney/Newman	BioEngineering	iTeams
Lages, Luis Filipe	New University of Lisbon	3/5/2007	5/31/2007	Dava Newman	BioEngineering	iTeams
Lages, Luis Filipe	New University of Lisbon	1/17/2010	7/31/2010	Charlie Cooney	BioEngineering	Sloan Lisbon MBA program
Lages, Carmen	ISCTE	1/17/2010	6/1/2010	Cooney/Newman	BioEngineering	iTeams

MIT PORTUGAL Faculty Fellows						
Researcher		**Dates of Visit**		**MIT Host**		
Name	**University**	**Start**	**End**	**Person**	**Focus Area**	**Subject of Research/visit**
Llussa, Fernanda	New University of Lisbon	1/29/2009	5/15/2009	Dava Newman	BioEngineering	iTeams
Lopes, Louisa	New University of Lisbon	9/1/2009	12/20/2009	Cooney/Newman	BioEngineering	iTeams
Prazeres, Miguel	Technical University of Lisbon - IST	3/1/2007	4/30/2007	Dava Newman	BioEngineering	iTeams
Rodriquez, Ligia	University of Minho	Spring 2008		Kris Prather	BioEngineering	iTeams
Rocha, Luis	University of Minho	3/8/2009	6/20/2009	Chris Magee	EDAM	Collaborative research and EDAM course development
Rocha, Isabel	University of Minho	3/1/2007	4/30/2007	Bruce Tidor	BioEngineering	iTeams
Silva, Carlos	Technical University of Lisbon - IST	10/6/2008	10/31/2008	David Marks	Engineering Systems	Collaborative research and EngSys and Energy networking
Saraiva, Pedro	Coimbra	3/1/2007	6/10/2007	Dava Newman	BioEngineering	ITeams
Sousa, Joao	Technical University of Lisbon - IST	9/1/2008	6/31/2009	Daniel Roos, Richard Larson	Engineering Systems	Building relationships with ESD faculty,furthering his understanding of EngSys for transfer to PT university context
Simoes, Ricardo	University of Minho	3/1/2007	4/30/2007	Chris Magee	EDAM	Collaborative research and EDAM course development
Silva, Arlindo	Technical University of Lisbon - IST	5/11/2009	9/1/2009	Chris Magee	EDAM	Collaborative research and EDAM course development

4 Technology Diffusion, Transfer and Commercialization

Throughout the Program we developed and refined multiple innovation activities geared mainly to education and, through Innovation and Entrepreneurship Initiative (IEI), to venture formation. Despite the fact that these activities grew organically as distinct experiments in the separate areas of MIT Portugal Program, that is, there was no holistic approach to innovation in MIT Portugal Program, we learned how to adapt lessons from the MIT innovation ecosystem to Portugal. At the conclusion of MIT Portugal Program, we feel that we have developed and transitioned curriculum, events, and activities that will continue to foster innovation as theme within the PhD and Executive Masters programs of participating Portuguese universities, have initiated a national-level venture competition to bring investors and industry into MIT Portugal Program activities, and have established collaborations that are the foundation for successful collaborations going forward.

4.1 Main participants and agents of change

Contributions to the Innovation program are the product of a broad collaboration among multiple faculty and entities within MIT, and Portuguese Universities. Innovation activities were led by Professor Charles L. Cooney, Robert T. Haslam Professor of Chemical Engineering at MIT, and Founder and Faculty Director of the Deshpande Center for Technological Innovation at MIT, and Dr. Luis Perez-Breva, research scientist and lecturer, and co-faculty director of MIT I-Teams. In Portugal, innovation activities were led by the following faculty: Isabel Rocha, and Ligia Rodrigues (U Minho), Pedro Saraiva (Coimbra), Luis Filipe Lages, Fernanda Lluça (Nova), Frederico Ferreira, Miguel Prazeres, Rui Baptista (IST), Jose Manuel Mendonça (Porto). Additionally, the following faculty from Portugal and MIT supported the innovation activities in some capacity (Manuel Mota, Manuel Nunes da Ponte, Antonio Cunha, Dava Newman, Ken Zolot).

The entities that have supported and participated in the MIT Portugal Program-IEI are ISCTE-IUL, ISCTE-IUL's AUDAX center for entrepreneurship, MIT Sloan Entrepreneurship Center, MIT Deshpande Center for Technological Innovation, and the MIT Portugal Program. The IEI is led by ISCTE-IUL Professor José Paulo Esperança, Professor of Finance and Dean of International Relations at ISCTE-IUL, Founder and Chairman of the Audax Centre for Entrepreneurship; Professor Edward B. Roberts, David Sarnoff Professor of Management of Technology, MIT Sloan School of Management, Founder and Chair of the MIT Entrepreneurship Center; and Professor Charles L. Cooney, Robert T. Haslam Professor of Chemical Engineering at MIT, and Founder and Faculty Director of the Deshpande Center for Technological Innovation at MIT, and MIT Professor Daniel Roos, MIT Director of the MIT Portugal Program. José Estabil, IEI Program Director at MIT, Gonçalo Amorim, Project Director at Audax / ISCTE-IUL, and Catarina Madeira (ISCTE) oversee day-to-day activities. Additionally, Professor Fiona Murray, the Sarofim Family Career Development Professor, Sloan associate professor and associate director of the MIT Entrepreneurship Center; and Dr. Luis Perez-Breva, research scientist – who are the co-faculty directors of MIT I-Teams—contributed significant design to an interactive "go-to-market workshop", and Dr Luis Perez-Breva contributed to the architecture of the venture competition.

4.2 Main activities

We developed, delivered and transitioned to local faculty three courses, we trained Portuguese faculty on the pedagogy behind i-Teams, we designed events that support the connection between these courses and the local community, and in MIT Portugal Program Year 4 we initiated a venture competition. Innovation activities were hosted by Bioengineering, EDAM, and IEI.

- ***I-teams:*** We adapted i-Teams to Portugal as a two-stage approach:
  - *Innovation Leadership module*: A two-week action-based introductory module on innovation early on in the program empowers students with a can-do attitude and basic skill-set to engage in a hypothesis-driven exploration of technology impact. The course was designed as a "crash course" to MIT's approach and attitude about innovation. Content on basic business skills, interaction in academia, market exploration, innovation management, or IP, was used as adequate given student backgrounds. The course succeeded in opening student eyes to the process of innovation: bridge from research to society, connect real problems and communicate innovations to a broader audience.
  - *Bio-teams:* a semester long course in which teams of students explore the go-to-market feasibility of current Portuguese technologies. The course implements i-Teams concepts in a unique set-up: students are in different Portuguese locations based on their ongoing research projects, they meet three times in the same location that coincide with events, and have mentoring, milestones, and lectures throughout the semester.
  - Bioengineering and EDAM implemented variants of the innovation leadership course. Additionally, we designed content for a pre-module to introduce students to the full innovation program and the value of IP and, in connection with IP, the danger and inadequacy of plagiarism. Over 400 students, faculty, guest lecturers, and audience guests, have participated in BioTeams and EDAM's innovation classes to date.
  - Bio-teams host the community in three events: to select technologies for the course, gather feedback in the mid-terms and showcase the final results.
  - Innovation in bioengineering has had immediate impact on how students approach and understand technological innovation. As an example, Cell2B is a recently incorporated and funded biotech startup based on Portuguese technology, developed by students from the first cohort of the program in parallel with their PhD studies, and participated in the inaugural Venture Competition.
- ***Venture Competition:*** In Y4 (through IEI with ISCTE) we designed and implemented a venture competition. The competition attracted 100 established and soon-to-be technology companies into an opportunity refinement process that is the competition itself, and has awarded €500,000 to four teams. We hosted the community in three events to showcase the progress of the teams and connected the eight finalists to industry mentors (Catalysts).
  - Future editions will expand on this success to create a unique competition with a strong brand and attract international and MIT Portugal Program entrants.
- ***Visitors at MIT:*** We hosted over 20 Portuguese Faculty in i-Teams at MIT. We shared with them the pedagogy behind our technology innovation courses. Many joined the bio-teams team, some developed new courses borrowing from the pedagogy of i-teams.
- ***Research:*** numerous research projects including one MIT Portugal Program PhD project in innovation in bioengineering addressed the topic of innovation under the MIT Portugal Program I research framework.
- ***6 yearly innovation related Events:*** 3 connected with bio-teams, 3 connected with I-teams.

4.3 Promoting an innovation ecosystem throughout Portugal and MIT: Lessons Learned

The following bulleted list summarizes the main takeaways from the distributed experiments in innovation that characterized the first phase of MIT Portugal

- All ecosystem participants crave action
  - Students are the glue.
    - to overcome prejudices students must learn about innovation and learn to appreciate incentives and opportunities to act and drive their MIT Portugal Program tenure.
    - A significant component of their education is an appreciation of the new attitude required to engage in innovation and put to use the skills they learn through their concentration areas.
  - Faculty want to engage in innovation events and activities that help associate incentive and opportunity and engage with industry
  - Community engages with faculty and students when there is
    - a concrete purpose (educational or domain-specific) in which they can have an active role.
    - a powerful brand backing a broader purpose such as MIT Portugal – IEI venture competition.
- The closer the connection with researchers and industry, the stronger the result.
  - Connections feed from the association of incentives and outcome, the knowledge surrounding the IP, and the synergies between researcher and industry.
  - Portuguese TTO support and leverage the ”business development” inherent to this closer relationship
  - The articulation of the interaction with the TTOs must address the above items to navigate the boundary between a knowledge and an IP economy.
- Ecosystem participants develop ideas in the context in which they connect.
  - If students meet in MIT Portugal Program activities their collaboration is more likely to have an MIT Portugal Program focus.
  - If students practice their new skills together in an interdisciplinary innovation project their collaboration is likely to yield technology innovation.

These lessons and the observations we made through the first phase of MIT Portugal lead us to formulate a hypothesis about the purpose of innovation in the creation of a long-lasting connection between industry and academia in which students and alumni act as a vehicle to disseminate and communicate technology innovation to Portuguese society:

> *Students that use MIT Portugal Program to explore and steer their careers are more likely to develop a long lasting Program affiliation reinforced by the connection with industry acquired through their participation in innovation and to look back to MIT Portugal Program for innovations.*

This hypothesis and the experience we (Luis Perez-Breva and Charles Cooney) acquired through our involvement in all these activities, leads us to believe there is an opportunity to consolidate these lessons through the implementation of coordinated and interlocking innovation activities for the purpose of establishing, in Portugal, a lasting channel for innovation and communication that can stimulate action-oriented participation from the ecosystem inside and outside academia and research laboratories, one that outlasts a programmatic connection between Portugal and MIT. We urge to act on this opportunity. Table 8 enumerates the innovation activities we created in MIT Portugal, their description, and the lessons we learned.

Table 8 - innovation activities developed in the context of the MIT Portugal Program

Innovation Activities		Description	Key Lessons
Bio-engineering	Innovation module	Designed as an "innovation leadership" action-based 2-week course for students to appreciate how to use existing and new skills, network, and intellectual property to build innovations out of technology research and engage effectively with the ecosystem to test their hypotheses of impact. The goal is to empower students to approach innovation with a can-do attitude with a quick overview of business basics, interaction with academia, and interaction with the market as pertinent for the development of technology innovations, and referred to Portuguese reality. Inspired in part in i-teams, the course uses different content to fit a two week schedule and is conceived as an introduction (with a short and well-bound project) to a longer project-based innovation activity (bio-teams or IEI)	• Critical to awaken in the students the entrepreneurial and can-do spirit that is a given at MIT. Helps students replace critique by action. • Helps strengthen bonds in a cohort of students and connect with previous cohorts • Can be used as an introduction to technology innovation in all areas and adapted to different mixes of with different mixes of students (engineers, MBAs scientists, …) • Students highly praise the high level of interaction with faculty on which this course is based.
	bio-teams	Adapted from i-Teams at MIT: student teams use a semester to explore go-to-market strategies for current Portuguese technologies, and work with the PI, a volunteer from the community, and coaching from faculty. Faculty identifies candidate technologies and let students form teams competitively around these technologies based on common interest. Lectures alternate with team time and throughout the semester. Deliverables are designed as milestones to advance in the project. Unlike i-Teams, bio-teams is a "virtual/distributed course" students are not co-located geographically.	• Mechanisms to coordinate students that are not co-located, with "distributed" lectures and faculty. • Due to already distributed nature, course can be scaled up to a larger number of students, for instance from different concentration areas. • Exposure to brief innovation leadership course is critical for students to engage effectively in distributed course
EDAM	Innovation Management 2-week course	This is a variant of the innovation module of bioengineering. In the first week, students receive theoretical content on innovation management. In the second week (normally a few months later) students engage in teams in an action-driven exercise to find a path to commercialization for a Portuguese technology. Students are given an extra month to finish the project before turning in a brief report. EDAM has a semi-professional curriculum with professional master and PhD students.	• The separation of the module in two sessions few months apart is a barrier to empower students. • Two weeks of interaction is not enough for students to engage in large projects. Papers that lead to a technology startup or other well-bound projects would more suitable. • The mix of professional and full-time students has to be managed carefully due to different time availabilities. • Doing an action-based innovation module close to the end of the program reduces the attention and time of students to engage in the project.
	Connection with UTEN and TTOs	Technologies used in the innovation module of EDAM were sourced from the different TTOs in coordination through UTEN. Representatives from TTOs presented the technologies to students to guide team formation. Additionally, resources from these offices were made available to students to analyze the IP and as a repository of the ongoing efforts to license or commercialize the technologies.	• The connection with UTEN is desirable but requires additional effort to seek the engagement of PIs as a resource for the students. • Direct participation of UTEN seems to bias students towards commercialization (license/startup) rather than assessing "what to do with the technologies" through hypothesis driven exploration of the market.

Innovation Activities		Description	Key Lessons
Events	3 events IEI 3 events per year in bio-teams	From the perspective of a member of the Portuguese innovation community, there are numerous opportunities to engage with technology innovation and entrepreneurship efforts already. Each event, however, has a different profile and represents a different means to engage in innovation activities within MIT Portugal Program.	• A "map of events" will help coordinate outreach and direct the community to the events that best match their participation interest. • Events are an opportunity for students to practice and exhibit their skills, a showcase of MIT Portugal Program technologies and efforts, but also mean to attract the community towards MIT Portugal Program. • Participants benefit most of these events with training on "navigating" the events with a purpose, for outreach, networking, and other non-technical skills.
IEI venture competition	Architecture and design of competition	The venture competition is currently a three stage process to filter participating projects until a grand finale winner is selected. Selection at each stage is mostly done by committee. Resources are made available to participants in the form of coaching, short seminars, etc. The architecture of the competition is still under refinement. The target audience for the competition is international teams (from and beyond MIT Portugal Program), ranging from existing companies to research projects seeking to "leave the lab".	• The stage-gate metaphor for the competition may be a missed opportunity to popularize the brand and get a more active engagement from teams • The mix of established companies and early projects is highly desirable. It requires refinements to the competition to bring all competitors to equal footing. Particularly, on the design of activities, competition progression, and awards • Additional outreach to community and to potential projects (especially within MIT Portugal Program) is desirable to establish the competition as an innovation activity of MIT-Portugal and a beacon to attract participation from the broader community beyond MIT Portugal Program. • IEI can be a community forming endeavor, which attracts an innovation ecosystem towards MIT Portugal Program.

	Curriculum development	There was substantial curriculum development based on i-teams and other experiences in MIT Portugal Program and at MIT that went in parallel to the multiple refinements of the first year of the competition. The goals are akin to those stated for the innovation module: inspire a can-do attitude and adapt to the Portuguese reality the entrepreneurial and direct spirit that is commonplace in similar activities at MIT.
		Much of the curriculum development, in the form of short seminars, events, and competition milestones will be implemented and refined in future editions.
			• Seminars and the structure of milestones throughout the competition is critical to
			  ○ direct entrants at research project level towards venture formation quickly
			  ○ inspire entrants that already have a company to communicate effectively goals that are ambitious and feasible.
			• Several participants noted they expect these courses to embrace the "MIT entrepreneurial spirit".
			• International entrants expect English.

	Practices to engage ecosystem	We developed numerous practices to engage the local community in the events of the competition, the selection committees and coaching activities. These are still under refinement, particularly, to increase international participation in the competition.	• Catalysts and mentors are critical to level the playing field across participants and gain access effectively to a broader community. • Involvement from US based catalysts has proven useful for teams to develop an international strategy. • When participants to engage directly with the community they improve their project and indirectly, broader competition outreach.

Innovation Activities		Description	Key Lessons
Research	1 PhD in technology innovation	There have been numerous research projects involving MIT Portugal Program- funded students to study different aspects of the program, innovation, and policy impact. Among these, there is at least one PhD in innovation in bioengineering.	
at MIT	Visiting faculty from bioengineering and other areas.	Over 20 of the faculty visitors on campus have sought involvement with i-Teams and innovation activities on campus. They have been offered full participation in i-teams with students, sessions to discuss the objectives and set-up of i-teams within the broader ecosystem, and occasionally to become part of the staff of the course for their visit. The purpose of their participation is to share pedagogy of i-teams and experience first-hand the results of it from the faculty and the student perspectives.	• The visitor program has been critical in the implementation of bio-teams in Portugal. All participants in innovation educational activities in Portugal have experience i-Teams on campus and remain in contact for i-Teams.

4.4 Innovation and Entrepreneurship Initiative

This new program aims at providing unique support and spotlight on new ventures and teams with emerging technologies that may have considerable economic impact to the Portuguese economy and international growth prospects. The main thrust of the program is a venture competition whose emphasis is to focus and educate select teams on Go-to-Market best practices, and leverage seasoned volunteers' (Catalyst) experiences and access to an international marketplace. We call our competition the ISCTE-IUL MIT-Portugal Venture Competition.

The unique features of the Venture Competition position it to focus on new venture creation in the context of Portugal and international markets; the design can be attributed on the one hand to over 20 years of the MIT100k business plan competition accumulated experience, and on the other to bottom-up research carried out with (i) CEO's of recent Portuguese tech start-ups, (ii) existing competition finalists and (iii) seasoned investors & entrepreneurs.

The resulting unique features of the Venture Competition can be summarized as follows:

1. The largest to date in financial support (up to 1M€) and in kind services to 4 finalist teams;
2. Foster entrepreneurial attitude and learning by doing and align incentive with results - half of the financial support is earmarked upon selection (500.000€) and the other half upon execution by fulfillment of mutually agreed upon milestones;
3. Unique educational experience through hands-on boot camp for entrepreneurship teams (building on MIT i-Teams), provided by ISCTE and Sloan specialist staff;
4. A unique catalyst program for semi-finalists through the first 9 to 12 months of venture phase of lawyers and functional area managers from leading Portuguese companies, complemented by seasoned MIT/Boston entrepreneurs & investors for Finalists;
5. Network and industry linkages to MIT venture ecosystem through the invitation of Finalists to participate in IdeaStream investor's presentation.
6. Parallel competition in four emerging technology tracks

Such uniqueness has contributed to the origination of success stories in entrepreneurial high tech start-ups or university spin-outs, along with the envisaged MIT Portugal Program-IEI objectives.

The quality and quantity of the submissions to the Venture Competition, and the strong interest of participating new ventures makes us cautiously optimistic with the outlook for the inaugural year of the MIT Portugal Program-IEI.

Commenting on the nature of the Venture Competition, Dr. Luis Reto, Dean of ISCTE-IUL, stated, "This competition and award is designed in an innovative way in order to put a great emphasis on the post-award, i.e. the venture phase, including the creation of conditions conducive to global projection of the selected companies. With this, we intend to open new frontiers to the competition's candidate projects, enhance the internationalization of the winning projects from their inception, through the contribution of members of the international jury and global information networks. Thus, the projects will be geared to truly global markets via networks of collaboration between MIT and Portugal. Because of this internationalized stance these projects are already attracting interest from foreign investors in capital projects carried out in Portugal".

We are happy to report that we met and exceeded the IEI program goals, as represented in table 9.

Table 9 – IEI Program goals

Year 1 Plan	Actual
The development of a national competition in Portugal to create new business ventures out of emerging technologies ("New Technology Ventures Competition"), in close cooperation with the MIT Portugal Program	ISCTE-IUL / MIT Portugal Venture Competition - launched March 2010 (on time) - at Grand Finale stage (10/27)
The support of the Innovation Teams initiative in Portugal through the MIT Portugal Program	Innovation Teams inspired class developed as special Boot Camp training element for Track Finalists and Honorable Mentions
The design and implementation of a series of meetings and events to showcase technological innovation in Portugal, in close cooperation with the MIT Portugal Program	From an initial Venture Competition selection event, three (3) events have been planned to highlight early stage technology company prowess and showcase university spin-outs. Track Finalists will be invited to MIT to participate at IdeaStream.

Specifically the IEI have:

- Adjusted focus of IEI in light of worldwide economic challenges to promote on knowledge-economy economic development
- Architected and launched a multi-year, multistage Venture Competition designed to be a sustainable and perpetual competition
- Venture Competition attracted a total of 95 early stage ventures and enrolled over 360 participants from Portugal, UK, and USA
- Launched several venues to connect "Innovators with Investors"
    - Venture Competition Semifinals 7/7/2010
        - Keynote: Jonathan Medved, CEO Vringo, and Founder, Israel Seed Partners
        - Portuguese Catalyst "Speed-dating" venue with Semifinalists

- eTeams Bootcamp
  - Hosted twenty (20) early stage high-tech teams at ISCTE-IUL for a 3-day entrepreneurial boot-camp
- Venture Competition Track Finals 9/30/2010
  - Keynotes:
    - Manuel Heitor, Portugal Secretary of the State of Science and Technology
    - José Epifânio da Franca, Co-Founder and Ex-CEO of Chipidea
- Venture Competition Grand Finale 10/28/2010
  - Keynotes:
    - Prof. Douglas P. Hart, Professor of Mechanical Engineering at MIT, cofounder Brontes Technologies, Inc. (acquired by 3M in 2006), and Lantos Technologies
    - Dr. Andrey Zarur, Manager Partner, Kodiak Ventures
- Venture Competition Business Development Bootcamp 4/11/11 – 4/15/11
  - Developed 4 networking venues with over 200 founders of US-based companies in the greater Boston area
    - MIT Portugal Founders Reception (w/MIT Enterprise Forum, Cambridge)
    - MassChallenge networking lunch
    - Cambridge Innovation Center Venture Café, networking featured guest
    - MIT IdeaStream Innovation Session
  - Hosted and staffed 10 business development interactive sessions with leading MIT and well-known Boston-based entrepreneurs. Highlights:
    - "5 Successful traits of Startups", J. Hadzima, MIT Sloan lecturer and CEO/ IPVision
    - "MIT Innovation Tour", J. Bronsen, MIT lecturer, MediaLab
    - "Entrepreneurial Marketing", W. Aulett, Exec Director, MIT Entrepreneurship Center
    - "Sales for the Technical Founder", M. Roberge, VP Sales, Hubspot (fastest growing US based company, 4Q2010)
    - 1-on-1 Value Proposition Coaching, Prof. F. Murray, Sloan and Associate Director, MIT Entrepreneurship Center
    - MIT Enterprise Forum Start-up Clinic
  - Coordinated 3 pitch sessions to Angels/VCs
    - MIT IdeaStream
    - Dogpatch Labs (Polaris Ventures)
    - TechStars (#1 Worldwide Accelerator)
- Secured an award sponsor (Caixa Capital) and €1,000,000 in award commitments
- Created a Catalyst program
  - Allows seasoned industry mentors to interact on behalf of the IEI with teams in the Venture Competition
  - Amplifies leverage of connected venture ecosystems in Portugal and in the Boston area
  - 20 Portugal-based catalysts
  - 10 US-based catalysts
- Garnered multiple media attention reinforcing the "Branding" and authored multiple press releases (see Appendix)
- Launched the MIT Portugal Innovation and Entrepreneurship website (http://mitportugal-iei.org)

4.5 Training Technology Transfer Officers and contributing for the Portuguese University Technology Enterprise Network, UTEN

Competences in technology transfer and commercialization have been systematically developed throughout Portugal and, today, most of the Portuguese universities, Associated Laboratories and research institutions consider specialized technical support fostering technology transfer and commercialization. This movement has been strengthened since 2007 through the University Technology Enterprise Network (UTEN), which comprizes scientific and academic institutions in Portugal oriented to emphasize technology transfer and commercialization at an international scale. This initiative is promoted and supported by the Foundation for Science and Technology (FCT), in close collaboration with the Council of Rectors of Portuguese Universities (CRUP) and the Portuguese Industrial Property Institute (INPI) and involving strategic partnerships with leading institutions worldwide, including MIT-Portugal. UTEN has evolved over the past four years and its mission has being strengthened to help build a professional, globally competitive and sustainable technology transfer and commercialization network in Portugal oriented for markets worldwide.

The joint collaboration between MIT-Portugal and the Portuguese institutions through UTEN started in 2008 and included two main types of actions: I) networking through a specialized workshop and II) on-the-job training of technology transfer officers at MIT.

4.5.1 Workshop "Experiencing technology transfer: Fostering a new dialogue with MIT"

Held from 29-31 March, this event was hosted by the Instituto Superior Técnico, IST (Technical University of Lisbon) and with the collaboration of the the Luso American Foundation (FLAD). The main objectives were to share MIT's experiences, to train and mentor less experienced attendees, and to encourage cross-group communication & learning among all Portuguese participants. This event brought MIT experts to discuss technology transfer and commercialization, and to explore successful case studies of technology-based university spin-out companies. It attracted more than 70 participants from technology transfer officers to researchers, college professors, and technology-based entrepreneurs. The workshop provided a strong, practical educational component that focused on commercializing and transferring technologies from the university to industry, and was divided into three parts:

1. Stimulating knowledge creation & entrepreneurial activities
2. Building and supporting entrepreneurial activity and academic/industry collaboration
3. Reaping the benefits of knowledge creation

The audience was drawn from UTEN's nationwide network of Portuguese universities, technology parks, and incubators, as well as select Portuguese intellectual property (IP) professionals and civil servants. Attendees exchanged ideas, and established connections as they continued the UTEN workshop series. Case studies of three successful Portuguese university spin-out companies were presented: Outsystems, represented by *Paulo Rosado*; CEV, represented by *Sara Monteiro*; and Critical Materials, represented by *Gustavo Dias*.

MIT presenters included *Dan Roos* (Director of MIT|Portugal), *Tony Knopp* (Senior Industrial Liaison Officer, MIT's Industrial Liaison Program), *Charles Cooney* (Professor of Chemical and Biochemical Engineering), *Lita Nelson* (Director Technology Licensing Office), *Ken Morse* (Senior Lecturer, Managing Director, MIT Entrepreneurship Center), *Karl Koster* (Executive Director, MIT Office of Corporate Relations/Industrial Liaison Program), and *Jack Oldham* (Director, Foundation Relations & Academic Development Support). Portuguese experts included *Teresa Mendes* (Pedro Nunes Institute), *José Carlos Caldeira* (INESC Porto), *Susana Barreiros* (Universidade Nova de Lisboa – New University of Lisbon), *António Cunha* (University of Minho), *Carlos Matos Ferreira* (Instituto Superior Técnico) and *Carlos Costa* (FEUP).

4.5.2 On-the-job training of technology tranfer officers at MIT

Under the scope of the international internships program for technology transfer officers (TTO), MIT hosted two internees during two weeks within the first phase of their internship period. That was the case of:

- *Maria Oliveira*, Director of the University of Porto's TTO, UPIN (University of Porto Innovation), experienced managind European projects and whose key interests at MIT were to deepen knowledge about efficiency of technology management of TTOs, licensing strategies, technology assessment, entrepreneurship support, and IP management.
- *Ana Teresa Pinto*, TTO from the University of Aveiro, experienced in the preparation of business plans and market, research for the commercialization of technologies, promotion of the relationship between university and enterprises (R&D in consortia, research contracts, applications of R&D in consortium funds), and promotion of researchers involvement in TT activities. Ana's key interests for this internship were University-industry liaison, licensing, intellectual property, entrepreneurship, and business development.

These immersions at MIT were supported by the FCT and competitively offered to Portuguese technology transfer managers and staff.

5 Scientific Culture

The MIT Portugal Program, in close partnership with Ciência Viva, has been contributing actively towards the promotion of a scientific culture in Portugal. Ciência Viva's main objective is to bring Portugal's society and science closer together, particularly among young students, by promoting a wide range of activities mobilizing a large number of people, and fostering simple and accessible communication between the parties.

With this objective in mind, MIT Portugal and Ciência Viva have developed several initiatives to foster Portugal's scientific culture, namely: 1) lectures conducted since 2006 by faculty from MIT and Portuguese universities, focused on 1st and 2nd cycle students; 2) promotion of internships for 2nd cycle students at research centers that are involved in the MIT Portugal Program; 3) participation at the Ciência 2008, Ciência 2009 and Ciência 2010, Science and Technology Summits, focused on fostering the public understanding of science and to promote industry-science relationships.

The first initiative, "Professores MIT vão à Escola" (MIT professors go to school), was launched in 2006 at Escola Secundária da Amadora, and had as key speakers Prof. David Marks and Stephen Connors from MIT. The lecturers talked with the audience about renewable energy, and then debated the future of renewable energies in Portugal, with questions asked by students from the Francisco Manuel de Melo School. Also in 2006, MIT professor Dava Newman presented a lecture (*Human Space Flight: from Earth to Mars)* to students from Escola Secundária Emídio Navarro and Escola Secundária Anselmo de Andrade, detailing a project for a new space suit in development at the time.

From 2006 to 2011, 14 "Professores MIT vão à Escola" sessions have been organized jointly by MIT Portugal and Ciência Viva, reaching an audience of more than 2,500 1st and 2nd cycle students. Within this context, several professors have contributed to the dissemination of scientific culture in Portugal, including Dava Newman, António Cunha, Lino Ferreira, John Fernandez, Carlos Silva, David Marks, Larry Young, Paulo Ferrão, James Kirtley, Stephen Connors, Chris Magee, Elly Nedivi, Randolph Kirchain, and Bruce Tidor, among others.

The most recent session of the "Professores MIT vão à Escola" session was held in the morning of 7th of February 2011, where students from the Escola Secundária D. Dinis in Lisbon attended a presentation by the former astronaut, Larry Young. He stressed that keeping a crew of astronauts in shape during a long journey, such as a trip to Mars, requires the creation of artificial gravity. In the afternoon, Larry Young went to the Pavilhão Ciência Viva to satisfy the curiosity of the 1st cycle students from Colégio Aljubarrota, at Amadora, that questioned the astronaut about his profession and other curiosities of space.

The development of summer internships for 2nd cycle students in Portuguese research centers has been another of the activities developed jointly by Ciência Viva and the MIT Portugal Program. Within this scope, the program aims to provide young students a summer internship at a research center involved in the MIT Portugal Program, during which they may participate in a range of research activities and also develop their own projects.

Altogether more than 30 summer internships have been organized for 2nd cycle students in the School of Engineering of the Minho University and the Institute for Biotechnology and

Bioengineering at IST/UTL. At the School of Engineering of the Minho University, the internships were focused in the following areas: 1) Charge transportation by teams of mobile robots; 2) Polymers – how are they processed? and what are their properties?; 3) From Electronics to Medicine: vital sign measurement, 4) The study of inertial sensors; and 5) Development of an electronic compass.

At the Institute for Biotechnology and Bioengineering, the internships were focused in the following areas: 1) Stem Cell Bioengineering; 2) Biocatalysis and industry; 3) Production and purification of DNA vaccines; 4) Molecular microbiology and functional genomics; and 5) strategies for the production of bioethanol.

Aiming at fostering the public understanding of science and to promote industry-science relationships, MIT Program students, faculty and researchers have actively participated at the Ciência 2008, 2009 and 2010 Summits.

Ciência 2008, took place from 2nd to the 4th of July at the Gulbenkian Foundation in Lisbon, gathering several hundred investigators from Portuguese Science and Technology institutions. About 300 publications and thematic sessions where held continuously on four auditoriums over a period of two and a half days.

The newest and most cutting-edge, commercial bio-technologies were among several of the presentations given by MIT Portugal PhD students from the Bio-Engineering Focus Area. For example, twenty-one PhD students in six Bio-Teams delivered presentations of their latest innovations derived from research collaborations with Portuguese universities, companies and research labs.

Ciência 2009, was held on July 29th to 30th also at the Calouste Gulbenkian Foundation in Lisbon, and was organized by the CLA with the support of the Fundação para a Ciência e a Tecnologia (FCT). The event gathered researchers from across the Portuguese scientific community, including many who work at Associate Laboratories. Several of the scientific panels were organized in collaboration with MIT Portugal. The session themes varied from Stem cells, tissue engineering and regenerative medicine; Electric vehicles and new forms of mobility to new materials for new products; and Sustainable energy and transportation systems.

MIT Portugal participated actively at the Ciência 2010 Conference, held July 4-7, 2010 at the Lisbon Centro de Congressos, and organized by the Portuguese Science Foundation (FCT) and the Council of Associated Laboratories (CLA), in association with Ciência Viva. Ciência 2010 edition was marked by the participation of a record 2,500 participants, 150 research units, more than 400 PhD posters, and many university representatives and elected officials. It gathered not only students and faculty but also around 60 companies and research centers, allowing the program to address a wide variety of thematic areas and to foster symbiosis among companies, universities, and research centers.

The MIT Portugal Program presence in Ciência 2010 was highlighted by the posters of 96 PhD students from the Program's four educational areas, as well as several session speakers and moderators. MIT Portugal National Director Paulo Ferrão, Lino Ferreira from the Center for Neuroscience and Cell Biology - CNC, José Viegas and Miguel Tavares da Silva from IST, Vítor Leal

from LAETA, and Luís Rocha from Minho University were some of the faculty that presented sessions in their fields of expertise.

In short, all these initiatives in which MIT Portugal is involved have served to actively promote the scientific culture in Portugal as well as to advance the two-way dialogue between scientists and a more general audience.

Table 10 – Summary of "MIT professors visit high-school" sessions

School	Date	Brief summary of the session
Escola Secundária da Amadora	16 Nov. de 2006	The first session was opened by Rosalia Vargas, Director of Living Science and Paulo Ferrao, coordinator of the Sustainable Energy Systems Focus Area of MIT Portugal, with the presentation of the objectives of this initiative in the Portuguese context. The session on renewable energy was led by David Marks, co-director of the MIT Laboratory for Energy and Environment and Steve Connors, Director of Analysis Group Alternative Energy Regional. Also present at the meeting were MIT professors James Kirtley, Joe Ferreira and John Fernandez. There followed a debate on the future of renewable energy in Portugal with questions from students.
Escola Secundária Emídio Navarro – Almada	21 Nov. de 2006	During the Week of Science and Technology, Dava Newman, MIT Professor of Bioengineering, presented a session on human space flight: from Earth to Mars to the students and teachers of Emidio Navarro Middle School and High School Anselmo de Andrade. The session was also attended by Manuel Nunes da Ponte, in charge of Bioengineering, MIT-Portugal Program, and Manuel Paiva, head researcher for scientific studies in space missions, the Free University of Brussels.
Escola Secundária de Cantanhede	25 Jan. de 2007	Dava Newman (Director of Technology & Policy Program) and Lino Ferreira (researcher at the Center for Neurosciences of Coimbra / Biocant and MIT) presented their work in the area of Bioengineering and answered questions from students. Present were students from Year 12 who showed interest in attending the meeting and pursuing the disciplines of biology and physics. The school has a protocol with Biocant Park, a research and development center in Life Sciences based in Cantanhede, which was also visited by the two professors.
Escola Secundária de Fontes Pereira de Melo, Porto	26 Jan. de 2007	Professors Stephen Connors and James Kirtley spoke about renewable energy, as the school is currently developing a project on this life science area. A group of students and teachers from Ancorense, School of Vila Praia de Ancora, also attended the session, and they recently built a photovoltaic stand presented in an international competition in Australia.
CENFIM - Centro de Formação da Indústria Metalúrgica e Metalomecânica, Porto	10 Out. 2007	Students and teachers received MIT Professor David Marks and discussed issues of sustainable energy.
Escola Secundária Jose Saramago – Mafra	8 Nov. 2007	Students and teachers received MIT Professor David Marks and discussed issues of sustainable and energy.
Escola Profissional Gustave Eiffel – Amadora	15 Nov. 2007	Students and teachers received Professor Randolph Kirchain of MIT, and discussed questions on the automotive industry and manufacturing technologies. This school has a great tradition in the area of robotics.

Escola Secundária Francisco de Holanda – Guimarães	28 Fev. 2008	Professor Chris Magee of MIT, coordinator of the Engineering Design and Advanced Manufacturing Focus Area, attended this session. This school has a great tradition in the area of Robotics, with the support of the School of Engineering, University of Minho. At the beginning of the session, students made a presentation about robots they had developed for the RoboCup 2008 competition.The session was also attended by Prof. António Cunha, Dean of the School of Engineering, University of Minho, who moderated the debate between students and teacher.
Escola Secundária da Amadora e Escola Secundária José Gomes Ferreira, Lisboa – Pavilhão do conhecimento	29 Abril 2008	Middle School students and the School of Amadora Jose Gomes Ferreira Benfica came to the Knowledge Pavilion to attend a session with Professor John Fernandez of MIT, on the theme Cities of the Future.
Escola Secundária Vergílio Ferreira	11 Nov 2008	Students of Middle School Virgil Ferreira received. Stephen Connors of MIT to discuss energy efficiency and renewables.
Escola Secundária Quinta das Flores – Coimbra	21 Jan 2009	Middle School students Quinta das Flores received Professor Elly Nedivi MIT brain scientist working in a group of Bioengineering.
Auditório da Escola Secundária de Camões, Lisboa	12 Jan. 2010	Middle School students received Larry Young, MIT professor of Aeronautics and Astronautics and Health Sciences and Technology and former astronaut.
Escola Secundária Carlos Amarante, Braga	12 Nov. 2010	Middle School students at Carlos Amarante received a visit from MIT Professor Bruce Tidor, researcher in the areas of Computer Science and Electrical Engineering and Biological Engineering.
Auditório da Escola Secundária D. Dinis, Lisboa	7 Fev. 2011	Students of the Dinis School received a visit from Larry Young, MIT professor of Aeronautics and Astronautics and Health Sciences and Technology and former astronaut.

6 Perspectives for the Future

The MIT Portugal Program is envisioned for a long term partnership to invest in high-impact research and novel educational training to significantly impact and enhance human resource development, educational reform, and world-class targeted research in Portugal. The program focuses on knowledge-based industries, fosters university/industry relations, and strives to help create an eco system to foster innovation and entrepreneurship in Portugal. The MIT Portugal Program is MIT's largest international program in Europe and the first program involving partnerships with many universities in the host country. All other MIT international programs involved only one or two universities in the partner country. The design of a long term program recognizes that for the full impact of the overall program on economic and societal development to be realized it requires a dynamic and flexible vision to adopt the lessons learned, which should thus inform the continuation of the MIT Portugal Program.

RESEARCH LESSONS

Develop a Few Large Scale Programmatic Research Initiatives - The program began by funding a diverse set of research projects in all four focus areas. Midway through the five-year program a decision was made to focus on a few application areas which would have the greatest impact. For example, in bioengineering systems the selected potential high-impact application area of Stem Cells and Regenerative Medicine was identified. This focused approach realizes advantages of larger, coordinated, and more impactful research. Research in Energy and Transportation Systems realizes considerable synergies and interconnections, which should be fostered.

System Thinking is an essential cross-cutting foundation for research success and impact in complex engineering systems; therefore, engineering system principles were introduced across the MIT Portugal Program. This systems thinking theme along with innovation in technological systems serve as foundation for the synergistic educational and research within MIT Portugal. Best examples in MIT Portugal include synergistic research and education with faculty fully committed to both teaching and research activities of MIT Portugal.

Programmatic Research Calls for the continuation of the program are envisioned in three research areas, initially, to span the entire five-year period, with a midway review to determine the research impact, success of collaboration and any necessary changes. High-priority research in Regenerative Medicine, Energy and Transportation Systems and Integrated Product Design have been identified.

The most successful projects have important stakeholder involvement involving industry, or others, in a collaborative team with faculty and students. Successful applied research, typically had industrial support although collaborations in bioengineering to hospitals and in transportation to public sector organizations were critical components for success.

Research Networks were formalized in Stem Cells, Energy and Transportation and Biomedical Devices to facilitate critical size and to attract research excellence. These research networks provide a mechanism for members to work with one another and to collectively plan large-scale national initiatives as well as to compete within the European Union for research support.

Foster Government Industry Interaction on National and International Policies- The Bioengineering Systems area holds yearly forums bringing together senior individuals from government, industry and universities from Portugal, the EU, UK, North America, and Asia to discuss the implications of MIT Portugal research. As such, the program acts as an “honest broker” to help government and industry explore complex policy concerns stemming from technological breakthroughs. These successful forums can be scaled across the program.

An entrepreneurship ecosystem is necessary to foster innovation and effective technology transfer, and this was promoted with assistance from UTEN and ISCTE. MIT sent leaders from MIT innovation and entrepreneurship offices to UTEN sponsored events Portugal to provide assistance in formulating the Portuguese ecosystem. Future collaboration with the Portuguese universities and research institutions through the University Technology Enterprise Network (UTEN) will follow the accumulated experience so far and will take a step forward in the promotion of technology transfer and commercialization activities within the Portuguese research institutions. Most conspicuously, MIT-Portugal will participate in the following main actions, reflecting its goals and the strategy of this network:

- International internships at MIT, namely at the office of MIT's Industrial Liaison Program, the Technology Licensing Office, the MIT Entrepreneurship Center, the Deshpande Center for Technological Innovation and other relevant hosts at MIT;
- Networking – thematic workshops, training weeks, in-situ training, leaders roundtables and initiation brainstorms with students, annual conference, including various events during the years to come;
- Technology ventures competition, by strengthening the IEI venture competition with ISCTE-IUL;
- International business development, fostering the access of new Portuguese technology-based ventures to global markets;
- Observation, assessment, reporting, and annual conference.

Annex

Information on the Research Call Process and Project follow-up

General Information

2008 Call – Facts

Call Opened on: July 15th 2008

Call Ended on: October 15th 2008

Number of research areas calling for projects: 4

- Bioengineering Systems
- Engineering Design and Advanced Manufacturing
- Sustainable Energy Systems
- Transportation Systems

Supporting Documents issued by the Program Coordination:

- Edital - 2008 call for funding in the framework of the MIT|Portugal Program http://alfa.fct.mctes.pt/apoios/projectos/concursos/mit/2008/
- Terms of Reference for Bioengineering Systems
- Terms of Reference for Engineering Design and Advanced Manufacturing
- Terms of Reference for Sustainable Energy Systems
- Terms of Reference for Transportation Systems
- Suggested Modifications to the on-line application form (adapting it to MIT Portugal Program context)
- Frequently Asked Questions

Recruitment of Applicants:

In order to disseminate the call for projects and recruit potential applicants, two informative sessions were given: one in Lisbon, and the other one in Aveiro. The presentations were given by the Direction of the Program and the different focus area leaders/delegates.

- LNEC: Jul 23rd 2008
- University of Aveiro: Jul 29th 2008

Number of Applications Received: 40

Total of Funding Requested: 7.737.902,00 €

Evaluation Panel:

- Henk Sol (Coordinator)
- Jeremy Gregory (Evaluator)
- K. Dane Wittrup (Evaluator)

- Kenneth M. Strzepek (Evaluator)
- Lawrence G. Miller (Evaluator)
- Mort Webster (Evaluator)
- Ralph Gakenheimer (Evaluator)
- Robert Skinner (Evaluator)
- Sebastian Fixson (Evaluator)
  http://www.fct.mctes.pt/Evaluation/contents/C0301/PainelNetEspecificos/default2.asp?ID_ElemPainel=4107

Number of accepted projects: 14

- 4 Excellent
- 10 Very Good

Acceptance ratio: 35%

Date of Confirmation: March 12th 2009

Applicant Institutions: 14

- EE/U Minho
- FCT/UC
- FCT/UNL
- FE/UP
- FFCT/UNL
- ICS/UL
- INESC Porto/FEUP
- IST/UTL
- IST/UTL (IDMEC)
- IST/UTL (IN+)
- ITQB/UNL
- LNEC
- U Aveiro
- UBI

Applicant Industrial Partners: 32

- ALSTOM Transport
- APVE
- BAE
- BioDevices, Sistemas de Engenharia Biomédica, S.A.
- Biotempo, Lda
- Biotrend, SA
- CEIIA
- Delphi
- Delta

- ECBio
- Edia
- EDP
- EDP Inovação
- Efacec
- FiberSensing
- GALP
- Hospital S. João
- Hovione
- Iber-Oleff
- INAC - Instituto Nacional de Aviação Civil IP
- INiR, Tranquilidade, PRP
- Inteli
- ISA, S. A.
- MacLaren Electronics
- Petratex
- Plux
- QUERCUS
- Simoldes
- STCP
- Sunviauto
- TMG
- Volkswagen Autoeuropa

Other non-MIT international consultants:

University of Antwerp (UA)

Total of FCT funds allocated to these projects: 2.881.486,00 €

Source of FCT funding: PIDDAC 2009: budgetary program 002: measure 05: projects 3599 and 5876

Total of non-FCT funds allocated to these projects: 617.820,00 €

- Own Funding: 100.000,00 €
- Other Private Funding: 517.820,00 €

MIT involvement: 23 Faculty/Students

- Amedeo Odoni
- Brian Wardle
- Bruce Tidor
- Chris Zegras
- Cynthia Barnhardt
- Dava Newman

- Diana Young
- Dianne Newman
- Dina Katabi
- Hugh Herr
- John Fernandez
- Linda Griffith
- Marta Gonzalez?
- Minji Kim
- Moshe Ben-Akiva
- Muriel Medard
- Nancy Leveson
- Paula Hammond
- Qi Hommes
- Qui Holmes
- R Roth
- Richard de Neufville
- T Wierzbicki

MIT Portugal Program Students' involvement: There are MIT Portugal Program students involved in at least 8 of the 14 projects approved.

Scholarships requested:	63
• (BCC) Bolseiro Cientista Convidado	3
• (BI) Bolseiro de Investigação (Mestre)	28
• (BI) Bolseiro de Investigação (Lic ou Bach)	7
• (BIC) Bolseiro de Iniciação à Investigação Científica	23
• (C) Contratado	2

2009 Call – Facts

Call Opened on: September 7th 2009

Call Ended on: November 13th 2009

Number of research areas calling for projects: 4

- Stem Cell Engineering for Regenerative Medicine
- Materials & Design Inspired Products
- Sustainable Energy and Transportation Systems
- Engineering Systems Fundamentals

Supporting Documents issued by the Program Coordination:

- Edital - 2009 call for funding in the framework of the MIT|Portugal Program http://alfa.fct.mctes.pt/apoios/projectos/concursos/mit/2009/
- Terms of Reference for Stem Cell Engineering for Regenerative Medicine
- Terms of Reference for Materials & Design Inspired Products
- Terms of Reference for Sustainable Energy and Transportation Systems
- Terms of Reference for Engineering Systems Fundamentals
- Guide for Applicants in 2009 MIT Portugal Program Call
- Research Profile for Partner Search

Number of Applications Received: 31

Total of Funding Requested: 5.945.049,00 €

Evaluation Panel:

- Henk Sol (Coordinator)
- Andrea Hanson (Evaluator)
- António Cunha (Evaluator)
- Bill Rouse (Evaluator)
- Bruce Tidor (Evaluator)
- Cezar Dopazo (Evaluator)
- David L. Greene (Evaluator)
- David Levinson (Evaluator)
- Esteban Chornet (Evaluator)
- G. de la Fuente (Evaluator)
- Hani S. Mahmassani (Evaluator)
- James J. Zucchetto (Evaluator)
- Jeremy J. Michalek (Evaluator)
- João Rocha (Evaluator)
- Joel Clark (Evaluator)
- John Clarkson (Evaluator)
- John Heywood (Evaluator)

- John Woodley (Evaluator)
- Jonathan Seth Dordick (Evaluator)
- José Antonio Puértolas (Evaluator)
- Laszlo Bax (Evaluator)
- Makoto Shimamura (Evaluator)
- Michael E. Hahn (Evaluator)
- Michael Meyer (Evaluator)
- Paulien Herder (Evaluator)
- Peter R. Cavanagh (Evaluator)
- Robert Skinner (Evaluator)
- Roland Clift (Evaluator)
- Rolf Kunneke (Evaluator)
- Srinivas Tadepalli (Evaluator)
- Thomas H. Speller, Jr. (Evaluator)
- Uwe Sauer (Evaluator)

http://alfa.fct.mctes.pt/apoios/projectos/consulta/aavaliar.phtml.pt?iep=7029

Number of accepted projects: 6

Acceptance ratio: 19,4%

Date of Confirmation:

Applicant Institutions: 11

- ADAI-LAETA
- CNBC
- FCT/UC
- FE/UP (INESC-Porto)
- INESC-Coimbra
- ISA/UTL
- ISR-Coimbra
- IST/UTL (CESUR)
- U Coimbra
- U Minho (IBB)
- UTAD

Applicant Industrial Partners: 10

- Critical Move
- EDP distribuição
- EV Iberia
- General Motors
- ISA, S.A.
- Portucel Florestal, S.A.

- Prio Advanced Fuels
- Prio Biocombustíveis
- RAVE
- Stematters

Other non-MIT international consultants:

- Reinhard Madlener (RWTH Aachen University, Germany)
- Étienne Mullet (Institute of Advanced Studies, École Pratique des Hautes Études, Paris,France)
- Robert Stüssi (APVE/AVERE/WEVA)

Total of FCT funds allocated to these projects: 1.181.646,00 €

Source of FCT funding: State Budget or FEDER depending from the region of proponent institution

Total of non-FCT funds allocated to these projects: 135.724,00 €

- Own Funding: 132.893,00 €
- Other Private Funding: 2.831,00 €

MIT involvement: 12 Faculty/Students

- Adam Ross
- Ali Khademhosseini
- Dana Rhodes
- Daniel Livengood
- Jeremy Gregory
- Joseph Sussman
- Randolph Kirchain
- Richard de Neufville
- Richard Larson
- Robert Langer
- Sevara Melibaeva
- Travis Dunn

Scholarships requested: 19

- (BI) Bolseiro de Investigação (Mestre) 14
- (BIC) Bolseiro de Iniciação à Investigação Científica 3
- (BPD) Bolseiro de Pós-Doutoramento 2

Follow-up Meetings

FOLLOW-UP ON CALL 2008 RESEARCH PROJECTS

The 14 research projects approved on the 2008 call for projects in the context of MIT-Portugal Program were jointly presented at a meeting held at FCT on April 1st of 2009.

After this initial meeting, the projects have been grouped in the appropriate target application areas in the Program, and their implementation and development have been followed in regular research meetings.

Generally, it can be said that the projects are timely and expected to be accomplished in a reasonable time. The involvement of both PhD and Master students has been remarkable. The research has been truly collaborative between Portuguese institutions in the team, and most of the times with the MIT. The companies need to be more firmly involved.

Sustainable Energy and Transports Systems

- 1st Meeting: May 14th, 2009, FCT - Activity Plan and Milestones Presentation
- 2nd Meeting: October 28th, 2009, IST-Taguspark - Results Presentation / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)
- 3rd Meeting: May 6th, 2010, FEUP - Project Results of the 1st Year / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)
- 4th Meeting: February 9th, 2011, FCTUC - Project Results to date / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)

MIT-Pt/SES-GI/0008/2008 - Power demand estimation and power system impacts resulting of fleet penetration of electric/plug-in vehicles

- Principal Investigator: Carla Alexandra Monteiro da Silva (IST/UTL)
- http://www.mitportugal.org/2008-projects/power-demand-estimation-and-power-system-impacts-resulting-of-fleet-penetration-of-electricplug-in-vehicles.html
- This project aims to estimate the impact on energy consumption, CO2 emissions and electric power demand resulting of introducing electric and hybrid plug-in vehicles in Portugal and in a specific region (AZORES).
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
    - Report on the project development: tasks 1-6 on schedule (please refer to presentation for details)
    - Project meetings with all stakeholders: 2 so far (September 2009; January 2010)
    - PhD students: 10 MIT Portugal Programs: Patrícia Baptista (IST), Cristina Camus (IST), André Pina (IST), João Lourenço (IST), Rui Bernardo (IST), Jorge Borges (IST), Filipe Sim-

sim (IST), Antero Silva (FEUP), Filipe Soares (FEUP), Pedro Almeida (FEUP); 3 Others: João Bravo (IST), Gonçalo Gonçalves (IST), Ricardo Rei (FEUP)
    - Master students: João Ribau (Masters Mech.)
    - Collaboration with MIT: 1 MIT PhD Co-supervision; 4 MIT PhD Assessment Committee Members
    - Collaboration with industrial partners: good collaboration with GALP not directly through the project but in coincident research issues
    - Effective collaboration with other MIT Portugal Program project: Integrated Systems for Electric Vehicles (Jorge Martins)
    - Outputs: 4 papers on International Journals, 12 papers on International Conferences, 1 Reports (submitted FCT 1 April 2010), 1 Master thesis, 2 Computational applications (PATTS & GRID), 2 posters of divulgation of the project.
    - During this first year the conclusion of the Flores Island case study is highlighted.
    - The project is generally on schedule, has a good degree of MIT Portugal Program students' involvement, and achieved more scientific outcomes to date than expected. Attention should be given on how to attract industry direct engagement.

MIT-Pt/SES-SUES/0037/2008 - Net Zero Energy School - Reaching the community

- Principal Investigator: Carlos Augusto Santos Silva (IST/UTL)
- http://www.mitportugal.org/2008-projects/netzeroschool-reaching-the-community.html
- The NetZero Energy School aims to design and implement energy efficiency strategies in schools, and measure impact on the community / residential.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
    - Report on the project development: The milestones for the first year comprised performing the socio-economic and the technical description of the reference scenario. The milestones have been performed in a timely manner, with no significant delays.
    - Project meetings with all stakeholders: The project team, including the project partner QUERCUS, meets every month. The project team members also meet with the School personal on a monthly bases, to collect data and prepare the studies with the school community. The project team had also a presentation with the Parents association from the school.
    - PhD students: Joana Abreu (MIT Portugal Program 2007-208) and Nuno Santos (MIT Portugal Program 2008-2009)
    - Master students: There is one master student from ICS (Augusta Correia), and another one from IST Inês Ramalho
    - Collaboration with MIT: The collaboration with MIT is done through the presence of the student Joana Abreu at MIT during the academic year of 2009-2010
    - Collaboration with industrial partners: QUERCUS participates in the project team meetings and has provided equipment for residential experiments. GALP participation will occur during the second year, during the intervention in the school.

- Effective collaboration with other MIT Portugal Program projects: There is collaboration with the I-TEAM in terms of methodologies discussion. During the second year is envisaged that the projects will share data.
- Outputs: 1 Energy audit [report], 1 Survey [report], 1 Experimental setup for residential experiments

- Other issues:
  - During this first year is highlighted the successful installation of experimental set-ups in residential homes.
  - The project is on schedule, has almost reached the number of students expected to be involved, and the achieved scientific outcomes to date are generally below to the expected at the statement of work. Attention should be given on its interaction with MIT, and on how the collaboration with Galp develops on year 2.

MIT-Pt/SES-SUES/0041/2008 - iTEAM - integrated Transportation and Energy Activity-based Model

- Principal Investigator: Francisco Colunas Pereira da Câmara Pereira (FCT/UC)
- http://www.mitportugal.org/2008-projects/iteam-integrated-transportation-and-energy-activity-based-model.html
- The iTEAM project aims to develop an integrated model of land use, transportation, and energy, evaluating a range of "green policies" for an enhanced sustainability and well-being.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Report on the project development: milestones 3-6 achieved; milestone 2 to be completed soon.
  - Project meetings with all stakeholders: two – 1st July 2009; 25th November 2009 (several partial meetings during the whole year)
  - PhD students: Marisa Figueiredo (PhD student, FCTUC, iTEAM grant), Andreia Zanella (PhD student, FEUP, iTEAM grant) e Camila Garcia (PhD student, IST, iTEAM grant)
  - Master students: José Ricardo Teixeira (MSc student, FCTUC, iTEAM grant), Bruno Santos (MSc student, FCTUC, own funding from CISUC/FCTUC)
  - Collaboration with MIT: continued collaboration with Profs. Moshe Ben-Akiva, Chris Zegras and John Fernandez. Investment (on their side) on a MSc thesis (Anwar Gauche, already defended) and several other items (including a visit of Bruno Santos from FCTUC to MIT). One joint publication.
  - Collaboration with industrial partners: ISA, S.A. collaboration is still weak, but interest has increased recently to strengthen it. We are targeting new partners currently.
  - Effective collaboration with another 4 MIT Portugal Program projects (SCUSSE, SOTUR, CityMotion, Netzero): SCUSSE and SOTUR are providing behaviour models; CityMotion is providing real data for accessibility measures; In Netzero, collaboration is being made with Joana Abreu in Data Analysis for activity inference, also the plan is kept to share data.
  - Outputs: Eureka! Excellence network award; 3 related new project proposals (jointly with MIT and other EU institutions); Collaboration is also strong with EPFL (Switzerland); 4 publications.

- Other issues: Very low budget for large scale smartphone survey; Very low budget for large scale telemetry survey; currently having administrative problems with budget agreement (related overhead calculations).
- During this first year is highlighted the Eureka! distinction and the strengthening of the research collaborative network through 3 European proposals.
- The project is on schedule, has a good involvement of students and exchange between the PT and MIT teams, has a good partnership with other MIT Portugal Program projects, and the achieved scientific outcomes to date are in agreement with the expected at the statement of work. It is necessary to see how the new negotiations with industry partners develop.

MIT-Pt/TS-AAS/0046/2008 - AIRDEV - Business Models for Airport Development and Management

- Principal Investigator: Maria do Rosário Maurício Ribeiro Macário (IST/UTL)
- The Airdev project aims to contribute to change the dynamics of air transport business in Portugal, in particular airport management, and to create value through knowledge on: a) design of business models able to sustain stable engagement of private partners along the life cycle of the infrastructure; b) system dynamics associated to the economics of the development of the airport, the region and the associated economic agents.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Report on the project development: tasks 3, 4, 5 and 7 ongoing (please refer to presentation for details)
  - Project meetings with all stakeholders: 1
  - PhD students: 1 MIT Portugal Program student (started in September 2009)
  - Master students: 7 MSc (UBI), 2 MSc (CTIS), 2 MSc (IST)
  - Collaboration with MIT: builds on the collaboration with Profs. Amedeo Odoni, Cynthia Barnhart, Richard de Neufville already in the team of AirNets
  - Collaboration with industrial partners: INAC, Alstom. Contacts are now being made with NAV, Thales, ANA, NORTAVIA, TAP Air Portugal
  - Effective collaboration with other MIT Portugal Program project: Airnets
  - Outputs: 2 book chapters, 2 papers on International Journals (+1 submitted), 5 papers on International Conferences
- Other issues: planning a seminar for December 2010
- During this first year is highlighted the model being already fully conceived.
- The project is on schedule, has a good degree of students' involvement and MIT and other alive international collaborations, and the achieved scientific outcomes to date are generally in agreement with the expected at the statement of work. Attention should be given on how to reach key decision-makers for Portuguese airports.

MIT-Pt/TS-ITS/0059/2008 - MISC - Massive Information Scavenging with Intelligent Transportation Systems

- Principal Investigator: João Francisco Cordeiro de Oliveira Barros (FE/UP)
- http://www.mitportugal.org/2008-projects/misc-massive-information-scavenging-with-intelligent-transportation-systems.html
- The MISC project aims to devise adequate models for network information flow in vehicular networks and urban environments; quantify the benefits of network coding for massive data gathering; characterize human stress in traffic situations; provide solid guidelines for the design secure and dependable system architectures.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
    - Report on the project development: tasks 1, 3 and 4 are on schedule; task 2 and 5 are ahead of schedule (please refer to presentation for details)
    - Project meetings with all stakeholders: next meeting planned for June 2010
    - PhD students: 1 MIT student: Minji Kim, 7 Others at FEUP: João Rodrigues, Pedro Santos, Luisa Lima, João Paulo Vilela, Rui Costa, Paulo Oliveira, Gerhard Maierbacher
    - Master students: Susana Bula Cruz (MIEEC/FEUP)
    - Collaboration with MIT:
    - 3 joint papers (1 journal and 2 conference papers)
      FEUP-MIT: Prof. João Barros spent five weeks in July / August at MIT working on this project with Prof. Muriel Médard. He also had work meetings with Chris Zegras, Moshe Ben Akiva, and Francisco Pereira.
      FC/FEUP-MIT: UP PhD Student Rui Costa spent 6 weeks in August /September working with Prof. Médard on network coding protocols for intelligent transportation systems.
      MIT-FEUP: MIT PhD student MinJi Kim spent 3 weeks in January/February 2010 working with Prof. Barros on security protocols for intelligent transportation systems.
      MIT-FEUP: MIT graduate Dr. Daniel Lucani finished his PhD under Prof. Médard and is now an assistant professor at FEUP and a researcher at IT-Porto
    - Collaboration with industrial partners: The envisaged collaboration with TMN didn’t come through
    - Outputs: 6 papers (2 journal and 4 conference papers)
- Other issues: Dr. Daniel Lucani graduated from Prof. Médard's group at MIT and joined the ECE department at FEUP as an assistant professor. He is now part of Prof. Barros' team in Porto.
- During this first year the development of the simulation tool - Divert 2.0 - and the prototype are to be highlighted.
- The project is on schedule, has a good degree of students’ involvement and exchange between the PT and MIT teams, and the achieved scientific outcomes to date are generally in agreement with the expected at the statement of work. Though the collaboration with Biodevices and STCP has worked fairly well, attention should be given to attract direct interest from a telecommunications company.

Materials & Design Inspired Products

1st Meeting: May 20th, 2009, FCT - Activity Plan and Milestones Presentation

2nd Meeting: October 2nd, 2009, Óbidos - Results Presentation / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)

3rd Meeting: April 16th, 2010, FEUP - Project Results of the 1st Year / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)

4th Meeting: January 26th, 2011, UMinho, Braga - Project Results to date / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)

MIT-Pt/EDAM-EMD/0007/2008 - New Technological Solutions for Smart Cardiovascular Medical Devices

- Principal Investigator: Luis Alexandre Machado da Rocha (U Minho)
- http://www.mitportugal.org/research-highlights/sensecardiohealth-new-technological-solutions-for-smart-cardiovascular-medical-devices.html
- The main objective of this project is to prove the feasibility of the next generation of stent grafts: implantable devices deployable using minimally invasive surgery, with enhanced medical performance and with embedded diagnostic function for bad placement and leakage detection.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
    - Report on the project development (official starting date 1st August 09). There is a recoverable delay in IST task due to late hiring of the respective researcher
    - Project meetings with all stakeholders: Sept'09, Nov'09, Jan'10. Next meeting: Jun'10
    - PhD students: Isa Santos (LTI) and Alexandra Sepúlveda (LTI)
    - Lígia Figueiredo and Alfredo Moreira (scholarship) associated to the project
    - 2 UMinho and 1 FEUP integrated Master Students also associated to the project
    - MIT collaboration: Brian Wardle and a PhD student on the use of CNT built-in sensing device
    - An internship (at Hospital S. João) of an LTI student is foreseen
    - DSM, as industrial partner, abandoned; Hospital de S. João (Dr Roncon de Albuquerque) involved
    - Social Sciences Institute (UMinho) recently involved in the project
    - Technological developments are being followed by a cost model
    - Publications: 1 journal paper and 4 conference papers submitted
    - During this first year is highlighted the identification of a set of specifications for the ideal stent-graft, which led to the choice of three materials, now being compared for best performance. It was also established the model for sensor communication. It is very positive the involvement of a known specialist in the field, of Hospital S. João. This project has attracted media coverage.
    - The project is almost on schedule, has a good degree of students' involvement and exchange between the PT and MIT teams, and the achieved scientific outcomes to date are generally in agreement with the expected at the statement of work. Attention should be given to the abandon of DSM in order to prevent similar situations in the

future. MIT involvement to facilitate a new industry partner through the Industry Liaison Program could be of value.

MIT-Pt/EDAM-SI/0025/2008 - Development of Integrated Systems for Smart Interiors

- Principal Investigator: Francisco Manuel Andrade Pires (FE/UP)
- This project seeks to develop smart devices and materials for automotive interiors that incorporate sensor and actuator capabilities for both conventional and new functions in terms of: safety, comfort, performance, aesthetic and information processing.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Report on the project development (official starting date 1st July 09)
  - Task 2 (sensing composites) with very good development, benefiting from the previous work on the early project Smart Flooring
  - PhD (LTI) students engaged in the project
  - 1 additional PhD student is envisaged
  - MIT engagement well established on the cost models (R Roth), initiated on human perception (Qui Holmes) and expected to be improved on materials characterization (T Wierzbicki)
  - Industrial partners: Iber-Oleff, TMG, FiberSensing, Sunviauto
  - Publications: 1 patent submitted, 4 journal papers, 2 conference papers
  - During this first year is highlighted the submission of one patent.
  - The project seems to be on schedule, has a good degree of students' involvement, and the achieved scientific outcomes to date are generally in agreement with the expected at the statement of work. The collaboration with TMG and FiberSensing has worked fairly well. Attention should be given to improve the engagement of MIT regarding materials characterization, and students' exchange.

MIT-Pt/EDAM-SMS/0030/2008 - Assessment and Development of Integrated Systems for Electric Vehicles

- Principal Investigator: Jorge José Gomes Martins (U Minho)
- http://www.mitportugal.org/2008-projects/mobi-mpp-assessment-and-development-of-integrated-systems-for-electric-vehicles.html
- The MOBI-MIT Portugal Program project aims to develop novel integrated systems for concepts of green vehicles, based on use of sustainable motorization and environmentally friendly materials, including: i) new functional concepts, ii) reliable and low cost manufacturing solutions, iii) functional prototype modules to be tested, and iv) life cycle assessment and impact evaluation of concepts.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Report on the project development (official starting date 1st April 09): some tasks are delayed, but without compromising the project development

- Two prototypes are being developed: one in association with a Shell Marathon Challenge and another consisting in the transformation of a conventional car
- LTI Students assigned to the project (Nuno Loureiro and João Pedro); there are still 3 vacations
- 11 Integrated Master students from Minho associated to the project
- scholarships associated; 3 are still missing
- Difficulties on hiring students (specially on electric/electronic areas)
- MIT collaboration: R. Roth
- Industrial partners: Simoldes, TMG
- Publications: 1 book chapter, 1 journal paper (+1 submitted), 4 conference papers, 1 Master thesis
- During this first year is highlighted:
- The creation of the database on electric/hybrid vehicles and systems built (> 600 entries); results published.
- The selection and acquisition of the equipment: test vehicle (VW Polo), engine for range extender adaptation (BMW K75) after simulation tests performed by engine model built previously by the group, electric motors, raw materials for sustainable components.
- Studies on Flexible Design Concepts and Sustainability Assessment published.
- Design, simulation and construction of power/command systems for the motors and of Smart Grid system: intelligent charging and discharging (vehicle-to-grid) of batteries.
- The project is a little behind schedule mainly due to difficulties on hiring students with electric/electronic areas, has a good degree of students' involvement and exchange between the PT teams, and the achieved scientific outcomes to date are generally in agreement with the expected at the statement of work. It is necessary to see how the interaction with the companies can prove an added value to them, improving their competitiveness.

MIT-Pt/EDAM-IASC/0033/2008 - Lean, agile, resilient and green supply chain management

- Principal Investigator: Virgílio António Cruz Machado (FCT/UNL)
- http://www.mitportugal.org/2008-projects/lean-agile-resilient-and-green-supply-chain-management-largscm.html
- The main objective of this research project is to develop a deep understanding of interrelationships (conflicts and trade-offs) across lean, agile, resilient and green manufacturing paradigms, in the auto industry sector. This understanding is believed to be vital to turn these concepts really compatible.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Project started in 1st Jun 09
  - Development in accordance with the project planning for the 1st semester
  - 6 PhD and 2 MSc students involved in the project; additional 1 PhD and 1 MSc are expected
  - Difficulties on hiring students

- MIT collaboration: It is being scheduled a mission to MIT to define their involvement in the project and the displacement of students and researchers
- Industrial partners: Autoeuropa and Delphi
- Publications: 4 journal papers submitted, 4+6 conference papers presented/to be presented
- During this first year is highlighted the organization of a major conference, involving speakers from industry and academia, to present case studies related with the project, and the dissemination of research prototypes using the WWW as open source applications.
- The project is on schedule, has a good degree of students' involvement and the achieved scientific outcomes to date are generally in agreement with the expected at the statement of work. Attention should be given to the negotiations with MIT in order to develop their direct interest in the project and to improve students' exchange.

MIT-Pt/TS-ITS/0036/2008 - System for Adapting the Vehicle dynamic parameters to the driving Environment and Driver capabilities (SAVED)

- Principal Investigator: José Manuel Caré Baptista Viegas (IST/UTL)
- http://www.mitportugal.org/2008-projects/saved.html
- The main aim of this study is to contribute to the improvement of road safety through the application of Intelligent Vehicle Combined Passive and Active Safety Systems. Its main objective is to recommend a system to adjust the vehicle's dynamic attributes to the driver's state and driving circumstances, which will ultimately grow into a technological device. As such, this work proposes to contribute to developing the specifications of a three-unit (Sensor Module, Risk Profiling System, and Control Tool) in-vehicle technological system which will continuously assess drivers' competencies and surrounding conditions, and automatically adjust the action space of the driver to preserve the desired safety levels.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Project started in 1st Sep 09
  - The project has not been present at the last two meetings
  - PT research faculty and post-doc: José Manuel Viegas (IST), Sílvia Shrubsall (IST), Ana Paiva (IST), Picado dos Santos (IST), Jorge Santos (UMinho), João Dias (IST) Difficulties on hiring students
  - Student Researchers: Mohammad Mahdi Hajizamani (IST), Filmon Habtemichael (FCTUC), (to be chosen soon) UMinho.
  - MIT collaboration: none
  - Industrial partners: INiR, Tranquilidade, PRP
  - During this first year is highlighted the development of an initial computer model for about 500 meters of a non-urban highway and 80 cars driven, using Agents in a MultiAgent-Based program named AnyLogic. This will be scaled up by using the outputs of this sort of models in traffic programs, like AIMSUN.
  - The project needs to be better fitted in the group. Efforts have been done to bring MIT abroad, through a continuation project (Saved 2) on 2009 call. The fact of not being

selected deepened the difficulty to gain MIT involvement without a specific budget. Attention should be given to the active integration of companies and to prove them, the project is an added value to them.

MIT-Pt/BS-HHMS/0042/2008 - DACHOR - Multibody Dynamics and Control of Hybrid Active Orthoses

- Principal Investigator: Miguel Pedro Tavares da Silva (IST/UTL)
- http://www.mitportugal.org/research-highlights/the-dachor-project-multibody-dynamics-and-control-of-hybrid-active-orthoses.html
- The DACHOR project proposes the development of an innovative powered Ankle-Foot Orthosis (AFO) to aid individuals with reduced mobility and neuromuscular disabilities of the locomotion apparatus, providing not only the support for general gait disabilities but also the rehabilitation of the musculoskeletal apparatus. The hybrid nature of this powered orthosis is due to an external mechanical actuation that is complemented by Functional Electrical Stimulation (FES).
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Project started in 1st Jan 09
  - Development in accordance with the project planning for the 1st year, including the partnership between academic partners
  - 2 Physical prototypes being developed (FES and AFO).
  - 3 MSc and 2 PhD MIT Portugal Program students involved presently in the project. Another PhD is expected next year.
  - MIT collaboration: Dava Newman, Hugh Herr and Diana Young
  - Contact determination methodologies in collaboration with UTAustin-Portugal Program (1 PhD student)
  - Industrial partner Plux
  - Organization of a MIT Portugal Program Course Module (Biomedical Devices and Technologies) in 2009/10 – 50 participants
  - Publications: 3 Master thesis, 3+1 papers published/submitted, 15+5 papers present/to be presented in conferences
  - During this first year is highlighted the development of seven computational models and the good development towards the implementation of the two physical prototypes (FES and AFO). This project has attracted media coverage.
  - It is also highlighted the exceptional organization of the open course module 'Biomedical Devices and Technologies', and the major specialty meeting organized at Óbidos.
  - The project is on schedule, has a very good involvement of students and exchange between the PT and MIT teams, has a good partnership with other MIT Portugal Program and international partnerships projects (namely with the UTAustin), and the achieved scientific outcomes to date exceed the expected at the statement of work. It is remarkable the engagement of the company partner, Plux.

Stem Cell Engineering for Regenerative Medicine

1st Meeting: May 20th, 2009, FCT - Activity Plan and Milestones Presentation

2nd Meeting: January 7th, 2010, IST-Taguspark - Results Presentation / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)

Next Scheduled Meeting: March, 2011, TBD - Project Results to date / Project Tracking (Actual Standing vs. Planned) / Collaboration (Status, Issues)

MIT-Pt/BS-CTRM/0051/2008 - Smart small-scale devices: systems for controlled delivery of bioactive molecules, cell expansion and for sensing cell environment.

- Principal Investigator: Ana Isabel Nobre Martins Aguiar de Oliveira Ricardo (FCT/UNL)
- http://www.mitportugal.org/2008-projects/smart-small-scale-devices-systems-for-controlled-delivery-of-bioactive-molecules-cell-expansion-and-for-sensing-cell-environment.html
- In this project, different hydrogel-based smart small-scale systems will be developed (i) for in vivo drug delivery (smart microporous particles); (ii) for ex vivo cell expansion (3D matrices or scaffolds); and (iii) for monitorization of cell environment (bioactive beads).
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
    - Project has been very well presented, and covering the 3 parts: in vivo drug delivery; matrices/scaffolds for ex vivo cell expansion; bioactive beads (synthetic cells) for cell environment monitoring
    - Task 1.1 Porous particles; Milestones 1 SAA apparatus assembled and tested. Meetings with Hovione May 2009, Feb 2010; ECBio June 2009
    - Task 2 Design and preparation of scaffolds and membranes, BI recruited; synthesis of crosslinkers for chitosan (scaffolds); development of scaffolds with antimicrobial activity (needs biocompatibility tests)
    - Task 3 Eunice Costa (MIT Portugal Program PhD student) smart beads synthesis in scCO2 Milestone 3. Eunice was 6 month at MIT (Paula Hammond)
    - Communications at congresses
    - Project meetings by videoconference on Feb, May, and Oct 2009
    - Presential project meetings: Dec 2009 at MIT (Paula Hammond, Linda Griffith; Ana A Ricardo; Eunice Costa); Dec 2009 and Jan 2010 at FCTUNL (Paula Hammond; Ana A Ricardo; Eunice Costa).
    - During this first year is highlighted the achievement of production capacity, using green technologies, of biomedical materials with a potential to be used as drug delivery systems, scaffolds to sustain in vitro cell adhesion and proliferation for possible applications in tissue engineering and regenerative medicine and bioactive beads for cell sensing. This project has attracted media coverage.
    - The project is on schedule, has a good involvement of students and exchange between the PT and MIT teams, has a good partnership with other MIT Portugal Program projects (namely with the IPO project), and the achieved scientific outcomes to date exceed the

expected at the statement of work. It is necessary to see how the negotiations with industry partners develop.

MIT-Pt/BS-BB/0082/2008 - Bridging Systems and Synthetic Biology for the development of Improved Microbial Cell Factories

- Principal Investigator: Eugénio Manuel de Faria Campos Ferreira (U Minho)
- http://www.mitportugal.org/2008-projects/bridging-systems-and-synthetic-biology-for-the-development-of-improved-microbial-cell-factories.html
- The primary goal of this project is to develop and apply systems and synthetic biology tools for improving E. coli microbial cell factories for the production of amino acids.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
  - Very well presented: motivation and objectives – aminoacids production through rational approaches (systems and synthetic biology, model: E. coli)
  - Task 1: Development of Whole-Cells and Simulation Tools: Metabolic transcriptional regulation; Inhibition/Activation; Information systems for E. coli metabolic regulatory model. The model was not yet validated, but conclusions were already drawn, namely the metabolic pathways were characterized; as soon as the model is completed, the Optflux framework for the manipulation/ simulation can be used.
  - Task 2: Generation of Experimental Data for Model improvement and validation of metabolic engineering strategies: Methodology for running controlled fed-batch fermentations; experimental set-up; performance of specific growth rate, database from literature still needs to be created
  - Publications: 1 submitted paper; 1 MSc thesis;
  - MIT Portugal Program Students hiring: Carlos Daniel Machado (Sept-Dec 2009 at MIT in Bruce Tidor lab)
  - Team meetings: interaction among team members, June
  - The main output so far of this project is the open-source OptFlux Software tool (www.optflux.org). The software aims at allowing researchers both from industry and academia to simulate, in a user-friendly way, the behaviour of industrially important microorganisms under a variety of conditions and also indicates which genetic modifications may lead to enhanced strains for a particular application. Therefore, the platform expedites research by decreasing significantly the number of experiments that have to be performed to achieve a better biotech industrial process.
  - The article, "OptFlux: an open-source software platform for in silico metabolic engineering," (by Isabel Rocha, Paulo Maia, Pedro Evangelista, Paulo Vilaça, Simão Soares , José P. Pinto, Jens Nielsen, Kiran R. Patil, Eugénio C. Ferreira, and Miguel Rocha) was distinguished as the most-viewed article of the month in April 2010 by the journal BMC Systems Biology.
  - The project is on schedule, has a good involvement of students and exchange between the PT and MIT teams, and the achieved scientific outcomes to date are close to the expected at the statement of work. It is necessary to see how the engagements with industry partners develop.

MIT-Pt/BS-BB/0014/2008 - Structural and functional study of the proteins mediating electron transfer between microorganisms and solid substrates with relevance for bio-energy production

- Principal Investigator: Ricardo Saraiva Loureiro de Oliveira Louro (ITQB/UNL)
- http://www.mitportugal.org/2008-projects/bioenergy-production.html
- This projects aims to determine the molecular mechanisms underlying the iron based anaerobic photosynthesis performed by purple photosynthetic bacteria Rhodopseudomonas palustris TIE-1 and Rhodobacter sp strain SW2. This knowledge will establish the conditions for a rational design of electrodes with optimized contact between the Microbial and the Electrical component of microbial fuel cells.
- Key issues on resources utilization, task monitoring, and overall performance can be summarized as follows:
    - Very clear objectives and well presented
    - Task 1 Milestone 1 (efficient expression systems) was attained
    - Milestone 2 (inducible expression systems) not yet, some problems
    - Task 2 Milestone 3 (Structural characterization) partially attained (DLS, CD, EPR)
    - Outlook: optimization of growth conditions; stabilization conditions
    - Collaboration: Simtejo (express interest in the project)
    - Publications: 1 paper in press Dalton Trans
    - MIT Portugal Program Students hiring: No
    - Team meetings: Yes, through contacts between members – Ivo Saraiva (August 2009) stay at MIT with Dianne Newman
    - During this first year is highlighted:
        - Development of expression systems for three of the target proteins
        - Purification to homogeneity of two of the target proteins
        - Preliminary biochemical and biophysical characterization of the target proteins
        - Proof of principle for the methods to be used in the analysis of the results
    - This project has attracted media coverage.
    - The project is on schedule, has a reasonable involvement of students and exchange between the PT and MIT teams, and the achieved scientific outcomes to date are close to the expected at the statement of work. It is necessary to monitor how the engagements with industry partners develop.

2.2. FOLLOW-UP ON CALL 2009 RESEARCH PROJECTS

The 6 research projects approved on the 2009 call for projects in the context of MIT-Portugal Program were jointly presented at a meeting held at Centro Cultural de Macau on June 17th of 2010.

In this meeting, these 6 new projects had the possibility of presenting the aims of their work to the teams already engaged in the projects of 2008 call. At the same time, they could listen to achievements obtained during this first year of activity, by the 2008 colleagues. It was a great opportunity to meet everybody, and get to know better what everyone is working on.

After this initial meeting, the projects have been grouped in the appropriate target application areas in the Program, and their implementation and development will be followed in regular research meetings.

Sustainable Energy and Transports Systems

Next Scheduled Meeting: February 9th, 2010, FCTUC - Activity Plan and Milestones Presentation

MIT/SET/0014/2009 - Capturing Uncertainty in Biofuels for Transportation. Resolving Environmental Performance and Enabling Improved Use

- Principal Investigator: Fausto Miguel Cereja Seixas Freire (ADAI)
- The Bio-Trans project aims to estimate to develop innovative methodologies for the implementation of biofuels systems for sustainable transportation in Portugal, by developing an integrated life cycle technology, economic, and environmental assessment, explicitly incorporating uncertainty. The research will: 1) develop a decision support approach for biofuels improvement and evaluation; and 2) quantify key sources of uncertainty in an engineering systems context.
- The partners foreseen in this research team include:
- ADAI-LAETA: contributes with experts on biofuels, integrated life cycle assessment (LCA) approaches and uncertainty in LCA
- INESCC: adds experts in multi-criteria decision analysis (MCDA) for sustainable energy, uncertainty, and economic and environmental analysis
- MIT Materials Systems Laboratory: bring expertise in LCA and optimization methodologies
- Two industrial firms in Portugal (both part of Martifer Group, industrial affiliate of MIT Portugal Program): Prio Biocombustíveis, Prio Advanced Fuels
- MIT Portugal Program students: 4 newly graduated Masters
- Other researchers: 3

MIT/SET/0018/2009 - Energy Box - development and implementation of a demand-responsive energy management system

- Principal Investigator: Carlos Alberto Henggeler de Carvalho Antunes (FCT/UC)
- This project aims to develop and implement in practice the concept of Energy Box proposed by Livengood and Larson (2009) as a 24/7 background processor operating on a local computer or in a remote location, to manage in an intelligent manner, that is, responding to price signals, comfort requirements, etc., one's home or small business electrical energy use.
- The partners foreseen in this research team include:
- INESCC, Dept. of Electrical Engineering and Computers
- UC, Faculty of Psychology

- MIT Center for Engineering Systems Fundamentals: Professor Richard Larson (the Co-Applicant) and Ph.D. candidate Daniel Livengood
- ISA – Intelligent Sensing Anywhere: provides the technological basis to develop a hardware/software prototype
- External Consultants:
- Prof. Reinhard Madlener - RWTH Aachen University, Germany
- Prof. Étienne Mullet - Institute of Advanced Studies, École Pratique des Hautes Études, Paris, France
- PhD students:
- Other researchers: 3

MIT/SET/0023/2009 - EXPRESS - EXploration of Portugal's high speed Rail and Economic development Strategy Solutions

- Principal Investigator: João António de Abreu e Silva (IST/UTL)
- The EXPRESS project, using Portugal as a case study, aims to provide important insights and policy conclusions for other countries beginning to consider High Speed Rail-
- The partners foreseen in this research team include:
    - CESUR, ISTUTL
    - FCTUC
    - MIT: Professor Joseph Sussman (the Co-Applicant), Dana Rhodes, Adam Ross, and the students Sevara Melibaeva and Travis Dunn
    - RAVE: João Gonçalves Henriques, brings diverse expertise, project management, and access to critical data
    - MIT Portugal Program students: 2 newly graduated Masters
    - Other researchers: 6

MIT/FSE/0064/2009 - FIRE-ENGINE - Flexible Design of Forest Fire Management Systems

- Principal Investigator: João Alberto Vieira de Campos Pereira Claro (FE/UP)
- The key goal of the project is to establish foundations for an integrated approach to the design of wildfire management systems.
- The partners foreseen in this research team include:
- Expertise in Engineering Systems approaches and domains, in particular in flexible design and system dynamics
- MIT PI– Richard de Neufville (MIT Engineering Systems Division)
- PT PI – João Claro (INESC Porto / FEUP)
- Expertise in forest planning and fire management
- José Cardoso Pereira (ISA)
- José Calvão Borges (ISA)
- Paulo Fernandes (UTAD)
- Tiago Oliveira (Portucel Florestal SA – gPS)

- Tiago Oliveira is the Fire Program Manager of the largest Portuguese forest private landowner and forest producer
- invests more than EUR 3 million annually in prevention and fire suppression activities,
- recognized by its role, importance and contribution to this critical national issue.
- MIT Portugal Program students: 1 newly graduated Master
- Other researchers: 4

Materials & Design Inspired Products

1st Meeting: January 26th, 2011, UMinho, Braga - Activity Plan and Milestones Presentation

MIT/MCA/0066/2009 - Economic and Environmental Sustainability of Electric Vehicle Systems

- Principal Investigator: Luís Miguel Cândido Dias (FE/UC)
- The project will assess the economic and environmental sustainability of electric vehicle systems
- The partners foreseen in this research team include:
- INESCC, Faculty of Economics
- ADAI, Department of Mechanical Engineering
- ISR, Department of Electrical and Computer Engineering
- MIT, Materials Systems Laboratory: Professors Randolph Kirchain and Jeremy Gregory
- General Motors (US), Critical Move (Portugal), EVIberia (Portugal), EDP Distribuição (Portugal)
- External Consultants:
- Robert Stüssi, M.Sc. - President of APVE / AVERE / WEVA
- MIT Portugal Program students: 5 newly graduated Masters
- Other researchers: 3

Stem Cell Engineering for Regenerative Medicine

Next Scheduled Meeting: March, 2011, TBD - Activity Plan and Milestones Presentation

MIT/ECE/0047/2009 - Micro/nano design of functional stem cell-instructive materials for bone tissue regeneration

- Principal Investigator: Maria Manuela Estima Gomes (U Minho)
- This project will address the development of micro/nano technologies for obtaining natural origin hydrogels with the ability to direct stem cells behavior through nano/micro design features combined with the controlled release of biological molecules and hence obtaining highly functional bone tissue engineered substitutes.

- The partners foreseen in this research team include:
- U. Minho, Group of Biomaterials, Biodegradables and Biomimetics (part of IBB associated laboratory):
- Natural origin polymers sourcing and characterization
- Processing and modification of natural origin hydrogels
- Osteogenic and endothelial differentiation of adipose stem cells
- Cell encapsulation of developed hydrogels and characterization of cell behavior
- Natural origin polymeric nanoparticles with encapsulated growth factors
- In vivo assessment of the functionality of developed constructs (cells-hydrogels)
- UC, Center for Neuroscience and Cell Biology
- Incorporation of growth factors or other relevant biomolecules into the developed hydrogels, using nanoparticles or non-viral carriers.
- MIT: Professors Ali Khademhosseini and Robert Langer (Co-PIs)
- Modification of natural polymers
- Processing and characterization of hydrogels by microfabrication technologies
- Design of the architecture of micro-hydrogels
- 3B's-IBB/Stemmatters: João T. Oliveira
- Isolation and cryopreservation of adult stem cells from adipose tissue
- Expansion and differentiation of stem cells from adipose tissue (ASCs)
- Autologous approaches for bone tissue engineering
- External Consultants:
- Robert Stüssi, M.Sc. - President of APVE / AVERE / WEVA
- MIT Portugal Program students: 2 newly graduated Masters
- Other researchers: