Center for Innovation, Technology and Policy Research, IN+
Instituto Superior Técnico, Lisboa

IN+ Report 2014
and Plan 2015-2016

Prepared for the Meeting with the External Review Committee, 15-16 June, 2015
and the IN+ Annual Event, 16 June, 2015

Lisboa, May 2015
IN+ is a space for interdisciplinary research on contemporary issues in technology, innovation and policy, with main applications in science, industry and society.
Acknowledgements
We thank all researchers involved in IN+ and acknowledge all those that have made significant contributions over last years, since the official installation of IN+ in 1998, which have made this report possible.

The main strategic goal of IN+ continues to reflect our founding principles in terms of linking basic and applied research to technology development, and focused on the issues of sustainability. We aim at: i) consolidating successful research lines and increasing the level of interaction among them, ii) developing new lines of research that show considerable promise, and iii) fostering interaction with stakeholders and establishing common joint ventures on issues with scientific, societal and economic relevance.

The institutional support of Instituto Superior Técnico is particularly acknowledged, as well as the collaboration with colleagues in the Associate Laboratory LARSYS. The financial support for the Portuguese Science and Technology Foundation, FCT, is recognized and acknowledged.

Manuel Heitor
Professor and IN+ Director
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1. Introduction

1.1 Overview: The Center for Innovation, Technology and Policy Research, IN+

Instituto Superior Técnico, Lisboa
http://in3.dem.ist.utl.pt/

The center has been developed as a space for interdisciplinary research on contemporary issues in technology, innovation and policy, with main applications in science, industry and society. The research agenda has been oriented to those who are working in engineering systems, as well as to those who have serious interest in exploring this area together with social scientists and scholars in the humanities. In addition, it aims to foster scientific culture among society and the economy, as well as of university students and other researchers interested in discussing challenges and new opportunities for engineering systems and related policy implications.

The activities of the Centre are multidisciplinary, linking basic and applied research to technology development, and focused on the issues of sustainability, namely in terms of the needs to secure the development and quality of our societies, together with the management of energy resources and scientific and economic development. To achieve these objectives, the activities of the Centre are directed towards leading-edge developments and to promote the learning ability of graduate engineering students with the following specific goals:

- To promote the exchange of knowledge in the management of technology and innovation, as a way to promote competitive advantages at the corporate level, including advanced technologies for the optimization of industrial processes;
- To derive science and technology policies and innovation strategies, namely in terms of modern opportunities of knowledge for development, together with environmental protection, rational use of energy, waste management and economic growth;
- To develop and use advanced techniques for the analysis, monitoring and control of processes at laboratory and industrial scale, the latter including technology and risk assessment, together with advanced and strategic technologies with emphasis on turbulent mixing and combustion processes, which have the potential to optimize the environment and the rational use of energy in industry.

In this context, besides the development of basic research in energy and environmental-related processes, the Centre thus undertakes interdisciplinary research involving technology and policy, promoting ways in which industrial development can proceed in a sustainable and socially responsible manner.

Overall, the research conducted in recent years at IN+ has attempted to be “problem oriented” and “project-based”, in a way that guarantees our research activities to be established under relevant problems for our societies and the economy. Among many others, the main issues that have oriented our research include: i) the sustainable development of cities, including the complex interactions of people, technology, policy and urban infrastructures, as well as the way we can foster “smarter citizens”; ii) the sustainable development of industry, in a way to foster economic growth and jobs, with specific work under development in sectors such as aeronautics, consumer products, biotechnology and off-shore industries.

In addition, the research conducted in recent years at IN+ have allowed to deepen our understanding in range of processes and issues dealing with “illities” associated with the sustainable development of our societies. “Illities” are non-functional technical and engineering requirements, including but not limited to sustainability, efficiency, flexibility or capability, which are increasingly associated with modern technical solutions and depend on the way people, institutions and the social environment interact with science and technology. Their understanding
requires dealing with holistic perspectives on the increasing complexity of our daily life and related technical, cultural, social and economic relations. And, above all, it requires learning how to manage uncertainty. Learning, *per se*, requires the personal and social appropriation of scientific and technological knowledge, including processes of inquiry, skill acquisition, and connoisseurship. This has driven most of the policy research at IN+.

Research activities undertaken over the last year have allowed the following targets:

- **Thermofluids, Combustion and Energy Systems**: The optimization of energy processes has been accomplished in terms of new research on microscale thermal phenomena and multiscale transport phenomena in energy systems, including interfacial transport in view of enhanced heat and mass transfer, fuel/liquid atomization, lean-combustion, burning biomass and gun-powder under unsteady combustion.

- **Industrial Ecology and Sustainability**: research has been oriented to develop the necessary knowledge base to support a reduction of 20% of the water supply and energy use and to support the transition to a resource efficient economy in urban regions. To help achieving this goal, the metabolism of different urban areas was further developed and applied to support decision making in energy and waste management networks.

- **Technology Management and Policy**: the target is to foster science, technology and industry policies to help increasing significantly the amount of exports of engineering products and services from Portugal in a time horizon of 2020. This is attempted by deepening the understanding of new science, technology and business dynamics along the full value chain of emerging industry fields, including aeronautics and the sustainable exploration of Atlantic.

It should also be noted and emphasized that the scientific program of IN+ has been implemented to guarantee relevant international scientific trends, as well as economic and social importance of science and technology. Sample examples of our international partnerships include:

- **MIT-Portugal Program**, through its overall coordination (by Paulo Ferrão) and an active involvement of researchers in the areas of Sustainable Energy Systems (SES) and Engineering Design and Advanced Manufacturing (EDAM);

- **Carnegie Mellon Portugal Program**, through an active involvement of researchers in the areas of Engineering and Public Policy (EPP);

- **IRGC, International Risk Governance Council**, through the coordination of IRGC-Portugal, which involves five Associate Laboratories in Portugal (under the coordination of Manuel Heitor);

- **Step4EU, Science, Technology, Education and Policy for Europe**, through the coordination of an European network in science policy (as coordinated by Manuel Heitor);

- **OIPG, International Observatory for Global Policies for the Sustainable Exploration of Atlantic**, through the coordination of an international network in Europe and Brazil, including the development of the “+atlantic” agenda (as coordinated by Manuel Heitor);

This Report was prepared for discussion with the “External Review Committee”, in June 2015, and for an open discussion at the IN+ Annual Event 2015.

1.2. A brief historical context: IN+ 1998-2014

The R&D activities included in the current programme at IN+ have derived from those developed between 1986 and the mid 90’s within the scope of the Combustion Laboratory of the Department of Mechanical Engineering at IST. They have been extended with the aim to integrate competencies at the level of sustainable energy systems, technology policy and advanced socio-economic research methods.
This is because the successful development and subsequent exploitation of energy and environmental technologies requires, apart from improved knowledge of basic thermofluid science, the understanding of policy issues and innovation strategies, in a context which promotes the sustainable development. The ultimate goal is to improve the process of industrial and societal assimilation of knowledge, through a stepwise and interactive approach considering the overall values chain associated with industrial, corporate and social processes.

In addition, the activities developed in last years have been planned on the basis that the most important challenges in maximising the impact of Science and Technology, S&T, on the well-being of nations, is to understand and optimise the complex processes that underlie world-class S&T research, commercialisation and management, including the protection of intellectual property and the integration of knowledge in a context of enhanced economic wealth and shared prosperity.

The concepts presented above are the result of a strong involvement of a number of researchers in a considerably large number of international R&D projects since 1986 and in the early 90’s. These projects were developed in the scope of national projects and the BRITE/EURAM, Science, STEP, Environment, Joule and Esprit Programmes of the European Commission, as well as an increasing involvement with Portuguese and European industry. Apart from the national sectors of glass and crystal, R&D links have been established for a number of years with major European aeronautical companies (Rolls Royce, SNECMA, TURBOMECA, MTU, Rolls-Royce- BMW) and process industries (Saint Gobain). Briefly, the work evolved from basic research on turbulent fluid mechanics and combustion, namely through several master and doctorates programmes.

Moreover, the research work has gained considerably from the successive organisation of the International Symposia on Applications of Laser Techniques to Fluid Mechanics, which have been held in Lisbon since 1982. The symposia have contributed significantly to promote a series of international contacts and research activities in international cooperation.

In the late 90’s and the early 2000’s, the development of competencies in the area of science, technology and innovation policy has been successfully achieved following three main lines of development, namely: i) advanced training of young researchers in leading American universities, through Ph.D. Programmes in key and emergent topics; ii) launching in IST of the Master programme on “Engineering Policy and Management of Technology” in 1998 and of the Master programme on “Engineering Design” in 2002, which has allowed to train young people in new areas of education at IST and promote new links with Portuguese companies; and iii) the organization of the International Conferences on Technology Policy and Innovation, ICTPI, which were launched in July 1997 and carried out in close collaboration with a number of leading research groups worldwide.

In 2000 the Center was a co-founder of the Associate Laboratory LARSYS, “Robotics and Systems in Engineering and Science”, bringing together a research network of several research centres, which was further extended in 2010 and recently re-structured and focused in 2014.

The Center coordinated in 2002-2003 a national initiative and exhibition on the history of engineering in Portugal in the 20th century, which won the Dibner Award of the Society for the History of Technology, SHOT. The Center was named in 2005 one of the top 50 global research centers in technology management by the International Association of Management of Technology, IAMOT.

Since 2006, the Center has extended and enlarged its activities in close association with three new PhD programmes launched at IST in close national and international cooperation, namely in “Sustainable Energy Systems, SES”, in “Technical Change and Entrepreneurship, TCE” and in
“Engineering and Public Policy, EPP”. These programs have gained from a number of government-driven international partnerships with the Massachusetts Institute of Technology, MIT, and Carnegie Mellon University, CMU, which has also allowed to drive a number of new industry-science relationships in Portugal and abroad. In 2011 the Center launched “IRGC-Portugal”, as a network of research laboratories in close cooperation with the “International Risk Governance Council”. From 2013, the Center has become involved in the KIC-Innoenergy.

In 2014, under the re-organization of LARSyS in the context of a national research assessment, the Center was re-focused on its initial 3 laboratories. Among other international activities, the Center launches the networks “Step4EU - Science, Technology, Education and Policy for Europe” and “OIPG - International Observatory for Global Policies for the Sustainable Exploration of Atlantic.

1.3 Research Team, 2014

The IN+ Research Team during 2014 is listed below, including Doctorate Researchers, Senior Research Fellows and Research students. Individual Research information and all CVs are available online.

**Doctorate Researchers** (by alphabetic order)

Abel Martins Rodrigues  
Alexandra Penedo de Sousa Marques  
Ana Catarina Henriques da Silva Gonçalves  
Ana Filipa da Costa Redondo Cancela de Amorim  
Ana Rosa Trancoso  
Ana Sofia Oliveira Henriques Moita  
André Alves Pina  
António Luís Nobre Moreira  
António Miguel Areias Dias Amaral  
Carla Maria do Rosário Costa  
Carlos Augusto Santos Silva  
Cláudia Azevedo Sousa  
Cristina Maria Marta Rosa Pedroso  
Daniel Wiesmann  
Daniela Andreia dos Santos Couto  
Edgar Caetano Fernandes  
Fernanda Maria Ramos da Cruz Margarido  
Gabriel Paulo Alcantara Pita  
Gonçalo José Monteiro Marques  
Helena Margarida Guerra Pinheiro Vieira Reis  
Helena Maria Campos Martins  
Hugo Duarte Alves Horta  
Jisun Jung  
Joana Serra da Luz Mendonça  
João Filipe Dias Rodrigues  
João Miguel Pires Ventura  
José Joaquim Delgado Domingos  
Lia Laporta  
Manuel Frederico Tojal Valsassina Heitor  
Maria João Rodrigues Corte Real  
Miquel Simões Torres Preto  
Muriela Hinard de Pádua  
Nuno José Mota Clímaco Pereira  
Nuno Miguel da Silva Melo Ferreira  
Paulo Manuel Cadete Ferrão  
Ricardo Filipe Chorão da Silva Vieira  
Ricardo Manso  
Rui Pedro Matias G. Mota  
Samuel Pedro de Oliveira Niza  
Silvia Manuela Azevedo de Castro  
Tânia Alexandra dos Santos Costa e Sousa  
Tatiana Raquel Alves Valada  
Tiago Morais Delgado Domingos  
Vânia Andreia Malheiro Proença  
Zeus Guevara

**Senior Research fellows** (by alphabetic order)

Armando Caldeira Pires  
Eduardo Beira  
Georg Rosenfeld  
Nuno Arantes e Oliveira  
Tiago Brandão
1.4 Organization

The organization of the Centre in 2014 includes three main Laboratories, two main Research Programmes, several experimental facilities and a number of other related activities and projects, in a way to effectively allow for the dynamic construction of a "space" for interdisciplinary research about contemporary issues in innovation, technology and policy, with main applications in engineering, science and society.

The activities are organized on the basis of projects which provide the necessary external funding, namely from national and international funding agencies and/or private companies from which research areas emerge. Fundamental research builds the scientific knowledge necessary to give function a sustainable and human-oriented form, thus harmonizing technology with the environment, at the same time that application studies pursue the functionality of advanced technologies and their results (products and services) from a user perspective.
1.4.1 Laboratories

The researchers at IN+ have been traditionally organized and grouped in three main laboratories, as follows.

LABORATORY OF THERMOFLUIDS, COMBUSTION AND ENERGY SYSTEMS

Research at the Laboratory of Thermofluids, Combustion and Energy Systems is aimed at improving knowledge in advanced fields of strategic technologies with emphasis on principles of transport and reaction phenomena. The final goals include:

- To improve knowledge in advanced fields of strategic technologies with emphasis on turbulent mixing and combustion processes, which have the potential to optimise the environment and the rational use of energy in industry;
- To develop and use advanced techniques for the analysis, monitoring and control of processes at laboratory and real scales.
- To promote the exchange of knowledge in advanced technologies for the optimisation of industrial processes and energy systems

The core goal of fundamental research is the innovation of new engineering concepts and is addressed as a driving force for new technologies. It covers interdisciplinary scientific fields, such as Thermal-fluid-dynamics, Combustion and Advanced Techniques for Flow Measurements, Control Engineering, Materials Engineering, Transport and Thermophysical Properties of Materials, Electronics and Microsystems.

Application studies are conducted which benefit from most recent advances in engineering fields to integrate them in advanced functional systems. This is aimed to be developed in close collaboration with the IST Design Studio with the objective to create new engineering products and systems.

LABORATORY OF INDUSTRIAL ECOLOGY AND SUSTAINABILITY

Research activities at this Laboratory aim to improve the design of complex sustainable systems by understanding and modelling relationships between population dynamics, energy and materials use, ecosystem services, environmental impacts of human activities and economic growth.

The ultimate goal is to promote a holistic view of engineering systems which requires the development of a set of tools to bridge different scales, from site or product specific analysis, to the whole economy and ranging across the economic, the social and the environmental dimensions, thus resulting in a multi-disciplinary set of analytical tools, whose development and extension will be a continuous goal for the future. These tools will be used to design and promote new policy instruments that may contribute to improve the environmental performance of products and services through their life-cycles, as well as more efficient economic metabolisms at different scales. Cooperation with industry and governments gives rise to innovations in sustainable buildings, in designing more efficient renewable energy-based systems, including intelligent transportation systems and in managing ecosystem services.

The ultimate goals for this Laboratory include:

- To develop fundamental theory for sustainability assessment and translate this theory in operational tools.
- To develop and empirically calibrate modelling tools for environmental processes, and for integrated environmental-energy-economic processes.
- To develop and use advanced research methodologies for the analysis of sustainable energy systems.
• To promote the exchange of knowledge in advanced technologies for the optimisation of industrial processes and environmental systems

**LABORATORY OF TECHNOLOGY MANAGEMENT and POLICY**

The research agenda for this Laboratory aims at policy analysis, through multidisciplinary activities, namely in terms of science, technology and industry policy formulation and the need to secure sustainable development. The conditions for the social construction of technological systems in both developed and developing societies are addressed in terms of their impact on the emergence of new social realities, and their potential as factors of economic and social change and development on a global scale.

To achieve these goals, science and technology development case studies are developed worldwide, including in Portugal and Europe. The emphasis is on issues in which the interaction of technology, humans and institutions is of central importance to foster the quality of life. Enabling technologies will be developed and assessed under a systems view, comprising the use and environmental implications of materials, energy, and products in modern societies. The ultimate goals are:

- To derive science and technology policies and innovation strategies, namely in terms of socio-economic development.
- To develop and use advanced research methodologies for the analysis of techno-economic systems.
- To promote the exchange of knowledge in advanced technologies and the management of technology and innovation for the optimisation of industrial processes, as a way to promote competitive advantages at the corporate level;

**1.4.2. Research Programmes**

In parallel with the activities of the Laboratories described above, IN+ has launched **two main Research Programmes** in 2014, as described below.

**Research Program - Urban Metabolism and Sustainable Cities (UMSC)**

The program aims at strengthening knowledge about drivers of cities metabolism, to support sustainable management of urban-driven flows and defining policies for urban sustainable management. For this purpose, it is intended to create a multidisciplinary model of the urban area, including impacts of energy and materials use, energy generation within the city, urban spaces outdoors’ quality and issues of materials sustainability, namely life cycle assessment and pollution.

Additionally, the programme will contribute to provide appropriate tools and methods for managing over multiple space and time scales, integrate biophysical and social components, adapt and deal effectively with uncertainty, visualize and identify planning problems and work to identify trade-offs and synergies in undertaking interventions.

The existing Doctoral Program on “Sustainable Energy Systems, SES”, at IST-Lisbon (Technical University of Lisbon), allowing degrees in association with the Universities of Porto and Coimbra and in collaboration with the Massachusetts Institute of Technology, MIT, is acting as the main “vehicle” to foster doctoral research in the areas of this initiative.
Research Program - Science, Higher Education and Policy (SHEP)

SHEP is aimed to foster in-depth research of issues in science and technology, higher education and public policy. The conditions for the social construction of technological systems in both developed and developing societies will be addressed in terms of their impact on the emergence of new social realities in those societies, including Portugal and Europe, and their potential as factors of economic and social development on a global scale. To achieve these goals, science and technological development case studies will be developed worldwide.

The program is centered on the interaction of science and technology and higher education, regarding the learning capacity of people, institutions and their regions to evolve. The emphasis is on issues in which the interaction of technology, humans and institutions are of central importance.

The existing Doctoral Program on “Engineering and Public Policy, EPP”, at IST-Lisbon (Technical University of Lisbon), allowing double-degrees with Carnegie Mellon University, will act as the main “vehicle” to foster doctoral research in the areas of this initiative.

In addition, the Center launched by the end of 2013 the European network “Step4EU - Science, Technology, Education and Policy for Europe”, which is providing a major mechanism for cooperation in Europe in SHEP related areas.

It should also be noted that a Springer book was prepared during 2014 about emerging issues in America Latina and as a result of the ALTEC 2013 meeting organized in Portugal in the Autumn 2013.

1.4.3 Experimental Facilities and Programmes

The Center runs a number of experimental facilities and programmes, which represent an important feature of the long-standing research agenda of IN+. They have been developed with particular emphasis on the Combustion Laboratory at IST (Department of Mechanical Engineering), which includes main facilities and instrumentation for experimental thermofluids and combustion, as well as the design of modern smart energy systems. In addition, the Centre integrated until the end of 2014 significant capabilities in micro-meteorological measurements, including a research “tower”, as well as an operational weather forecasting (http://meteo.ist.utl.pt).

The Centre has integrated in recent years the Laboratory for Waste Characterization and Management” of IST. Other facilities includes the “IST Design Studio”, as created in 2002 and further developed in close cooperation with other centres at IST and the recently formed “Laboratórios na Rua” (i.e., “Street Labs”), which aims at stimulating field work by students and researchers at a community level, with emphasis on vulnerable communities in urban contexts. The following paragraphs briefly describe the various experimental facilities at IN+.

COMBUSTION LABORATORY at IST

The Combustion Laboratory includes facilities for basic experimental work in thermofluids and combustion research, including:

- small furnace (biomass flame);
- small test rigs (premixed flames);
- swirling premixed flame stabilizer;
- spray models, and single droplet systems;
- heat transfer in micro channels;
- ignition flame system.

The available instrumentations includes:
The research undertaken has a background on experimental and mathematical/physical modeling of thermal-fluid-dynamics and combustion systems making use of advanced techniques for flow measurements. It is focused in understanding the fundamental relationship between concurrent thermodynamic transports phenomena involved in energy conversion processes.

Within this framework, the research agenda has been oriented towards combining efforts in developing mathematical/physical models to downsize of energy conversion systems. Flow phenomena occurring in microfluidic devices has been studied, with and without chemical reaction, towards the development of new theoretical and empirical models for micro-scale flow phenomena, as well as on the design on new practical systems. It is a multidisciplinary research field, combining branches of physics, mechanics, optics and fluid dynamics with chemistry. The general objective is to develop and use different tools and new approaches to support the development of energy sustainable products towards consumers, ranging from heating/cooling suppliers to medical devices.

**WASTE PROCESSING AND MANAGEMENT LABORATORY at IST**

The Laboratory is a modern infrastructure equipped with modern equipment, including:

- a magnetic separator;
- a particle size analyser by laser diffraction;
- an optical microscope;
- a stereoscope microscope with photography equipment;
- an electric arc furnace;
- a mechanical shredder;
- a centrifugal ball mill, sample splitter, electromagnetic sieve shaker;
- several precision electronic balances, for determining the moisture content of the samples
- and miscellaneous equipment for hydrometallurgical testing (reactors, process control equipment).

The activities of the Laboratory are directed towards leading-edge developments and to promote the learning ability of graduate engineering students and young researchers aiming to conserve and manage resources and acknowledge the potential impact of waste on public health and the environment, promoting the recycling and valorization of residues.

In recent years a substantial research effort has been dedicated to recycling and valorisation of residues, which has required to spread existing capacities in domains like materials characterisation, physical-chemical and environmental analysis, physical separation (mineralurgical and other related techniques), chemical and metallurgical engineering, modelling, process development and design.

Recycling processes of metallic residues in the scope of mercury removal from waste sources, recycling of sealed Ni-Cd and Zn-Mn type batteries, valorisation of residues from military activities, waste of electric and electronic equipment and other waste streams were developed with scientific success. Main goals for coming years consider enlarging research activities to other class of materials and end-of-life products.
CLIMATE LABORATORY at IST (integrated at IN+ until the end of 2014)
Researchers of IN+ Laboratory for Industrial Ecology and Sustainability are associated with the IST’s micrometeorology laboratory, which has a research “tower”, 33 m high. It is equipped with an automatic weather station and an eddy covariance unit comprising an ultrasonic Gill, R2 anemometer and an open path, IRGA LI-7500 analyzer with a 20.8 Hz acquisition rate. It also has two other field automatic weather stations.

EXTENSITY – Environmental and Sustainability Management Systems in Extensive Agriculture (integrated at IN+ until the end of 2014)
EXTENSITY is an integrated research and action programme, dedicated to promoting sustainable rural development. It aims at developing integrated sustainable rural development solutions, assessing in an integrated way these solutions, and then implementing them in practice, then closing the loop by assessing the practical effects and hence generating new research issues.

EXTENSITY started with a Life project in 2003, and has been successively growing in number of research collaborations, partnerships with governmental agencies and environmental NGO’0s and participating farmers and farmers’ organisations. It has led to the development of a spin-off from IST, Terraprima – Environmental Services. The EXTENSITY network now covers around 1000 farmers, with management contracts for around 100 000 ha (more than 1% of Portugal).

IST Design Studio
IN+ has been involved since 2002 in promoting engineering design, at a research and teaching level, in close cooperation with other centres at IST and in Portugal. These activities have been launched and developed through the installation of the “IST Design Studio”, which aims at renewing and strengthening research and education in engineering design in a way to improve manufacturing competitiveness and innovation.

The studio was initially centred on activities developed through the IST’s M.Sc. on “Engineering Design”, http://in3.dem.ist.utl.pt/mscdesign/, in close collaboration with industry, bringing together staff, researchers and students from the IST’s Department of Mechanical Engineering, as well as from the Department of Engineering and Management Science, the Department of Civil Engineering and Architecture and the Department of Informatics. Its ultimate goal is to help extending the enterprise value chain in emerging and traditional sectors by incorporating the necessary design skills for new product development practices. To achieve this goal, the studio’s strategy is to introduce and promote product development strategies in Portugal by establishing a sustainable research and education programme to develop and transfer knowledge of engineering design, which will enable companies to continually: i) integrate design competencies; ii) improve product quality, and iii) significantly reduce leadtime in product development, while iv) increasing performance/cost ratio.

“Laboratórios na Rua” (“Street Labs”)
IN+ has been involved since 2012 in promoting research and dissemination activities in vulnerable communities, with the ultimate goal of engaging students and researchers in addressing emerging issues associated with the social appropriation of knowledge. Emphasis has been given to “design for uncertainty” in urban contexts under specific vulnerabilities and in a way to foster the analysis of risk perceptions of lay people from vulnerable communities.

The rationale for “Laboratórios na Rua” is driven by the need to help designing resilient cities, with emphasis on flexibility, sustainability, inclusiveness and integration of knowledge and technological infrastructures. During 2012, the focus was on launching a team for innovative “hands on”
approach based on the design of new engineering-based products and processes to help shape perceptions and peoples’ behavior.

Two areas of intervention were chosen in terms of risk mitigation, including energy consumption and non-communicable diseases (e.g., diabetes). While it is increasingly acknowledged that there is a need for intervention in these areas, there is considerable debate about the factors and policy mechanisms that can bring awareness of lay people towards these areas of risk. The research at this stage did not aim to cover all these factors but to identify gaps and future research needs. At this point, we focused on how engineering design and the usage of engineered-based products can support change of perceptions and behavior.

1.4.4 Projects (R&D, Experimental development and dissemination)
Following current practices in many other research centres, the main organizational element at IN+ is based on “Research Projects”, in particular those resulting from external and competitive funding sources. The following table lists the main projects under developed by IN+ researchers and identifies main funding sources.
## Research Projects at IN+, 2014: Main competitive funding sources and projects

<table>
<thead>
<tr>
<th>Typology of sponsorship</th>
<th>Brief Project title</th>
<th>Brief description</th>
<th>PI (Principal INVESTIGATOR)</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>ADB - II</td>
<td>Análises de fluxos de materiais urbanos em seis cidades asiáticas</td>
<td>Paulo Ferrão</td>
<td>05-02-2013 to 05-02-2014, 12 months</td>
</tr>
<tr>
<td>EDP CDP 2013</td>
<td>Tiago Domingos</td>
<td>10-02-2014</td>
<td></td>
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<tr>
<td>EDP EMISSOES 3</td>
<td>Tiago Domingos</td>
<td>21-05-2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEKA-AIR</td>
<td>Edgar Fernandes</td>
<td>21-04-2014 to 21-02-2015, 10 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A sua casa a sua energia</td>
<td>Paulo Ferrão</td>
<td>01-01-2014 to 01-01-2016, 24 months</td>
<td></td>
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</tr>
<tr>
<td>APA - GESTAO RESIDUOS</td>
<td>Paulo Ferrão</td>
<td>10-12-2009 to 10-12-2014, 60 months</td>
<td></td>
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</tr>
<tr>
<td>APA CIRVER</td>
<td>Paulo Ferrão</td>
<td>30-10-2007 to 30-12-2014, 86 months</td>
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<tr>
<td>APA-PNGR</td>
<td>Paulo Ferrão</td>
<td>07-11-2008 to 07-06-2015, 79 months</td>
<td></td>
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<tr>
<td>Crescer com eficiência</td>
<td>Paulo Ferrão</td>
<td>01-01-2014 to 01-01-2016, 24 months</td>
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<td>EDP-ACV</td>
<td>Paulo Ferrão</td>
<td>15-05-2009 to 15-12-2016, 91 months</td>
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<td>EDPP</td>
<td>Paulo Ferrão</td>
<td>29-07-2014 to 29-10-2014, 3 months</td>
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<tr>
<td>EVORA-MOBILIDADE</td>
<td>Paulo Ferrão</td>
<td>01-02-2006 to 01-06-2015, 112 months</td>
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<tr>
<td>IGNITION</td>
<td>Edgar Fernandes</td>
<td>28-10-2009 to 28-10-2019, 120 months</td>
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<tr>
<td>LOWNOX</td>
<td>Edgar Fernandes</td>
<td>28-10-2009 to 28-10-2019, 120 months</td>
<td></td>
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<tr>
<td>RAES</td>
<td>Paulo Ferrão</td>
<td>01-04-2010 to 01-03-2015,</td>
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<tr>
<td>Project</td>
<td>Description</td>
<td>Responsible</td>
<td>Duration</td>
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<tr>
<td>SDMP-AEP</td>
<td>Desenvolvimento de um conjunto de orientações que incorporam as melhores práticas tendo em vista a sustentabilidade do empreendimento Algarve Energy Park.</td>
<td>Paulo Ferrão</td>
<td>15-03-2010 to 15-07-2015, 64 months</td>
<td></td>
</tr>
<tr>
<td>SmartGalp</td>
<td>Realização de estudo técnico na área de smart metering, com o objetivo de demonstrar e quantificar o potencial que a monitorização de consumos em tempo real, assim como as novas formas de interação com consumidores residenciais poderá ter na melhoria da eficiência energética, na redução de consumos e emissão de gases com efeito estufa, na redução do custo final de energia para o consumidor final.</td>
<td>Paulo Ferrão</td>
<td>01-10-2010 to 01-06-2015, 56 months</td>
<td></td>
</tr>
<tr>
<td>TEKA-S</td>
<td>Subsídio p/ apoio ao ensino e desenvolvimento de projetos de mestrado.</td>
<td>Edgar Fernandes</td>
<td>23-05-2014 to 23-11-2014, 6 months</td>
<td></td>
</tr>
<tr>
<td>European Commission BIOAPRONFS WETT</td>
<td>Biomimetic Approaches of Natural Functional Surfaces with hierrarchical micro &amp; nano structure and the extreme Wettability</td>
<td>António Moreira</td>
<td>01-04-2012 to 01-04-2016, 48 months</td>
<td></td>
</tr>
<tr>
<td>CitySDK</td>
<td>Production of three large-scale pan-European smart city service pilots in the eight partner cities. The pilots are in the domains of smart mobility, smart participation and smart tourism.</td>
<td>Paulo Ferrão</td>
<td>01-01-2012 to 01-07-2014, 30 months</td>
<td></td>
</tr>
<tr>
<td>INSCAN</td>
<td>Development of a high speed spectrophotometer</td>
<td>Edgar Fernandes</td>
<td>01-01-2012 to 01-07-2015, 42 months</td>
<td></td>
</tr>
<tr>
<td>SHREDDERSORT</td>
<td>Selective recovery of non-ferrous metal automotive shredder by combined eletromagnetic tensor strectoscopy and laser indiced pasma strectoscopy</td>
<td>Fernanda Margarido</td>
<td>01-12-2013 to 01-01-2017, 37 months</td>
<td></td>
</tr>
<tr>
<td>Smart Campus</td>
<td>Building-User Learning Interaction for Energy Efficiency</td>
<td>Paulo Ferrão</td>
<td>01-08-2012 to 01-05-2015, 33 months</td>
<td></td>
</tr>
<tr>
<td>SOUTH ZEB</td>
<td>Concepção e desenvolvimento de módulos de formação Edifício de Balanço Energético quase Zero (nZEB) para profissionais da construção nos países do Sul da Europa</td>
<td>Paulo Ferrão</td>
<td>01-03-2014 to 01-09-2016, 30 months</td>
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<tr>
<td>FCT: Portuguese Science and Technology Foundation (Research Projects) DINAMICS</td>
<td>Dynamics of INterfacial transport phenomenA in Micro scale energy Conversion Systems</td>
<td>António Moreira</td>
<td>01-06-2013 to 01-06-2016, 36 months</td>
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<tr>
<td>E2web</td>
<td>Dinâmicas de inovação em aeronáutica e na Embraer em Évora: uma plataforma distributiva para iniciativas empresariais, emprego e desenvolvimento de capacidades</td>
<td>Joana Mendonça</td>
<td>01-06-2014 to 01-06-2018, 48 months</td>
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<tr>
<td>EntHuCap</td>
<td>The Impact of Entrepreneurial Human Capital on Careers, Earnings and</td>
<td>Miguel Preto</td>
<td>01-03-2012 to 01-09-2015,</td>
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<tr>
<td>Project</td>
<td>Description</td>
<td>Duration</td>
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<tr>
<td>EXIT</td>
<td>Saída ocupacional e performance empresarial entre empreendedores e gestores de topo</td>
<td>42 months</td>
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<tr>
<td>Integersum</td>
<td>Modelo integrado e geo-referenciado para a promoção da sustentabilidade do metabolismo urbano</td>
<td>Miguel Amaral (01-03-2011 to 01-09-2014, 42 months)</td>
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<tr>
<td>IRGC Portugal</td>
<td>IRGC Portugal is affiliated to the International Risk Governance Council, an independent organisation whose work includes developing concepts of risk governance, anticipating major risk issues and providing risk governance policy recommendations for key decision makers.</td>
<td>Manuel Heitor (01-01-2012 to 01-01-2015, 36 months)</td>
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<tr>
<td>MEMO</td>
<td>Evolução do metabolismo da área metropolitana de Lisboa. Lições para um futuro urbano sustentável.</td>
<td>Samuel Niza (02-05-2013 to 02-08-2015, 27 months)</td>
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<tr>
<td>Mesur</td>
<td>Sistema de indicadores para a sustentabilidade do metabolismo urbano</td>
<td>Samuel Niza (01-02-2011 to 01-05-2014, 39 months)</td>
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<tr>
<td>MIT – Gestão da Coordenação</td>
<td>Acordo de colaboração para a gestão e coordenação de programa MIT Portugal</td>
<td>Paulo Ferrão (01-01-2014 to 01-01-2015, 12 months)</td>
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<tr>
<td>MIT – Sistemas Sustentáveis de Energia 2013</td>
<td>PhD em Sistemas Sustentáveis de Energia</td>
<td>Paulo Ferrão (01-01-2014 to 01-01-2015, 12 months)</td>
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<tr>
<td>MIT-Pt/ EDAM 2014</td>
<td></td>
<td>Manuel Heitor (01-01-2014 to 01-01-2015, 12 months)</td>
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<tr>
<td>Plataformas biomedicina</td>
<td>Plataformas tecnológicas e modelos de negócio emergentes. Novos modelos de criação e apropriação de valor na indústria biomédica.</td>
<td>Muriela Pádua (01-02-2014 to 01-08-2015, 18 months)</td>
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<tr>
<td>SURWET-COOLS</td>
<td>Study of the effects of surface wettability and micro patterning on micro-channel evaporative heat transfer with application to cooling systems.</td>
<td>António Moreira (01-03-2011 to 01-09-2014, 42 months)</td>
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<tr>
<td>Trajectórias</td>
<td>Trajectórias profissionais de doutorados: um aprofundar de conhecimento sobre tipos de mobilidade.</td>
<td>Hugo Horta (01-06-2013 to 01-06-2015, 24 months)</td>
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<tr>
<td>Others</td>
<td>Atlântico + Mobilização da Capacidade Tecnológica e de Valorização Industrial para a Exploração Sustentável do Atlântico</td>
<td>Manuel Heitor (18-09-2014 to 18-03-2015, 6 months)</td>
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<tr>
<td>Projetos</td>
<td>Descrição</td>
<td>Autor</td>
<td>Período</td>
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<tr>
<td>Balanço de materiais do Concelho de Lisboa</td>
<td>Elaboração de um estudo de análise de fluxos de materiais para a cidade de Lisboa, o qual deve resultar na construção de uma matriz de balanço de materiais do concelho de Lisboa.</td>
<td>Paulo Ferrão</td>
<td>01-09-2005 to 01-09-2015, 120 months</td>
<td></td>
</tr>
<tr>
<td>Ensino Experimental</td>
<td>Desenvolvimento de acções de formação junto da escola secundaria de Benfica no âmbito do THERMOCUP</td>
<td>Edgar Fernandes</td>
<td>01-01-2013 to 01-10-2014, 20 months</td>
<td></td>
</tr>
<tr>
<td>FLUX</td>
<td>Desenvolvimento de uma visualização na web e em Google Earth da rede de espaços internet utilizando a plataforma flux.</td>
<td>Paulo Ferrão</td>
<td>01-11-2006 to 01-11-2014, 96 months</td>
<td></td>
</tr>
<tr>
<td>Fogos florestais</td>
<td>Fogos florestais: factores de risco associados a danos económicos e ambientais</td>
<td>Paulo Ferrão</td>
<td>01-09-2005 to 01-09-2015, 120 months</td>
<td></td>
</tr>
<tr>
<td>Programa A+</td>
<td>Confirmação e desenvolvimento de um programa avançado de design e engenharia</td>
<td>Manuel Heitor</td>
<td>02-10-2013 to 02-01-2015, 15 months</td>
<td></td>
</tr>
<tr>
<td>SEEK</td>
<td>Análise do impacto da crise económica no perfil dos empreendedores em Portugal - comparação com a Alemanha</td>
<td>Joana Mendonça</td>
<td>01-04-2014 to 01-10-2015, 18 months</td>
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</table>
1.4.5 Integration of IN+ in the Associate Laboratory LARSYS (2014)

**LARSYS (2010-2014)**
The Center is a co-founder (since 2000) of the Associate Laboratory LARSYS, “Laboratory of Robotics and Systems in Engineering and Science”, which was funded through Portuguese Science and Technology Foundation, FCT, and brought together during the period 2010-2014 a research network of six research centres, as follows:

- ISR: Institute for Systems and Robotics at Instituto Superior Técnico (ISR/IST);
- IN+: Center for Innovation, Technology and Policy Research at Instituto Superior Técnico (IN+/IST);
- IMAR: Centre for Maritime Research at the University of the Azores (IMAR/UA);
- CREMINER: Centre of Mineral Resources, Mineralogy, and Crystalography of the University of Lisbon (CREMINER/FCUL);
- CAMGSD: Center for Mathematical Analysis, Geometry and Dynamical Systems at IST (CAMGSD/IST);
- MITI: Madeira Interactive technologies Institute, at the University of Madeira (MITI/UM).

The research activities of LARSYS are organized in five thematic areas:

- A-Complex Systems in Engineering and Fundamental Sciences;
- B-Sustainable Urban Systems and Technologies;
- C-Science, Technology and Sustainable Development;
- D-Ocean Systems Technology;
- E-Ocean Resources and Ecosystems.

The activities in these areas are scientifically supported by the eleven research groups that compose LARSYS (IMAR-Centre of IMAR of the University of the Azores; CREMINER- Centre of Mineral Resources, Mineralogy, and Crystalography of the University of Lisbon; LIES-Laboratory of Industrial Ecology and Sustainability at IN+/IST; LTPM-Laboratory of Technology Policy and Management at IN+/IST; LTCE-Laboratory of Thermofluids, Combustion and Energy Systems at IN+/IST; DSOR - Laboratory of Dynamical Systems and Ocean Robotics at ISR/IST; ESBE- Laboratory of Evolutionary Systems and Biomedical Engineering at ISR/IST; IRS- Laboratory of Intelligent Robots and Systems at ISR/IST; SIPG-Signal and Image Processing Group at ISR/IST; VisLab - Computer and Robot Vision Laboratory at ISR/IST; and CAMGSD-Center for Mathematical Analysis, Geometry and Dynamical Systems of IST).

IN+ researchers participate in two main thematic areas of LARSYS, respectively areas B and C mentioned above, as follows.

The thematic area of Sustainable Urban Systems and Technologies (i.e., Area B) provides a comprehensive approach to R&D focused on the following topics: Surveillance and Activity Monitoring; Urban Metabolism - natural resources usage in economic activities; Networked Robot Systems; Cognitive Systems for Human-Machine Interaction; and Distributed Inference in Sensor Networks and Environmental Surveying. The contributions from these broad areas will provide the diversity and richness that foster cooperation across research groups and visionary multidisciplinary research.

The thematic area of Science, Technology and Sustainable Development (i.e., Area C) undertakes multidisciplinary research aiming at developing complex science and technology systems to promote sustainability, namely in terms of science, technology and industry policy formulation and the need to secure sustainable development. The conditions for the social construction of technological systems in both developed and developing societies are addressed in terms of their
impact on the emergence of new social realities, and their potential as factors of economic and social change and development on a global scale. To achieve these goals, science and technology development case studies will be developed worldwide, including in Portugal and Europe. The emphasis is on issues in which the interaction of technology, humans and institutions are of central importance to foster quality of life. Enabling technologies are developed and assessed under a systems view, comprising the use and environmental implications of materials, energy, and products in modern societies.

**LARSYS re-organization (2013-2015) and the future, LARSYS (2015-2021)**

LARSYS has undergone a major re-organization in the period November 2013 – March 2015, under the context of a new national research assessment exercise. By December 2013, a new proposal was submitted to the Portuguese Science and Technology Foundation, FCT, for a new 6-year contract under the title LARSYS, “Laboratory of Robotics and Engineering Systems”, which brings together a research network of four research centres, as follows:

- ISR: Institute for Systems and Robotics at Instituto Superior Técnico (ISR/IST);
- IN+: Center for Innovation, Technology and Policy Research at Instituto Superior Técnico (IN+/IST)
- MITI: Madeira Interactive technologies Institute, at the University of Madeira (MITI/UM);
- MARETEC: Centre for Maritime Technologies at Instituto Superior Técnico (MARETEC/IST);

It should be noted that, under this re-organization of LARSYS, part of the group of researchers involved in the LABORATORY OF INDUSTRIAL ECOLOGY AND SUSTAINABILITY of IN+ was transferred to MARETEC. They keep their overall affiliation within LARSYS, but officially left IN+.

The new entity LARSYS was approved by FCT by March 2015, with an overall mark of “Very Good” and funding guaranteed for the period 2015-2021.

**1.4.6 Coordination and integration of IN+ in “IRGC-Portugal”, Intl. Risk Governance Council**

IRGC Portugal was set up towards the end of 2011, under a grant from the Portuguese Science and Technology Foundation, FCT, aiming to establish in Portugal an academic node of the International Risk Governance Council, IRGC, [http://www.irgc.org/](http://www.irgc.org/). It has taken the form of a research consortium and network involving five Associate Laboratories (LARSys; INESC Porto; IT; IBB and IBMC-I3S) and the two main Engineering Schools in Portugal (IST-Lisbon and FEUP-Porto). Overall governance, coordination of activities and the secretariat have been guaranteed through the Center for Innovation, Technology and Policy Research, IN+.

The IRGC Portugal’s website ([www.irgc-portugal.org](http://www.irgc-portugal.org)) was also launched in 2012 and maintains updated information on the consortium’s activities.

IRGC Portugal sponsors Research Fellowships making use of grants from the Portuguese Science and Technology Foundation, FCT. The Research Fellowships launched in 2012 considered a senior doctorate researcher, two doctoral fellowships and other research fellowships to initiate university students and other graduates in research activities in risk governance issues.

The recruitment process and overall scientific coordination was guaranteed through the Scientific Council, with representatives from all the partner institutions. A group of young researchers has been successfully recruited by the end of 2012. Others joined the team in early 2013. In addition, Research Associates that are affiliated with the partner research centers have initiated their work in collaboration with IRGC Portugal’s projects.
IRGC Portugal targets research on the governance of emerging and systemic risks that are relevant to the Portuguese and European frameworks, as well as to Portuguese speaking countries, and provide advanced training in this field. It will ultimately work as a research and learning platform, engaging policy makers, researchers, companies and civil society organizations, towards the assessment, appraisal, evaluation, management and communication of systemic risks and knowledge-based policies.

The research areas launched IRGC Portugal during 2012 built on competencies of different partners, together with integrating a few novel approaches regarding risk governance in association with major socio-economic vulnerabilities influencing processes of technical change. Main focused research areas include:

- **Emerging forms of technological innovation**, with emphasis on regulatory frameworks at the convergence of life sciences, physical sciences and engineering, namely focused on innovative cell therapies and the need to develop adaptive governance based on new regulatory issues;
- **Design for uncertainty in urban contexts**, by looking at risk perceptions of lay people from vulnerable communities, focusing on risk communication and stakeholder engagement and including risks and their perceptions of non-communicable diseases, such as diabetes, and energy security issues;
- **Governing deindustrialization risks** and related issues to foster technical change and industrialization strategies in diverse regional contexts, in which the lack - in some cases - and the reduction - in others - of industrial activity has fostered socio-economic vulnerabilities.

In addition, novel complementary approaches were developed regarding a comprehensive analysis of the evolution of science and technology policies, including the training of human resources, aiming to help establishing innovative frameworks for developing regions worldwide, with emphasis on Latin America, Africa and Asia.

Additional information on the agendas for the main research areas and themes is presented below and more detailed information on these areas and the remaining ones can be found at the IRGC Portugal’s website, [www.irgc-portugal.org](http://www.irgc-portugal.org).

1.4.7 Coordination of IN+

The year of 2014 is characterized by a changing organization induced by alterations in the structure of the Associate Laboratory LARSYS, as driven by a national research assessment exercise conducted by FCT. The following paragraphs list the researchers involved in the coordination of IN+ for the period 2013-2015.

President of the Scientific Council: **Paulo Ferrão**, Full Professor, IST

**Director:** **Manuel Heitor**, Full Professor, IST

**Deputy Director:** **Hugo Horta**, Doctorate Researcher, IST

Board of Directors:
- **Manuel Heitor**, President
- **Hugo Horta**, Deputy President
- **Edgar Fernandes**, Director of the Lab. of Thermofluids, Combustion and Energy Systems
- **Tiago Domingos - Paulo Ferrão**, Director of the Lab. of Industrial Ecology and Sustainability
- **Miguel Amaral – Hugo Horta**, Director of the Lab. of Technology Policy and Management
- **André Pina**, Doctorate Researcher
Jose Rodrigues, Research Student

Coordination of Research Programmes:

- **Research Program - Urban Metabolism and Sustainable Cities (UMSC)**
  - Research Director: Samuel Niza, Doctorate Researcher
  - Scientific Coordinator: Paulo Ferrão, Full Professor

- **Research Program - Science, Higher Education and Policy (SHEP)**
  - Research Director: Hugo Horta, Doctorate Researcher
  - Scientific Coordinator: Manuel Heitor, Full Professor

The **External Review Board** of IN+ includes (since 2013):

- **Jean-Pierre Contzen** (Chair)
  - Chairman, Von Karman Institute for Fluid Mechanics; Belgian Academy of Sciences, Belgium

- **Cesar Dopazo**
  - University of Zaragoza, Spain, [http://www.unizar.es/dopazo/](http://www.unizar.es/dopazo/)

- **Jussi Välimaa**
  - Finnish Institute for Educational Research, University of Jyväskylä, FINLAND

- **Mete Sen**
  - Istanbul Technical University, Faculty of Mechanical Engineering, Istanbul - Turkey

- **Gary Rhoades**
  - University of Arizona, USA
  - http://www.coe.arizona.edu/faculty_profile/788

- **Helge Brattebø**
  - Norwegian University of Science and Technology, NTNU, Norway
  - http://www.ntnu.edu/employees/helge.brattebo
2. Main Research Activities and Results: 2014

The paragraphs below describe main results of activities performed by IN+ researchers in recent years, with emphasis on 2014. The results are presented in terms of the activities performed under the various groups involved in the three Laboratories established at IN+.

Laboratory of Thermofluids, Combustion and Energy Systems

The research activity in this Laboratory is focused on combustion/acoustics and on multiscale transport phenomena in a variety of flows. Boiling mechanisms and heat transfer processes over enhanced surfaces were analyzed for pool boiling and forced convection boiling in micro-channels, making use of laser techniques that have been developed and tailored to the particular geometries and flows studied. Interfacial phenomena related to a customized modification of the wettability and/or actuation on liquid surface tension was also explored, particularly for the transport and manipulation of bio fluids.

Regarding combustion acoustics, the work developed focused on the study of fluid-chemical interaction processes between rich-lean flames, supported by chemiluminescence and laser based techniques. Research work was also conducted on the developing of three distinct techniques: chemiluminescence sensor for flame analysis, digital stethoscope for flow analysis and spark discharge process as a sensor for Air-to-gas ratio measurements.

The work is described in the following paragraphs under 6 specific themes (Themes 1 to 6).

Theme 1: Dynamics of interfacial transport phenomena in multiphase systems with phase change

The work deals with the hierarchical complexities of pool boiling, of velocity boundary layer flows at flat interfaces and of liquid flows in micro-channels with phase change. Experiments are performed to address the transport phenomena associated with surface tension gradients caused by temperature and concentration variations on the dynamical behaviour of interfacial phase change interfacial including nucleation, bubble motion and coalescence. Also, the effects of surface topography and chemical properties (wettability) on interfacial transport phenomena during liquid nucleation boiling is analysed and a further insight is given to develop/built appropriate experimental techniques and/or methods to quantify the physics of dynamic interfacial transport phenomena or processes including jet-like flows, bubble interaction and spatial scale effects.

Main Publications:


**Theme 2: Spark Discharges**

The spark ignition is the first and the most prevalent form of forced ignition present in internal combustion engines, gas turbines, industrial and domestic burners. In general, three phases are found in the process of a flame ignition, namely: i) voltage breakdown (to create a flux on electrons); ii) energy deposition in the gas mixture, promoting their expansion; and iii) mixture ignition. Attention has been focused on the understanding of transient processes of the first two ignition phases (voltage breakdown and gas thermal expansion).

A mathematical model is designed to obtain the instantaneous pressure, temperature and density of the spark, based on experimental input of electric energy measurements and high speed shadowgraphy data. Further quantification of all terms in the momentum and energy conservation equations was taken in order to characterize the relative importance of them in the discharge process. The modeling work was followed by spectral analysis of glowing light emission in order to evaluate the relation between absolute light intensity from discrete wavebands (CN, OH, NH radicals) and Air/Fuel mixture ratio.

The main conclusions are summarized as follows: a) the thermal expansion of the plasma is temporally decoupled from the electrical discharge; b) the spot of glow light emission occurs before the plasma thermal expansion; and c) the ratio between CN/OH and CN/NH radicals follows a linear monotonic relationship with air/fuel ratio.

**Main Publications:**


**Theme 3: Narrow pressure probes – pressure static probes and stethoscope applications**

Research under this theme considers the development, modeling and characterization of acoustic probe-tube to be used in turbulent non-reacting flows in the range of 100-7kHz. Two probe types
were studied: linear tube with a static hole and a stethoscope model. The probes were based on a condenser microphone encapsulated in a volume chamber and connected to a capillary stainless steel tube (internal diameter of 1mm) with a closed end and a hole in its surface. A mathematical model supported full analysis of probe acoustic response with viscous-thermal damping effect followed by experimental characterization. A detailed analysis was given to the T-junction modeling.

The results indicate that a precise identification of probe’s acoustic response should include the viscous-thermal damping effect and that the size of the hole is responsible for the resonance frequencies (and internal standing waves) present in the probe’s acoustic response. In general, the probe acoustic response has a low peak frequency due to a Helmholtz behaviour, a set of mid-to-high frequencies associated with internal standing waves and a band stop frequency. This type of probe-tube systems had proven to be 36dB more sensitive to pressure waves travelling inside the tube when compared with ambient noise. The mathematical model developed was shown to give accurate Acoustic Transfer Functions that can in used in deconvolution. The data and results collected with this work are a valuable support for adequate design of acoustic probes to fit the experimental needs.

Main Publications:

Theme 4: New Burner Development

Three types of burner configurations and related flame interactions were studied. First, Rich – Lean domestic burners are a promising technology towards reducing pollutant emissions, namely NOx. A prototype of this type of burner is analyzed in the present study, in the interest of understanding how burner stability can be extended, and how they are related with the rich – lean flame interaction. Chemiluminescence techniques were used to understand the chemical kinetics in the area where the different reaction zones interact. In addition, PIV measurements were carried in order to characterize the flow field. It was found that the lean flame is locally contaminated by the adjacent rich flame, which promotes an increase in the local burning speed hence enhancing stability. Furthermore, an optimal geometrical configuration for the burner plate was also studied in terms of flame stability.

Second, lean disc flames detached from burner were studied, to help searching for innovative strategies of stabilizing lean flames and the control/minimization of NOx emissions. Thermoacoustic instabilities arises as leaner mixtures are used, limiting working regimes. In this context, a mathematical-experimental approach was used to allow re-designing burners to passively cancel instabilities. Experimental analysis of the flames included high speed imaging, LDV, sound, and chemiluminescence measurements and has shown that the resonant frequency of impinging unsteady disc flames is coupled to the acoustic response of the burners (acting as Helmholtz resonator). The resonant frequency is dependent on the characteristic time taken by a perturbation to travel from the burner mouth to the flame tip, which is controlled by the Kelvin-Helmholtz instabilities of the jet shear layer.

Third, lean combustion was further studied to reduce NOx and to understand the stabilization and blow-off mechanisms in order to attain stable combustion while targeting the emission levels required. Multi-perforated burners have been in use for several decades but they still pose a challenge today in terms of flame stability due to the flame-flame interaction and flame-wall interaction. The stability limits a set of multi-perforated burner plates with different hole diameter
and spacing between holes were taken and the flame luminescence imaging was carried out to analyze the topology of the stabilized flame on each burner plate. Air-propane premixed mixtures were used solely. Mie-scatter and Particle Imaging Velocimetry was also applied to visualize the flow and measure the velocity gradients at the burner port. It was found that the gap between holes is the critical factor affecting the stability on these burners and that for those burners with a gap equal or greater than 2 mm stability is notably affected due to a secondary flow of fresh atmospheric air is entrained to the gaps between the holes on the multi-perforated plate which, consequently, undermines the reaction rates and affects the stability of the flame.

Main Publications:

Theme 5: Chemiluminescence emissions in premixed CH4/C3H8 fames
A comprehensive model for chemiluminescence analysis has been developed based on experimental data and numerical evaluation of chemiluminescence kinetics. It is proposed that a collected light intensity signal, by an optical sensor, can be decomposed as $I(h)Vi$, if $I_0$ is spatially invariant. Further mathematical development has shown that: a) the $I(h)$ function is an optical transfer function of the dimensions-location of the sensor relative to the flame surface-volume geometry; b) the emission volume $Vi$ is as a power function of a reaction volume (postulated based on analysis of chemiluminescence kinetic simulations); and c) the local light intensity $I_0$ can be modeled based on Arrhenius formulation, i.e. supported by a function of temperature and a function of fuel/air content.

The model was tested with OH, CH, and C_2 chemiluminescence collected from Bunsen type premixed flames, burning methane and propane fuels. Equivalence ratios from 0.80 to 1.30 were tested experimentally in a range of fuel mass flow rates of 0.75 up to 1.75 kW, depending on the burner stability limits. Model evaluation comprises the matching between experimental results and analytical descriptions, by defining coefficients for each emitter and fuel type. The results show that: a) the model describes the experimental trend, allowing a collapse of all data; b) the model enable a quantitative discrimination of effects in the light collected, i.e. among volumetric, thermal and species population effects; and c) in the classical analysis of OH/CH, CH/C_2 and C_2/OH ratios, the driving force is the function of air/fuel content. Other effects, such as thermal and volumetric functions, have a negligible impact except, under selected ratios, for far leaner and richer flame conditions.

Main Publications:
Theme 6: Exhausting Gas Systems

Exhaust hoods have been characterized in a bench test to determine performance curves, working points and fluid dynamic efficiency. The experiments were designed according to international standard IEC 61591 and consisted in a reference exhaustion pipe, a compensation chamber, a flow measuring system and an auxiliary fan. The characteristic curves were determined by plotting the pressure for different volumetric flow rates, which were obtained by applying different pressure losses, which were controlled according to the selected orifice plate, installed mechanical valve position and frequency supplied to the auxiliary fan.

The operational range was validated through the evaluation of the installation line pressure drops and the exiting velocity profile. In order to understand the compensation chamber influence on the bench test flow, a laser visualization technique was applied on the outlet exhaust hood flow. Considering a particular model of an exhaust hood, performed bench tests allowed to obtain two operating points according to IEC 61591, of 225.63 m$^3$/h and of 315.43 m$^3$/h, which are close to the indicated by the manufacturer, with a maximum efficiency of 6.8%.

A computational fluid dynamic tool was used to estimate uncertainties associated with numerical modelling for different internal flow regimes. The particular case of an exhaust hood inner flow was simulated and a qualitative influence between its geometry and the velocity profile was inferred.

Main Publications:

Theme 7: Energy Planning

Increasing concerns with reducing GHG emissions continue to support the investment in the use of renewable energy, particularly for electricity generation. However, the intermittence of most renewable resources may create problems to electricity grids stabilization when renewable energy provides a significant share of the energy mix can create (Gerbelova et al., 2014; Lagarto et al., 2014). It is thus critically important to provide a set of solutions that may minimize this problem, and this include the use of “demand side management strategies”, as well as a combination of different generation technologies managed under the microgrids paradigm. This intertwines the reduction of electricity consumption with greater efficiency and flexibility in the grid management, namely by enabling a better match between supply and demand (Cardoso et al., 2014; Neves et al., 2014). The research agenda to promote the use of renewable energies and “demand side management strategies” requires advanced energy systems modelling capacities, which were developed at IN+ in several studies (Amorim et al., 2014).

In particular, the application of the developed modeling methodologies to isolated micro-communities allows the optimized use of local resources, thus reducing the need for fossil fuel imports (Paleta et al., 2014; Neves et al., 2014).

Main Publications:
- G. Cardoso, M. Stadler, M. C. Bozchalui, R. Sharma, C. Marnay, A. Barbosa-Póvoa, P. Ferrão, Optimal investment and scheduling of distributed energy resources with uncertainty in electric vehicle driving schedules, Energy, Volume 64, January 2014, Pages 17-30.

Theme 8: Urban Metabolism and Sustainable Cities; Industrial ecology

Major urban areas in the world are facing major changes in land use and on their interaction with the environment, mainly due to increased levels of economic development, resulting in most cases in a huge urban sprawl and changes in their form. This clearly establishes an intertwining between economy, environment and quality of life at an urban level, whose understanding requires a new
set of tools that may correlate the use of natural resources, economic activities and consumption patterns (Rosado, Niza and Ferrão, 2014).

The urban metabolism concept is grounded on the analogy with the metabolism of living organisms’, as cities can transform raw materials into infrastructures, human biomass and waste. It quantifies the amount of materials that are consumed by each economic activity in urban areas. We have developed a set of new methods for quantifying urban metabolism making use of national statistical data publicly available and scaling it down to an urban level (Marteleira, Pinto and Niza, 2012). Considerable advances were achieved aiming to develop straightforward methodologies to model the urban metabolism of world urban regions. Additional studies for urban sustainability include the uncovering of opportunities for waste management systems (Ferrão et al., 2014; Niza et al., 2014). Furthermore, the life cycle impacts of the EU28 mobility needs and of composites in Aerospace Applications have been studied, in cooperation with the Joint Research Centre and Rolls-Royce Power Systems, respectively.

Main Publications:


**Theme 9: Ecological Economics**

**NOTE:** This research theme was transferred to MARETC/LARSYS by the end of 2014

The analysis and modelling of the energy dimension of the metabolism of economies was continued, comprising the following research lines:

- Improving the useful work accounting methodology, and systematising it such that it can be automatically applied to several countries in parallel; with applications to Portugal (1856-2009), UK (18th to 20th century, in collaboration with Roger Fouquet), EU15 (1960-2009), Mexico (1960-2009). (Serrenho et al., 2015; Guevara et al., 2015a)
- Carrying out economic accounting with broader than usual definitions of the energy sector: at the useful work boundary (hence requiring estimates of the price of useful work); at the energy services boundary (hence requiring estimates of the price of energy services). (Santos et al., 2015)
- Studying the short and long run relations between different energy measures (namely primary energy, final energy and useful work) and economic variables (GDP, capital, labour), using a whole suite of techniques, including index decomposition, structural decomposition, co-integration analysis, Granger causality, estimation of production functions and growth accounting.

The most interesting results obtained are:
• A remarkable constancy of the useful work/GDP ratio in Portugal with a 20% variation around the mean in the 1856-2009 period, with the value in 2009 very close to the value in 1856 (Serrenho et al., 2015);
• For the EU15, in the period 1960-2009, the useful work/GDP is statistically constant along time and equal for all countries, after removing the effects of residential energy use (which is dominated by the latitudinal difference in countries regarding domestic heating requirements) and of high temperature uses (which reflects the very variable significance, along time and between countries, of heavy industry) (Serrenho et al., 2014)
• For Portugal, in the period 1960-2009, (Santos et al., 2015, in prep.) the results show that:
  o the Solow residual (or total factor productivity growth) is equal to 2/3 of GDP growth when only capital and labour are considered in growth accounting, but drops to 16% of GDP growth when useful work is also considered as a production factor;
  o there are two co-integration relations: (A) capital/labour with useful work/labour; (B) capital/labour with GDP/labour. (A) implies a very strong complementarity between capital and useful work as production factors which then implies that "effective" capital calculated as a function of useful work is a better predictor of GDP than "measured" capital.

Understanding these results and developing their policy implications requires looking at issues such as the effect of urbanisation, and namely city size, on energy use (Gonçalves and Domingos, 2014), the effects of sectoral disaggregation (Rodrigues, 2014), the rebound effect (Lopez et al., 2014), and scenarios (Brito and Sousa, 2014), the possibilities for reduced energy consumption through “dematerialisation” (Coroama and Hilty, 2014).

Main Publications:

**Theme 10: Ecological Metabolism**
NOTE: This research theme was transferred to MARETC/LARSYS by the end of 2014

The main developments regarding ecological metabolism were associated to: furthering the analysis of metabolism at the organism level, based on Dynamic Energy Budget theory (DEB); biodiversity and ecosystem services. A major step forward in widening the scope of application of DEB theory was taken by showing that the biological modelling of the popular ERSEM marine ecosystem model is in fact a particular case of DEB (Marques et al., 2014). Applications of DEB theory to holometabolous insects (Llandres et al., 2015) and albatrosses were developed (Teixeira et al., 2014).

Significant advances were made in relating biodiversity with human impacts (Hudson et al., 2014), namely land use change (Martins et al., 2014) and in particular agricultural activity (Sutcliffe et al.,
2014), and in analysing the possibility of regional scale regime shifts in biodiversity and ecosystem services (Leadley et al., 2014). At the policy level, a case study was carried out for the Institute for Nature Conservation and Forestry on Mapping and Assessing Ecosystem Services in Alentejo and development in the analysis of marine spatial planning (Santos et al., 2014a,b).

Main Publications:


**Theme 11: Waste characterization and management: physical and chemical processing**

Research activities have been dedicated to improve methods to promote the extraction of metals from natural raw materials (ores) and also from secondary raw materials, as described by F.Margarido, N.Vieceli, et al. (2014). The work includes research across several engineering domains, including materials characterization, physical-chemical and environmental analysis, physical separation (mineralurgical and other related techniques), chemical and metallurgical engineering, modelling, process development and design. Substantial research efforts have been dedicated to recycling and valorisation of residues in the scope of aluminium alloys from end-of-life vehicles (e.g., F.Margarido, et.al., 2014).

Main Publications:

Laboratory of Technology Management and Policy
The research work is described under 3 specific themes (Themes 12 to 14), under the overall concept described in the following figure.

**Theme 12: Science, higher education and policy**
Research on “science, higher education and policy” has focused on broad and overlapping issues between science and technology systems and higher education systems. It has contributed to the knowledge pool in both literatures, providing informed evidence with a key practical relevance for emerging and developing regions worldwide. We follow a systemic and thematic approach to our studies that are synergetic and feed into each other area (Heitor and Horta, 2013).

The research had a broad focus in terms of:
1) methodologies - several quantitative and qualitative methods were used, including narratives, regression analysis, event analysis and typologies of quantitative historical analysis;
2) geography - the research on science policy and higher education policy included several case studies focused on Latin America, Europe and Asia;
3) The studies specifically analyzed issues related to scientific capacity building, qualification of the labor force, and training of researchers and academics. They also focused on dynamics of leadership and collaboration in international research projects, determinants of research productivity and impact, organization and management of research institutes, academic mobility and trends of brain-drain, brain-gain and brain circulation.
The results show that public investment in knowledge continues to be critical to the formation, sustainability and growth of scientific systems. It was found to be key to allow for the attraction of highly qualified people and to the creation of global networks of knowledge. Other findings suggest that diversified scientific policies that are mutually supportive create synergies, which provide resilience to scientific and higher education systems to endure financial and economic crisis. The results also show the non-linearity of policies concerning the organization of research institutions, and that often counter-intuitive practices are required. These are related to strong leaderships that at the same time promote academic independence and the participation of junior elements its evolution.

During 2013 and 2014, a major effort was established in Europe to foster “Step4EU”, as an European wide, research-based, independent network aimed to foster new understanding driving future policies of science, technology and higher education across Europe, together with new observation activities, “informed participatory debates” and the engagement of scientists in policy action. It as evolved to give emphasis to policy oriented thematic research, to help building and deepening a new research agenda on science, technology, education and policy for Europe, in a way to better understand innovation as a long-term cumulative, collective and uncertain process, involving an extensive division of labour over many stakeholders. It will include the systematic observation of national policies and budgets, as well as the observation of the changing dynamic environment between large firms, small firms, academic and non-academic research institutes, higher education institutions, government research and individuals in the innovation process. Potential initial ideas include:

- Mobility of EU students, researchers and citizens, including detailed analysis for STEM and emerging issues associated with the impact of immigration policies on science, technology and higher education;
- Innovation networks and growth through a multi-institutional framework, including the need to consider collective action of a quite large range of institutions and funding agencies;
- Governance structures for science, technology and education in Europe, including the changing nature of the state and the of policy advise, as well as the debunking of public and private myths;
- The multiple interactions between knowledge production and diffusion with urban dynamics and the need to foster smarter citizens and the continuous designing of cities for knowledge.

BOOKS:

Other Main Publications:
- M. Heitor (2015), “How far university global partnerships may facilitate a new era of international affairs and foster political and economic relations?”, Technological Forecasting and Social Change, 95, pp. 276-293.
- M. Heitor and H. Horta (2015), “Reforming higher education in times of uncertainty: are illilities important?”, Technological Forecasting and Social Change, accepted for publication.
Theme 13: Industrialization and innovation dynamics; technical change and entrepreneurship

The rational for this research theme on industrialization and innovation dynamics is driven by the observation that industrialization has been the main driver behind rapid productivity growth achievement and social well-being improvements in different countries in the last 200 years. However, the weight of manufacturing in the economy has been decreasing substantially in many countries and regions, and production has been concentrating in certain regions, while others have been increasingly loosing their productive ability, leading to changes in employment, and raising new concerns.

The research agenda has addressed issues associated with industrialization dynamics (and related desindustrialization risk), considering development patterns through technical change, integrating emerging science and technology capacity, the role of entrepreneurial activity and the creation of new firms and industries (Mendonca and Faria, 2012). In particular, the research work has focused on economic impacts of entrepreneurship in terms of employment generation and innovation, as well as on the value of entrepreneurial human capital, exploring its linkages with firm performance and quality of job creation. The role of the new technology based firms is acknowledged and its relationship with FDI, internationalization and knowledge creation has also been also explored, with emphasis on Portugal and on the basis of specific employment data sets.

Five main topics were considered in 2014, as follows.

First, research was focused on the aeronautics sector, motivated by the recent installation of two new Embraer plants in Évora, Portugal. This focus led to the development of a project Innovation dynamics in aeronautics and Embraer in Évora: towards a distributed platform for entrepreneurial initiatives, new employment and skills development, which has successfully gathered funding from FCT within the CMU-Portugal partnership. The project includes as partners IDMEC/IST, INESC TEC, Carnegie Mellon University, Embraer Portugal and CEIIA.

Within this project, analysis is focused on the capacitation of suppliers network in selected regions, and on the identification of key players for its development. Our interest is on the development of
suppliers’ capabilities for integration on the aeronautical supply chain, including the technologies that allowed this, the processes that lead to this integration, and the capabilities for industrial development for the capacitation of the suppliers’ networks.

Second, research was initiated on the effects of the crisis on industrial dynamics, leading to another project approved for funding by ZEW, entitled Human capital formation in young firms and the crisis: A comparative analysis of Portugal and Germany. This project is being developed with the Institute for Employment Research (IAB) of the German Federal Employment Agency (BA), Brunel University London and Centre for European Economic Research (ZEW).

Third, the consequences of MNC subsidiary closures for employees who lose their jobs is not in depth studied in the literature. In particular, the extent to which the human capital that these employees acquired while employed by the MNC influences the wages they receive in their new jobs. An employee displacement model for foreign MNC subsidiaries is proposed integrating insights from the labor economics and international business literatures. A new employer will pay higher wages when signals indicate that potential employees have valuable, foreign human capital (e.g., the closed subsidiary was highly productive by host-country standards), and lower wages when signals indicate that potential employees have highly MNC-specific human capital (e.g., the employee had a long tenure in the closed subsidiary). Empirical evidence is provided based on a sample of 110,133 displaced employees of closed MNC subsidiaries in Portugal. The data set spans the period from 2005 to 2009. Showing that MNCs create a valuable pool of human capital for host-country firms when they close subsidiaries, our findings have important implications for research and practice.

Fourth, the role played by public and private funding in fostering high growth firms in Portugal was analyzed. The following research question has been addressed: i) What are the main characteristics of HGF in Portugal (when compared to regular firms) and to what extent public and private funding strategies contribute to the abnormal development of these companies? Final results have been analyzed and discussed within a public policy framework.

Fifth, technology-based business incubation in Portugal has been studied. The research has been based on secondary data from a unique database composed of 48 business incubators and covering nearly the population of Portuguese incubators. For the purpose of the present investigation, primary data was collected through interviews and a questionnaire to be designed and delivered to the Universities and Incubators’ Directors. Qualitative and quantitative statistical techniques will be employed to analyze the data and results. The research is expected to advance the current knowledge on universities’ strategy towards business incubation, with particular focus different performance measures among University and technology-based business incubators. It may bring potential added value as a University management and Policy making supporting tool.

Main Publications:

- Reis, A., Mendonça, J., Amaral, M., Heitor, M., On the changing nature of industrial production: implications for a research agenda in aeronautical industrial policy, in “University Evolution, Entrepreneurial Activity and Regional Competitiveness”, David Audretsch, Erik Lehmann, Michele Meoli and Silvio Vismara, Springer (accepted for publication)
• Amaral, M. (2014). “Entrepreneurial Survival among Chinese and Native Individuals in Portugal” (Under revision – international journal listed in ISI)
• Amaral, M., Caetano, D. & Singh, G. (2014). “University and Regional business incubators: competing or complementary models?” (Submitted – international journal listed in ISI).

Theme 14: Risk Governance, science systems and the social appropriation of knowledge

The rational for research has been driven by the need to help facilitating the social appropriation of knowledge towards designing resilient cities. Since 2012, the focus was on launching a team for innovative “hands on” approach based on the design of new engineering-based products and processes to help shape perceptions and peoples’ behaviour.

Three main topics were addressed in 2014, as follows. First, the analyses of risk mitigation considered non-communicable diseases (e.g., diabetes). The main goal has been to assess risk perceptions of lay people belonging to vulnerable communities and, in the process, to examine strategies of risk communication towards these groups. While early studies on risk perception were based on “unilateral” expert views (i.e., “methods of expert elicitation”), it has become more and more clear that the involvement of lay people in the process is critical for risk governance (i.e., to ensure their participation). But, and despite these new trends, vulnerable groups remain an outlier category of this type of analysis (Pádua and Custodio, 2012).

The research team used the knowledge representation approach developed by Morgan (2002) to identify misconceptions of groups from different cultural backgrounds towards diabetes. In summary, a major initiative on learning for uncertainty in urban contexts was developed, including actions to look at risk perceptions, risk communication and stakeholder engagement of lay people from vulnerable communities. The Mouraria neighborhood, in Lisbon, has been used for fieldwork.

Second, community-based learning experiments have been conducted over the last three years, involving engineering students and vulnerable communities in Lisbon to foster new spaces of learning. Under the name “Street Labs”, this program emphasizes application-driven projects (see

http://www.narua.pt/), including the development of new sensing devices and communication systems that help mitigate energy and environment related risks affecting those communities. Our study focused on assessing the impact of problem-based learning methodologies and their role in fostering technical competences and social responsibility among engineering students. An exploratory design using a multi-method approach was applied using qualitative and quantitative evidence.

Experiments were conducted by mobilizing groups of university students in a way that also provided new insights into university learning methods. In addition to look at ways of lay people addressing risks, our results provide new insights into the modernization of university education though “hands-on” experimentation in vulnerable communities and the socialization of knowledge and knowledge networks.

The results show that the diversity of individual learning styles affect the performance of students in their collective capacity to learn and on their impact in the communities. They also suggest that the way lay people learn with students and effectively form new and informal learning spaces depends on the level of trust among all parties involved. This is important because it highlights the need to further develop specific skills among engineering students, as they become active learners in contexts of social and economic uncertainty. Our findings deepen the understanding on how student-learning styles may affect the collective learning capacity of engineers acting in complex community settings. Additionally, it provided grounds to explore student-learning strategies of risk communication towards lay people, aiming to foster collaborative social engagement, co-creation, and mutual learning towards risk governance.

Third, complex systems were studied through innovation in the life sciences in a way to consider systems that are interdependent and in continuous change. One key issue is to know whether this kind of problem can be solved through a linear approach, ignoring how parts interact. It is shown that this an old debate that dates back to Leibniz and Newton and, based on an historical review (namely the Leibniz's trail, e.g., researchers that have made major contributions to conceptualise real complex problems) it is argued that even this type of problems are susceptible to be handled to some extent through a linear approach (e.g., hierarchy and decomposition apply to a certain degree). Ideas of Louis de Broglie were to discuss the nature of weak methods, which can be used to solve this type of problems.

Fourth, research has been conducted in terms of the analysis of the rate and available funding influences direction of scientific and technical change in the prevention of Malaria. This is because we still know little on how funding can help dealing with problems that go beyond a recombinatorial logic. Using the case of malaria research we discuss how different types of incentives can help renew scientific opportunities thus contributing to the reduction of a knowledge gap.

Main Publications:

- Pádua, M, Santos, J; Horta, H, Heitor M, (2015),“The link between literacy, risk perception and health outcomes in diabetes: an observational cross sectional study in urban vulnerable areas” to be submitted
• Pádua, M., Santos J., Horta H., Can improved education levels, risk perception and knowledge be related with reduced risk of getting diabetes in the elderly? submitted
3. Main Dissemination Activities (2014) and Conferences/events

Major actions referring to dissemination activities, International symposia, as well as the promotion of scientific culture and the social appropriation of knowledge are briefly described in the following paragraphs. The following events were organized in close collaboration with IN+ and its researchers:

18 December 2014: Centro Republicano Almirante Reis, RUA DO TERREIRINHO, 77, á Mouraria. 14h30-19h30: “Diálogos Urbanos”, presentation and discussion of student projects. 19h30: IN+ Christmas dinner and party

13 December 2014: Take a break and meet Giorgio Sirilli for a bike tour in Old Sintra

11th December 2014: Impacts of the Aircraft AMX’s Acquisition Program (1982-1994) on Technological Capability of Brazilian Aeronautical Industry Leader - Josiane Francelino (Instituto Tecnológico de Aeronáutica - Brasil)

11th December 2014: A Europa e a mudança tecnológica, o emprego e os desafios dos mais jovens - Se non ora, quando? - Se não agora, quando?

4 December 2014: Convite para o lançamento da obra "Princípios Fundamentais de Ecologia Física" da autoria de Prof Dr. Abel Rodrigues e Prof. Dr. Gabriel Pita


26 November 2014: "A Criatividade na Escola" - Theatro Circo de Braga

24 November 2014: Engenharia e investigação industrial, o Programa A+, Maia


17 November 2014: ISEG, Lisboa, Aula Aberta

10th November 2014: Design for Uncertainty, @ Porto

6-7 November 2014: step4EU Leipzig Policy Research Workshop

15-17 October: CISTP - Canadian Science Policy Conference 2014

14-16th October 2014: "Open Innovations" Forum 2014, Moscow

13th-14th October 2014: OECD-IRGC: Improving Risk Regulation

13th October 2014: Global Education Futures Forum, Moscow

9th-10th October: WavEC 2014: "Estados Unidos da América - Portugal: Fomentar o Crescimento Transatlântico das Energias Renováveis Marinhas", Lisbon

3rd October 2014: Workshop - "memória oral e história local", Vilarinho da Castanheira

23rd September 2014: Manuel Heitor at the Real Academia de Ingeniería de España, Madrid

9th - 12th September 2014: 14th ICTPI, Brno, Chek Republic

2nd - 3rd September 2014: Apropriação social do Conhecimento, IUPERJ, Rio e Janeiro

29 July 2014: A+ Workshop, at CEIIA, Porto
7th - 10th July 2014, International Symposium on Applications of Laser Techniques to Fluid Mechanics

4th July 2014: LARSYS 2014 annual event

1st - 2nd July: Professor Penev Seminars

30th June 2014: Covione & MIT Portugal Symposium


23rd - 25th June 2014: Technology, Management and Policy Graduate Consortium 2014 Meeting

Annual Meeting and External Review 2014

4th June 2014: Seminário Embraer – FAP, Sintra

2nd June 2014, at IST: Risk Governance for South Atlantic

28th-30th May 2014, at IST, Lisboa: 3rd KIC InnoEnergy Agenda (IST Main building)

29th-30th May 2014, IST: Workshop - Designing Applied Research Agendas: discussing the Fraunhofer approach

26th-28th May 2014: World Bank Conference on The "How-to" of Technology Acquisition, Innovation and Entrepreneurship on May 26-28, 2014 (Istanbul, Turkey)

24th May 2014: Visita / Workshop - Arqueologia Industrial Ferroviaria: A Linha de Foz Tua a Mirandela

22nd May 2014: BIOREG Research Workshop

20th May 2014 at IST: "A sua casa, a sua energia"

15th - 17th May: Sharing Knowledge across the Mediterranean, Pavilion of Knowledge - Ciência Viva

28th - 30th April 2014: OIPG, Rio de Janeiro

15th April 2014: Engineering Design Seminar

11th April 2014: Workshop - Science and Higher Education Policy in Europe (shep4EU)

3rd April 2014: Opening of the Whitelaw Lab, Imperial College London

26th-29 March 2014: FUTURÁLIA 2014

18th-20th March: IN+ no Forum Políticas Publicas, ISCTE

13th March 2014: Research Seminar at IN+/IST - "Organizing Applied Research - The Fraunhofer Model" - Dr. Georg Rosenfeld

6th Feb 2014: IN+ in the 24th anniversary of JUNITEC

6th Feb 2014: "Unemployment and money. The principles involved"

28th Jan 2014: Conferência Future Cities 2014, Porto 28 de Janeiro
Main Conferences and International Symposia

17th Intl. Symposia on Applications of Laser Techniques to Fluid Mechanics
7 – 10 July 2014, Lisbon, Portugal

The International Symposia on Applications of Laser Techniques to Fluid Mechanics, held biennially in Lisbon since 1982, have been a continually renewed source of state-of-the-art experimental fluid mechanics for three decades. This series, often referred to simply as the “Lisbon Symposia”, was conceived and founded by James H. Whitelaw in 1981. The organization in Lisbon was initially chaired by Dimantino Durão and, then, by Manuel Heitor for the period 1992-2004 and by António Luís Moreira since 2006. All the papers presented since 2000 are available for download in http://ltces.dem.ist.utl.pt/lxlaser/.

There is no doubt that laser techniques now represent the most important diagnostic tools in experimental fluid mechanics. Technological developments in lasers, detectors, electronics and computers have continued to be the source of new techniques, improved accuracy, higher spatial or temporal resolution and new applications. This progress promises to continue in the future. The last symposium (16th Symposium) was organized in the period 9-12 July, 2012.

In July 2014, the Lisbon Symposia marked 32 years of promoting the development of advanced Laser techniques for flow measurements. Scientific contributions to the theory and practice of measurement methods are welcome where they facilitate new improved fluid mechanic investigations. Applications are also welcome, including their use to develop physical models and to validate numerical predictions. The Symposium calls the attention of all those working on cutting edge fields of microfluidics and biofluidics, such as on the analysis and development of BioMEMS, the macro-molecular transport in bio-system or the development of optical techniques for molecular imaging.

SPEIC14 – “Towards Sustainable Combustion”
November 19-21, Lisboa, Portugal, Novembro 2014.

SPEIC14 is the scientific conference on Combustion and related fields, jointly organized by the Portuguese and Spanish Sections of the Combustion Institute. The Conference addressed the following topics, with a special emphasis on sustainable combustion: Reaction kinetics, and large-molecule (soot, PAH, dioxines) phenomena; Flame theory; experiments and calculations of laminar and turbulent flames; single or multiphase; New diagnostic techniques; New computational methods; Sustainable combustion: Oxycombustion, chemical looping, hydrogen and syngas combustion, biomass combustion, mini- and microcombustors, and other novel combustion processes; Combustion systems: ICE, gas turbines, furnaces; The ignition and propagation of fires in the natural and built environments.

National Conferences

Dialogues in “Science, Technology and Society” (http://in3.dem.ist.utl.pt/dialogues/)

A space for interdisciplinary conversations about contemporary issues in science, technology and society that are relevant to people in fields such as history of science,
sociology, and public policy. We want to engage not only those who are working on intersections of science and public policy, but also those in the natural sciences, engineering, and architecture who have serious interest in exploring these areas together with social scientists and humanists."

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**Workshops on Industrialization, Geography and Policy**

The workshop series on INDUSTRIALIZATION, GEOGRAPHY AND POLICY was launched in 2012 in close cooperation between IN+ and IRGC-Portugal aiming to help to understand the risks of deindustrialization and the dynamics of technological change to build socioeconomic resilience. This is because there is a raising - and justified - concern that deindustrialization is hampering growth and undermining the competitiveness of developed economies leading to loss of jobs. Understanding deindustrialization processes over the last decades in many regions worldwide and related risks associated with the dynamics of the geography of innovation will allow framing new industry and technology policies leading to socioeconomic development and resilience.

**Engineering Design Roundtables**

The Engineering Design Roundtables aim to exchange ideas on critical issues to foster crosscutting and trans-disciplinary competences in “engineering systems” towards new product development, exploring solutions for complex industrial problems through project-oriented and project-based activities. In order to achieve these objectives, the Roundtables bring together doctoral students, researchers and experts from industry and government to discuss new frontiers in product development, new technical developments and project-based activities.

These events offer a space for interdisciplinary conversations about contemporary issues in engineering, including the emerging context of uncertainty in industrial development at a global level. Emphasis is given to the development of skills and related opportunities for new entrepreneurial activities and other challenges faced by modern engineering. We want to
engage not only those who are working in engineering, but also those in the arts, natural sciences, architecture and business who have serious interest in exploring these areas together with engineers.

Details are at:  

Aeronautics Innovation Roundtables: Uncertainty, Globalization and Skills;  
"Non-auto transportation equipment production has been a major contributor to job losses in the tradable sector in the US since 1990, and the vast majority of the loss occurred in the aerospace" (Spence and Hlasthwayo, 2011). This has been mainly associated to relocation of production and shifts in investment in certain fields. In the US, sectors such as air and spacecraft have lost 30% of their jobs in a 30-year period, and machinery and equipment, including computer, electronic and electric products and instruments have lost 45% of the number of jobs in the same time period, while increasing value added. At the same time, there was a growth in the number of jobs in certain tradable services, such as the computer systems design and related services, and management, scientific and technical consulting (Acs and Armington, 2004).

Labor productivity growth is increasingly being concentrated in knowledge intensive activities, ICT services and high technology and medium high technology manufacturing. Trade in high technology goods, such as aircraft, computers, pharmaceuticals and scientific instruments, accounts for more than 25% of total trade, which represents a significant increase over the last two decades (Markusen et al., 1986). This trend is followed by an increase in the generation and use of knowledge through investments in R&D, use of ICT, patenting, and development of scientists and engineers in the OECD countries (OECD, 2010).

The aeronautic sector is highly dependent on ICT technologies and systems for product design and the management of complex supply chains, is knowledge intensive, and represents an important case of innovation towards industrialization. The aircraft industry has been considered of strategic importance for nations due to their potential contribution to industrial dynamics, innovation, human capital development, enhancement and maintenance of national security systems and socioeconomic development in general. In fact, it has been the most important industry to US economy in terms of skilled production employment, value-added and exports (MacPherson and Pritchard, 2003).

The issue is how regions and economies develop processes of transforming human capital into competitive advantages in different sectors, and are able to contribute to knowledge generation and commercialize technology and from their acquire socioeconomic resilience. Or, in other words, how can regions benefit and use their increasing knowledge capabilities given by the growing levels of education? In addition, how far we all take advantage of opportunities that arise with the increasingly dynamic and globally distributed geography of innovation, as well as how it fosters a new global order and helps others to use similar advantages at local levels is an open question.

Details at:  

Student events and promotion of scientific culture  
ThermoCup – Steam Boat Regatta (2014):  
Development of "scientific toys" by students in the context of active-learning to exploit knowledge between theory, practice and free trials. The optimization of a handmade steamboat is supported by the general skills acquired and being acquired within the 1st cycle of University studies and in particular in the course of “Thermodynamics I”. The working principles of the steamboat are also used in theoretical classes of Thermodynamics to explore energy conversion cycles and the transfer of mass and energy processes.


**Laboratórios na Rua** (http://www.narua.pt/)

Beyond the research activities described before, “Laboratórios na Rua” also considers an University-based Platform for students and researchers volunteering, community social work practice and knowledge diffusion in urban context. Multidisciplinary teams of students and researchers work on projects in collaboration with community partners, field practitioners, and experts in relevant fields. Participants are involved into a broad set of activities aiming at designing engineering products and processes to mitigate risks in vulnerable urban contexts, including non-communicable diseases and other typical risks affecting the daily life of citizens, through filed research, experimentation and community dialogues. The main goal is to promote a new understanding of communication systems to engage and empower community-based innovations and help changing consumer’s behaviors. Projects have been developed in a few critical zones in Lisbon, including Mouraria, Bairro Padre Cruz, Barreiro, among other social residential areas.

**Urban Dialogues –Risk and Resilience:** http://www.narua.pt/encontros_dialogos.asp

A space for community conversations about local development patterns. Includes issues in science, technology and society with direct relevance to specific communities. Emphasis is on vulnerable and risk communities and issues.

Main events realized in 2014, as described in http://www.narua.pt/encontros_dialogos.asp.

“Se non ora, quando? - Se não agora, quando?”

Free Seminars for students, science, technology and education policy, December 2014-May 2015
4. Advanced Training (Master, doctoral and post-doctoral)

The R&D activities performed at IN+ have been developed in close collaboration with various post-graduation programmes at IST, with emphasis on several mechanical and environmental engineering related degree programmes. Members of IN+ directly coordinate three main PhD programmes and an Executive master, and these programmes have been particularly developed making use of IN+ resources.


Coordination: Paulo Ferrão

The Sustainable Energy Systems Doctoral Program (SES PhD) was launched in 2006 and considers a three- to four-year degree jointly offered at each of the Portuguese Institutions participating in the MIT Portugal Sustainable Energy Systems Program. The objective of the PhD Program on Sustainable Energy Systems is to use a multi-disciplinary approach to educate a new generation of sustainability-aware leaders with expertise in energy systems and economics. A focus on energy system design and analysis, research, and leadership and entrepreneurship provides graduates with the tools to be at the forefront of sustainable energy systems development.

The PhD Program emphasizes the policy and technology development necessary for the successful design and implementation of alternative energy strategies. Students have the opportunity to learn about the practical application of energy strategies through real-world case study research in conjunction with corporate and industry partners or affiliates.

The Program includes one year of coursework, including doctoral seminars. Students conduct dissertation research for 2 to 3 years, in the following areas:

- Sustainable Built Environment
- Energy Planning, including Economics
- Smart Energy Networks

The SES Doctoral Program welcomes candidates with engineering or management backgrounds. Candidates must be highly motivated to conduct innovative research activities, and must also demonstrate strong communication, leadership and entrepreneurship skills. SES PhD graduates will have the tools to play leadership roles in implementing sustainable energy policies and developing new business opportunities.

The SES Doctoral Program is a joint initiative offered by four universities in Portugal collaborating in the context of the MIT Portugal Program including the Technical University of Lisbon (Instituto Superior Técnico - IST, and Instituto Superior de Economia e Gestão - ISEG), the University of Porto (Faculty of Engineering, FEUP), the University of Lisbon (Faculty of Sciences, FCUL), and the University of Coimbra (Faculty of Economy – FEUC, and Faculty of Sciences and Technology - FCTUC). All the universities share a common core curriculum, and students can personalize their Program by selecting elective courses at any of the five schools that meet their specific interests and course requirements.
Coordination: Paulo Ferrão

The SES Executive Masters program was launched in 2006 (together with the PhD programme described before) as a one-year program offered at the Technical University of Lisbon and the University of Porto. The objective of the Executive Masters program is to educate mid-career professionals in energy systems and economics using a multi-disciplinary approach. With a focus on energy system design and analysis, as well as leadership and entrepreneurship, graduates will be at the forefront of sustainable systems development.

The program focuses on the policy and technology development necessary for the successful design and implementation of alternative energy strategies. Students have the opportunity to learn about the practical application of energy strategies through real-world case study research conducted in conjunction with industry partners. The Executive Masters helps students to develop an entrepreneurial spirit and to extend their professional and academic networks, promoting new job opportunities for them.

SES Executive Masters graduates will have the tools to play leadership roles in implementing sustainable energy policy and developing new business opportunities. Students may proceed to the PhD program as long as they fulfill the requirements and are approved by the SES Educational Committee.

The Executive Masters Program is a one-year (280-hour) program addressing multidisciplinary core areas in energy systems, including:
- Economics, management science and policy
- Environmental analysis and assessment
- Energy systems
- Energy technologies

The executive Masters corresponds to an Advanced Studies Program in the Technical University post-graduation system (the graduate is awarded a Bologna 3rd Cycle certificate). Each student in the Executive Masters Program creates a unique curriculum to fulfill her/his individual interests. Guided by a faculty member, the student is allowed to choose from a pool of optional courses (O) in order to complete 48 to 60 credits (ECTS).

Coordination: Manuel Heitor

The Doctoral Program on “Engineering and Public Policy, EPP”, was launched in 2009 at IST-Lisbon (Technical University of Lisbon) aiming to foster in-depth research of issues in science, technology and public policy in which the interaction of technology, humans and institutions are of central importance. The conditions for the social construction of technological systems in both developed and developing societies will be addressed in terms of their impact on the emergence of new social realities in those societies, including Portugal, and their potential as factors of economic and social development on a global scale. To achieve theses goals, science and technological development case studies will be developed worldwide.
The Doctoral Program on “Engineering and Public Policy, EPP”, at IST-Lisbon (Technical University of Lisbon) is currently running in close collaboration with a similar Program at Faculdade de Engenharia da Universidade do Porto (FEUP-Porto), allowing double-degrees with Carnegie Mellon University.

In addition, the possibility for research residences (between 6 and 18 months) in leading research and academic institutions and programs combining S&T expertise with public policies objectives are considered, including MIT, Harvard Kennedy School, EPFL, Tsinghua, Hong Kong University, UNICAMP, USP, UFF and UFRJ. The goal is to engage doctoral students in in-depth research of science, technology and policy issues in leading academic and research institutions in North America, Europe, China and Brazil, involving evidence-based analysis and the preparation of case studies in developing and developed countries and regions.

While bearing in mind the shaping factors of the emerging globalized economies and the current international financial crisis, the program focus on the following five main application areas, for which the interaction of technology, humans and institutions play a central role:

- **Industrialization, geography and policy**, with a clear focus on industrial policy and guiding S&T competences towards "modern manufacturing", in a way to contribute to productivity together with job creation;
- **Networked and critical infrastructures**, focusing on both technology and policy and giving priority to: i) energy systems and their integration with information and communication technologies, including the integration of renewables in the energy network; and ii) telecom security, including regulatory frameworks;
- **Knowledge for development**, with emphasis on developing countries and considering emerging understanding of science and higher education policies and forms of government–industry–university relationships. The main goal is to help training the future generations of science and technology policy leaders in developing and emerging countries and regions, including Portuguese-speaking countries.
- **Risk governance**, with emphasis on “design for uncertainty” in industrial and urban contexts, facilitating societies to benefit from technical change, while minimising the negative consequences of associated risks. Includes risk communication and processes of stakeholder engagement, as well as the analysis of practices and behaviors (e.g., consumer behavior in the rational use of energy).
- **Regulation and policies towards emerging forms of technological innovation**, with emphasis on adaptive regulatory frameworks and including the analysis of new convergence paradigms among health sciences, physical sciences and engineering (with particular application in bioengineering).

To address these issues, students are prepared in technology and policy analysis, decision making for uncertainty, the social construction of technological systems, and the managing R&D at a global scale, together with international flows of human resources.

Overall, EPP is a research-based program, with significant breath and depth, able to promote the learning ability of scientists and engineers to integrate new competencies in systems, management and policy and an “elite” of graduate experts with transdisciplinary skills acquired in close international collaboration. The ultimate goal is to help training the future generations of science and technology policy leaders.
PhD in Program in Leaders for Technical Industries – Engineering Design and Advanced Manufacturing (LTI-EDAM)

Coordination: Manuel Heitor

LTI/EDAM is a research-based doctoral program, aimed to explore solutions for complex industrial problems through problem-oriented and project-based activities. In order to achieve these objectives, the program emphasizes basic research in “engineering systems”, together with project-based activities in engineering design and advanced manufacturing, making use of a strategic partnership involving IST/FEUP/UMinho, together with MIT. The program is based on individual student research plans, including two main parts, as follows:

Research thesis (180 ECTS): Every student should propose a dissertation topic to the Program Scientific Council (PSC), together with a supervisor, co-supervisors (if applicable), and a Dissertation Committee (DC), in order to monitor and step up research activities, following internal rules, including:

- The student must identify the supervisor and, where applicable, co-supervisors, together with the DC during the program 1st year, preferably before the end of the 1st semester. This process is supposed to start at the preparation stage of applying to the program and must be concluded as soon as possible, so that the student concentrates in his/her research activity;
- The student must identify and plan adequate research residences in research laboratories at IST/FEUP/UMinho, as well as in MIT, as adequate. This requires the identification of research supervisors in the institutions selected.
- The DC consists of at least 4 people and must guarantee the multidisciplinary nature of the program. The DC must meet with the student at least once a year during the doctoral program and submit written recommendations to the student and the PSC.
- All the students should clearly identify the best way to develop their own research work under the strategic partnership involving IST/FEUP/UMinho, together with MIT. This requires the individual student research plans consider research periods in at least two different institutions and the co-supervision by faculty and researchers associated with the various partner institutions.

Doctoral Courses (60ECTS): Every student must follows the four following “tracks”:

- Research track: oriented towards the student thesis work and aimed to guarantee an effective research-based orientation of every student track since the early stages (i.e., since the very first day of student enrollment in the program). It should involve research residences in at least two different research laboratories and in one industrial environment, preferably in the first year, but to be completed before the end of 2nd year.
- Seminar track: involves the active participation in “design research seminars”, along the full duration of the program. It is compulsory in the first year and it should be oriented towards writing a research paper in close relation with the research residences to be developed under the “Research track”.
- Academic track: It involves 5 academic courses. It should last up to 24 months, preferably 12 months. It is based on “Problem-oriented, project-based” courses, oriented to help students writing research papers in the context of their doctoral thesis. It may consider options to be proposed by students, in order to foster student autonomy. One of this options may involve the practice of “Teaching Assistantship”, guaranteeing that each students works as “Teaching Assistant, TA”, for at least one semester.
- Transferable skills development track: to foster students skills in knowledge diffusion, innovation and technology leadership, as well as in understanding the job market and challenges for industrialization. It involves teamwork and the development of entrepreneurial-based projects.
This program stands out from doctoral programs offered in traditional areas of engineering through the development of crosscutting and trans-disciplinary competences in “engineering systems”. This should be achieved through a strong inter-institutional cooperation and industry relationships, to be based upon the individual student research plans. This includes:

- Students should perform research residences across the institutions involved in Portugal (IST, FEUP, UM) and at MIT. It is expected that, at least, all students awarded with FCT grants develop their research at least in two Portuguese institutions and at MIT.
- Student supervisory teams should emphasize inter-institutional arrangements, preferably identified under the cooperation among IST, FEUP and UMinho, as per the program approved by the Foundation for Science and Technology, FCT under the MIT-Portugal Program. Within this framework, the DC must consider enhanced cooperation at national level, namely through student research residences at IST, UM and FEUP, among other potential partner institutions.

The DC must also ensure that enhanced cooperation with MIT is promoted, mostly in order to make sure that all student experience research periods at MIT. The joint co-supervision of students by MIT faculty members should be promoted, if adequate.
5. Brief Plan of Activities for 2015-2016

The paragraphs below describe main issues to be considered in the proposed plan of activities for 2015-2016 at IN+. The Center was actively involved during 2013 in the preparation of the proposal for to renew and extend the contract with the Portuguese Science Foundation, FCT, through the Associate Laboratory LARSyS, “Laboratory of Robotics and Engineering Systems”. The new contract was approved by the end of March 2015, for a period of 6 years, 2015-2021.

The new institutional context: LARSyS, an Associate Laboratory

The new proposal considers a new configuration for IN+ and for LARSyS for the period 2015-2021. It brings together (from January 2015) four R&D units, involving the University of Lisbon (through IST-Instituto Superior Técnico) and the University of Madeira:

1. Institute for Systems and Robotics of IST (ISR-IST);
2. Centre for Innovation, Technology and Policy Research of IST (IN+/IST);
3. Marine Environment & Technology Centre of IST (MARETEC/IST)
4. Madeira Interactive Technologies Institute at the University of Madeira (MITI).

Through this association, which emerged naturally from previous consortia, LARSyS seeks for enhanced capacity to foster research at new frontiers of knowledge at the best international level. It considers researchers from different backgrounds and perspectives acquired in different areas of science (e.g., experimental, computational, and theoretical) and different sectors (university, industry, governmental, and regional administration).

LARSyS operates through its four research centers, which provide specific areas of expertise in their main domains of knowledge. They involve ten Laboratories and/or Groups, affiliating researchers in a way suitable to conduct specialized work in their main fields of expertise and to provide the necessary knowledge and experience to foster LARSyS’s scientific program, as follows:

1. Dynamic Systems and Ocean Robotics group. DSORG @ISR aims: i) to study challenging theoretical problems in the areas of advanced marine robotic vehicle systems design, navigation, and control and ii) to exploit the theoretical methodologies developed to yield efficient systems and tools for ocean exploration and exploitation.
2. Evolutionary Systems and Biomedical Engineering group. LaSEEB @ISR is dedicated to research and development in Biomedical Systems and Engineering, with emphasis on the study of human brain function, with applications in sleep and cognition, and more recently in pathologies such as epilepsy, dementia and cerebrovascular disease.
3. Intelligent Robots and Systems group.IRSg @ISR research approaches complex systems from a holistic standpoint, rather than focusing on some of the subsystems. The topic of cooperation is currently the group major research topic.
4. Signal and Image Processing group. SIP Group @ISR conducts research related to information processing from sensory data: Sensor and Information Networks, Ocean Acoustics, Image and Video Analysis and Biomedical Engineering.
5. Computer and Robot Vision group. VisLab group @ISR conducts research on computer and robot vision, focusing on video analysis, surveillance, learning, humanoid robotics and cognition.
6. Laboratory of Thermofluids, Combustion and Energy Systems. LTCES @IN+ the research has a background on experimental and mathematical/physical modeling of thermal-fluid-dynamics and combustion systems making use of advanced techniques for flow measurements focused in understanding the fundamental relationship between concurrent thermodynamic transports phenomena involved in energy conversion processes.
7. Laboratory of Industrial Ecology and Sustainability. LIES @IN+ includes a multidisciplinary group dedicated to develop models that can be used to support decision making in a set of
diversified but correlated areas ranging from the urban to the national or international scales.

8. **Laboratory of Technology Policy and Management.** LTPM @IN+ aims to foster policy analysis of emerging issues in science, technology and industry with emphasis on in-depth policy formulation and the need to secure the sustainable development of our societies.

9. **MITI - Madeira Interactive Technologies Institute.** M-ITI operates in the interdisciplinary domain of Human-Computer Interaction (HCI), with the goal of engaging in important scientific and technological challenges (e.g., aging population, sustainability in smart cities and digital culture).

10. **MARETEC - Marine Environmental Technology Center.** MARETEC research is focused on marine energies, environment and on environmental economy and economy of the energy.

The research agendas of the various Laboratories and/or groups is complemented and extended through “Thematic Areas”. On the top of that structure, the strategy of LARSyS is promoted and implemented through six Thematic Areas. They aim to explore new frontiers of knowledge driven by needs and markets as we envisage them today, making use of target objectives and linkages with end-users. They consider emerging themes under, on, above, in and beyond our daily human life.

Each Thematic Area has been defined together with a main target in a time horizon of 15 years (2030), without prejudice of involving other projects. They include five “Areas of Application-driven Research” and one area of “Fundamentals”. They provide a matrix-based form for the organization of LARSyS, facilitating networks of researchers from the various centers and groups to foster the exchange of ideas across disciplines and the exploration of new frontiers of knowledge in emerging themes.

The five Thematic Areas of “Application-driven Research” are as follows:

1. **OCEAN EXPLORATION and EXPLOITATION**, relying on competences and human resources of DSORg (ISR/IST), MARETEC, LTPM (IN+/IST) and MITI.

2. **URBAN SYSTEMS**, relying on competences and human resources of SIPg (ISR/IST), MARETEC, LIES (IN+/IST) and MITI.

3. **AERONAUTIC and SPACE SYSTEMS**, relying on competences and human resources of IRSg and DSORg (ISR/IST), MARETEC, LTCES and LTPM (IN+/IST) and MITI.

4. **ENGINEERING FOR AND FROM THE LIFE SCIENCES**, relying on competences and human resources of SIPg, IRSg, LASEEBg and VISLAB (ISR/IST), LTCES and LTPM (IN+/IST) and MITI.

5. **COGNITIVE ROBOTS AND SYSTEMS FOR ASSISTED LIVING AND WORKING**, relying on competences and human resources of VISLAB and IRSg (ISR/IST), LTPM (IN+/IST) and MITI.

The Thematic Area of “Fundamentals” consider formal and informal networks of researchers, from various centers, aimed to explore new frontiers of knowledge in themes without any specific known application. They consider basic knowledge beyond our current applications. It is named as follows:

6. **DISTRIBUTED INFORMATION PROCESSING AND DECISION MAKING**, relying on competences and human resources of SIPg (ISR/IST), DSORg, IRSg (ISR/IST), MARETEC, LTPM (IN+/IST) and MITI.
The new Configuration of IN+

The reconfiguration of LARSyS will involve part of the current researchers of the LABORATORY OF INDUSTRIAL ECOLOGY AND SUSTAINABILITY, who will be transferred from IN+ to the Research Unit MARETEC, under the overall scope of LARSyS.

For that reason the full research team will drop in 2015 to about **21 doctorate researchers, 4 Senior Research fellows** and **45 Research students**, as listed below.

Details can be found in:

### Full list of Researchers:

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<th>Doctorate researchers</th>
<th>Full list of Researchers:</th>
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The main research challenges for LARSyS and IN+
The ultimate goal of LARSyS is to be actively involved in a new generation of research questions and issues in Robotics and Engineering Systems and researchers at IN+ aim to contribute for that goal.

Regarding ocean exploration, IN+ researchers aim to promote the necessary industrial policies to secure new mineral, hydrocarbon, and offshore energy resources in a way to help maximizing deep-sea exploration. They will facilitate the necessary risk-preventing mechanisms and a web-based Observatory for participatory risk governance in South Atlantic.

In relation to urban systems, IN+ researchers aim to develop the necessary knowledge base to support a reduction of 20% of the water supply and 50% of the energy associated to the supply and treatment of the water and wastewater in urban regions. Lisbon region will be our main case study, but the tools and pilots developed will be able to be replicated elsewhere.

In addition, our target is to help increasing significantly the amount of exports of engineering products and services from Portugal in the area of aeronautics and space in a time horizon of 2020. This will be attempted by deepening the understanding of new technology and business dynamics along the full value chain in association with the installation of Embraer in Évora, as well as emerging challenges open to related industries in the area of engineering systems.

In the biomedical area, our researchers will design new MEMS. They are targeted to design, build and foster a new generation of diagnostics.

To succeed in all the above-mentioned application fields, we need to explore new frontiers of knowledge in themes associated with large-scale distributed decision. Our target is to enable new knowledge in network science to undertake core challenges such as distributed optimization and decision-making for large-scale dynamic networks, Big Data processing, and user communities’ representation for pro-social behaviors and actuation upon them.

Overall, our researchers at IN+, together with those across LARSyS, aim to contribute towards new frontiers in Engineering Systems, covering social-technical systems, as well as policy research dealing with uncertainty and risk governance.

The specific research plan for IN+
The plan is presented in terms of the proposed activities under the three Laboratories and the two research programmes established at IN+.

LABORATORY OF THERMOFLUIDS, COMBUSTION AND ENERGY SYSTEMS
The research groups involved in this Laboratory are focused in understanding the fundamental relationship between concurrent thermodynamic transports phenomena involved in energy conversion processes. Within this framework, the group is now combining efforts in developing mathematical/physical models to downsize of energy conversion systems. Flow phenomena occurring in microfluidic devices will be analysed, with and without chemical reaction, towards the development of new theoretical and empirical models for micro-scale flow phenomena, as well as on the design on new practical systems. It is a multidisciplinary research field, combining branches of physics, mechanics, optics and fluid dynamics with chemistry.

The general objective is to develop and use different tools and new approaches to support the development of energy sustainable products towards consumers, e.g. ranging from heating/cooling suppliers to medical devices.
The main topics include:

**A) Study the dynamics of interfacial transport phenomena in multiphase systems with phase change.** The goal is to pursue on the hierarchical complexities of pool boiling, of a velocity boundary layer flow at a flat interface and of liquid flow in micro-channels with phase change. The study must address: i) The interfacial effects and transport phenomena associated with surface tension gradients caused by temperature and concentration variations on bubble interfacial shape and dynamical behaviour including nucleation, bubble motion and coalescence; ii) The effects of surface topography and free surface energy on interfacial transport phenomena during liquid nucleation boiling; and iii) to develop/built appropriate experimental techniques and/or methods to quantify the physics of dynamic interfacial transport phenomena or processes including jet-like flows, bubble interaction and spatial scale effects.

Most activities have been developed in international cooperation with international research teams, namely:

- Center of Smart Interfaces, Technischen Universität Darmstadt, Germany  
  Professor Ilia Roisman; Equilibrium and dynamics of liquid/solid interfaces
- Università degli studi di Bergamo, Italy  
  Professor Marco Marengo; Progress and developments on the preparation of superhydrophobic surfaces
- Universität Stuttgart, Germany  
  Professor Norbert Roth, Institute of Aerospace Thermodynamics, Germany; Collisions of droplets of complex fluids
- Technology School Southampton Solent University, United Kingdom  
  Professor Kalin Penev, Thermal management of computer processors
- Institute for Bioinspired Structure and Surface Engineering, Nanjing, China  
  Create and control of wettability for the transport of fluids

**B) Combustion Dynamics and burner design.**

- **The Dynamics of Flame anchored in micro burners.** The research work will deal with the competing effects between heat- mass- and momentum transfer on the dynamics of small flames anchored on mini burners burning blended fuels. The work must address the influence of heat transfer and flame-to-flame interaction on NOx emission and lean stabilization limits, for geometries of mesoscales. Much effort will be given to the use of non-intrusive diagnostic technique (PIV) to continue the study about the flow pattern in between the holes.

- **The dynamics of spark discharge:** The research work must focus on the support of the mathematical modelling of a fast transient process focusing on:
  - Determination of Townsend coefficients for gaseous mixtures
  - Quantify the voltage breakdown for gaseous mixtures
  - Modelling the heat transfer process to electrodes
  - Evaluate the mathematical model to obtain pressure-temperature-density in transient process of spark discharges for gaseous mixtures

  The main objective is to understand the influence of the electrodes shapes (drain energy by convection-conduction) and the flow inter-electrodes on the ignition failure under lean mixture.

International cooperation activities and main research Projects (on-going), including with industry, include:
• **TANGO** - Marie Curie Initial Training Networks (ITN) Call: FP7-PEOPLE-2012-ITN, IST as associated partner. The research in TANGO is intended to address fundamental studies on thermo acoustic instabilities in gas turbine combustion chambers.

• **Design methods for durability and operability of low emissions combustors**

  Duration in months 36 Call (part) Identifier SP1-JTI-CS-2013-01, IST and UNIVERSITAT POLITECNICA DE CATALUNYA, Clean Sky proposal JTI-CS-2013-1-SAGE-06-005. Large Eddy Simulation (LES) models will be used to characterize the turbulent behaviour of the flow in the combustor under lean working conditions. (waiting)

• **Bosch Low Nox burners.** This work addresses a study of a burner system from a water-heater unit focusing on the analysis of flame stability and pollutant emission as a function of power, equivalence ratio and burner geometry, towards controlling the pollutant NOx/CO emissions. (Intellectual property procedures - waiting)

• **Noise control of Domestic exaust system-TEKA.** Identification of noise sources in exaust system. Redesign of attenuators and ventilator turbine to reduce noise emission. The work will base on experimental and numerical approach (Project starts in 2014).

• **UnBrasilia Cooperation on:**
  - the development of acoustic micro probes to be used in propellers (Prof. Marcus Vinicus-FT-LEA)
  - project about burning of biofuels-complementing the life cycle assessment of green fuels with optimum burning conditions to define a GreenFuelOptimumIndex (GFOI). (Prof. Armando Caldeira-Pires, FT-LEA)

The activities of the Laboratory includes the organization, every two years, of the International Symposia of Applications of Laser technics to Fluid Mechanics, which has been organized in Lisbon since 1982. The next edition will be in July 2014.

**LABORATORY OF INDUSTRIAL ECOLOGY AND SUSTAINABILITY**

Integrated models of environment-energy-economy interaction will be developed, at multiple spatial scales (cities, regions, countries), using models such as input-output, computable general equilibrium models, and economic growth. These will be used to support policy making on sustainable use of energy and raw materials in general, and regional, urban and rural sustainability planning in particular. Based on these models, work will be carried out in the development of sustainability assessment tools and indicators, e.g. Green GDP, ecological footprint and human appropriation of net primary production.

Given the past experience of this laboratory’s research team, particular focus will be given to the environmental themes of solid waste, greenhouse gases and carbon sequestration.

Urban metabolism will deserve particular attention, focusing on developing spatially comprehensive and temporally broad physical models of resource consumption of urban centers. Additionally, energy and materials consumption in buildings and new and innovative solutions to promote the concept of "Sustainable Buildings" will be studied.

In the context of the sustainable energy systems, which will constitute a major research area, the design of future intelligent energy and transportation systems which are "green", "smart", and "efficient", requires an understanding of a region's current systems, including detailed characterizations of its energy networks, supplies, and demands, and of the main factors influencing the evolution of those supplies and demands, including multiple renewable resources, and socio-economic and behavioral dynamics.
A major research topic is the development of models to facilitate the penetration and integration of forms of renewable energies. The need to foster aggressive energy efficiency end-uses introduces a new set of issues in energy systems planning that the current tools are not able to answer. This includes developing models that resolve the hourly dynamics of renewable resources in order to evaluate accurately the match between demand and supply; it is necessary to include the demand dynamics to evaluate accurately the impact of demand side management strategies like load shedding or load shifting.

LABORATORY OF TECHNOLOGY MANAGEMENT and POLICY
For 2014-2016 the research agenda for this Laboratory will emphasize three main thematic areas, as follows.

Research on science, higher education and policy will continue to focus on issues of key practical relevance for emerging and developing regions worldwide. We follow a systemic and thematic approach, analyzing from an historical perspective the evolution of science and higher education systems and the roles of policies, resources, investment and reforms on the development of those systems. Thematic studies performed over the last years include the analysis of academic inbreeding, the teaching-research nexus and knowledge sources, making use of quantitative and qualitative methodologies. They consider the growing complexity of knowledge systems, as well as the uncertain and complex conditions that societies in general are experiencing under globalized dynamics.

Special emphasis will be given to build and foster Step4EU is aimed to foster the systematic observation of science and technology, higher education and public policy in Europe based on in-depth research. The results will be publicly disseminated and available to policy-makers, scientists and, in general, to citizens, as well as actively communicated to them through “informed participatory debates”. In addition, the engagement of scientists in policy action will be attempted throughout Europe.

Industrialization, innovation dynamics, technological change and entrepreneurship have been addressed as the main drivers behind rapid productivity growth and social well-being improvements in the last decades. Research will focus on issues associated with development patterns through technological change, integrating emerging science and technology capacity, the role of entrepreneurial activity and the creation/growth of firms and industries and employment dynamics. Social and economic impacts of technical change have been considered in terms of employment generation and human capital, exploring related linkages with firm performance and quality of job creation. New research platforms will be set up with academic, regulatory and business partners to identify industrialization and specialization pathways through comparative studies of knowledge networks, supply chains, and industrial geographies.

Special emphasis will be given to at the increasing complexity and uncertainty of technological advances and related value chains and business configurations in modern aeronautics. It is motivated by the recent installation of two new Embraer plants in Évora, Portugal. It has the ultimate goal of securing their role as centers of excellence in aeronautics, with unique characteristics within the Embraer Group and worldwide. Evora’s plants are a singular case: although being fully Embraer, both plants are also considered first tier suppliers of Embraer Brazil. This requires the full integration of their activities within the needs of Embraer Brazil while also keeping a competitive edge with respect to other suppliers in Embraer’s supply chains.

Risk Governance and the social appropriation of knowledge, with the rational for research been driven by the need to help facilitating the social appropriation of knowledge under diversified
situations and knowledge contexts. It includes bio-sciences risk governance, with emphasis on regulatory frameworks in a way to deepen the idea of "smart and adaptive" regulatory frameworks (which seems to focus on "quick and easy" practices), with the idea of "intelligent and integrative" that would consider "careful and coherent" practices. In addition, risk communication to lay people is considered, to complement early studies on risk perception.

Emphasis will be given to design for uncertainty in urban contexts has been developed, including actions to look at risk perceptions, risk communication and stakeholder engagement of lay people from vulnerable communities.

Research Program - Urban Metabolism and Sustainable Cities (UMSC)
The program aims at strengthening knowledge about cities metabolism drivers, to support sustainable management of urban-driven flows and defining policies for urban sustainable management. For this purpose, it is intended to create a multidisciplinary model of the urban area, including impacts of energy and materials use, energy generation within the city, urban spaces outdoors’ quality and issues of materials sustainability, namely life cycle assessment and pollution.

Additionally it will contribute on providing appropriate tools and methods for managing over space and time scales, integrate biophysical and social components, adapt and deal effectively with uncertainty, visualize and identify planning problems and work to identify trade-offs and synergies in undertaking interventions.

**Urban Flows assessment**
Properly managing (optimizing and reducing) urban flows demands knowing the quantities involved. Despite broad acknowledgement of the concentration of global energy and material resource consumption in urban centers, very little is known of the actual resource consumption of contemporary cities, mainly because significant challenges remain in accounting for the resource burden imposed by cities.

Therefore, a critical task involves identifying and mapping the main flows of energy, water, materials and products in cities. Research will be performed in order to create a database format for translating, storing and crossing information from existing databases compiled by different urban agents (companies, utilities, municipal services and others).

Potential productive linkages between physical accounting tools usually used in the assessment of particular products, such as Life Cycle Assessment (LCA), assessment of economic relations between sectors (Input-Output Tables) and those tools used for spatially defined resource consumption, as Material Flow Accounting (MFA) should be evaluated. Tools integration should provide the basis for an analytical tool specifically oriented toward the assessment of urban metabolism.

**Critical factors for urban sustainability**
The urban subsystem is dynamic, so the status of the demand actors and the associated resource flows are constantly changing. This might be linked to the dynamics of land use, population growth or technological innovations. Some of these changes are intrinsic to the urban system under observation and other may be brought through (external) regional, national and international influences.

We may also distinguish between continuous (e.g. internal socio-economic) and discrete (deliberate intervention) influences and consider their rate of change (land use changes slowly whereas changes in tenancy or in employment status may happen relatively quickly). These changes
inevitably influence urban sustainability. Therefore, critical factors should be identified and studied in order to provide guidelines towards sustainable development. Case study designs and demonstration projects will be used to understand the correlation between resource consumption and several socioeconomic, geographical, climate and governance parameters. This will lead to the articulation of criteria for the planning of communities that better serve a resource efficient urban fabric.

**Supporting urban planning and policies for sustainability**

While the growth of many older cities consists of a densification of urban cores and metropolitan zones, certain younger urban centers continue to expand their perimeters by extending transportation, water, waste, and power infrastructure while annexing adjacent rural and agricultural land. The nature of various types of urban growth and change and the consequences for municipal consumption requires studying cities and propose policies towards a more sustainable planning of cities.

Together with the development and refinement of accounting methods, it is important to develop a spatially comprehensive and temporally broad physical accounting of resource consumption of a variety of urban centers. Material flows dynamic stock modeling should be used to analyze the industrial metabolism dynamics, namely the complex interaction between resource use and waste production and recovery, in order to contribute for the definition of more integrated and sustainable resource management policies.

The focus of this research area will be the coupling of emerging methods for assessing and tracking the resource consumption of cities with strategies for implementing design and planning recommendations for communities.

Research will examine the potential for applying to the design and planning of more resource efficient cities a variety of strategies that have emerged from the field of Industrial Ecology. Through current work in tracking the material and energy flows devoted to urban centers, this study will identify networks for symbiotic resource exchanges and productive reconfigurations of primary elements of urban form and infrastructure for sustainable city planning.

**Research Program on Science, Higher Education and Policy (SHEP)**

For 2014-16, particular emphasis will be devoted to foster the systematic observation and in-depth research of issues in science and technology, higher education and public policy in Europe. The ultimate goal is to create and promote a totally independent and credible international observatory of science, technology and higher education policies and budgets across Europe in a way to report, publicly and periodically, relevant information and early warnings on the state of policies and budgets in each country and at EU level. It should foster an international perspective and convey new research and understanding of the impact of the current economic situation in Europe on the “states of knowledge”, including science, technology and higher education capacity. It would, therefore, help to increase the public awareness of the strategic importance of science and higher education policy decisions, as well as to strengthen the motivation of scientists and the academy to engage themselves in policy action as informed and responsible citizens.

This is important because the conditions for the social construction of technological systems in both central and peripheral EU regions and societies will be addressed in terms of their impact on the emergence of new social realities in those societies, as well as their potential as factors of economic and social development on a global scale. To achieve these goals, science and technological development case studies will be developed across EU member states.
In addition to the tasks mentioned above about Europe, a research consortium is under establishment to foster the process of building human capital and scientific competencies in emerging and developing regions and countries, which do require adaptable and resilient scientific and academic institutions. It considers new research activities and fieldwork, together with the advanced training of a new generation of academic, scientific and policy leaders for emerging regions and countries, with emphasis on China, Brazil and Russia.

China, Russia, and Brazil are leading emerging regions at a world level facing the need and the opportunity for large investments in science, technology and higher education. These aim at responding to the explosive social demand for higher education and to the vast social and political transformations already induced by new waves of educated youth. These investments not only seek new skills and but also the certification of quality that may be expected from working along together with well-established academic and scientific institutions from developed countries.

Also, processes of brain-circulation, associated to concurrent patterns of brain-gain, brain-return and brain-drain, urge for a need to better understand flows of people and knowledge, and how the spillovers resulting from these flows are changing the way we learn, view the world, and countries and institutions act. This relates to the need for a new approach on the design of higher education (HE) at a world level and in very different socio-economic and cultural contexts.

Overall, The Research Program on Science and Higher Education Policy (SHEP) will consider different world regions and always with an international comparative approach. This will have an integrative and multidisciplinary approach as follows:

- **The career trajectories of the highly qualified**: The analysis of the career trajectories of highly qualified people is important to understand how policies, institutional and career incentives, and other factors impact on individual career choices, networking, and productivity. In this framework, features such as understanding the impact of mobility, internationalization, interdisciplinarity, educational backgrounds and family issues along the career, are important to illuminate the knowledge on how these individuals decision-making and contribution to institutional and regional knowledge building occurs. This will be performed for those developing activities in the higher education sector but also in the business enterprise sector.

- **The role of international science base partnerships**: It is important to understand how international science base partnerships (and other science policy policies as well) contribute to reform higher education systems. This will be pursued equally regarding institutional change at universities in terms of structural change, and research and teaching activities and practices. Through an international comparative analysis of several educational hubs, it aims to understand the impact that international science partnerships with lesser or broader scopes of action can have in promoting a more active role of universities in society, including in supporting of the knowledge base of communities and engagement in industry-university relations.

- **Employment policies for the highly qualified**: The aim is to understand on a historical perspective supply and demand policies concerning highly qualified people in emerging regions. This is to be contextualized and combined with the scientific and economic structure of the countries/regions under study, and focused on specific sectors of economic activity. The objective is to assess to what extent public policies focused on demand can be pursued in contexts that do not have developed the capacity to absorb highly qualified human resources. This has a clear linkage to public policies focused on the supply side and on the thematic of brain-gain, brain-drain and brain-circulation. Therefore, a complementary analysis is one of the fluxes of highly qualified people and Diasporas.

- **Geographies of knowledge and scientific structures**: As knowledge increasingly flows globally, it is essential to understand its geographical poles, its concentration, integration, and engagement drivers. A better understanding of the evolution of collaborations among regions, countries, and institutions, including universities and firms is of particular importance. Through
analyzing evolutionary mappings of knowledge production and collaboration one can realize the patterns of change at global level, and how knowledge global flows of are interacting and being constructed by national and regional knowledge bases. In this regard, the analysis needs to take into perspective the engagement of different scientific structures; by looking at how broader or narrower they are set in terms of disciplinary fields.

**Knowledge transfer**

IN+ and the Associate Laboratory LARSyS are actively engaged in technology transfer and commercialization processes, making use of four main formal and informal mechanisms: i) advanced training of skilled human resources and their employment in advanced, technology-based companies; ii) direct incubation of entrepreneurial projects; iii) indirect incubation of new technology based companies, in collaboration with networks of technology transfer offices, in particular through UTEN (University Technology Enterprise Network), involving linkages with the UT Austin, MIT and Carnegie Mellon University; and iv) through specific challenges and competitions to foster knowledge transfer processes and the creation of new business ventures.

Advanced training of human resources: IN+ is actively involved in doctoral programs that prepare students to face and solve difficult and complex problems, but also by fostering and supporting entrepreneurial initiatives or involve industry in R&D projects. A large number of former students integrate today national and international institutions and companies of great prestige.

Direct incubation of companies: In the last four years IN+ has supported the direct incubation and launching of several active spin-offs: CELL2B (www.cell2b.com), 3 Drivers (www.3drivers.pt), ALFAMA (www.alfama.com.pt), WATT IS (www.watt-is.com).

Indirect incubation of companies: IN+ has provided its students and external companies through additional training tools/support to entrepreneurship and innovation programs, which is certainly also a factor that has contributed to a better integration in the economic fabric of people with high technical and scientific skills. Protrude programs like Green-Wheel, Impact, VECTORe, Solvay Ideas, have been promoted very successfully through IN+ for a number of years.

Specific challenges and competitions: IN+ has also been actively involved in an annual international competition for new technology-based companies, the "Building Global Innovators", http://mitportugal-iei.org/.

Other activities include summer schools, invited talks, cooperation with science centers and the media, as well as the organization of events on robot competitions.
6. Funding: Overview of main sources and funding levels

The activities of the Center are organized on the basis of Laboratories, Programmes and Projects, which provide the necessary external funding, namely from national and international funding agencies and/or private companies from which research areas emerge. Fundamental research builds the scientific knowledge necessary to give function a sustainable and human-oriented form, thus harmonizing technology with the environment; at the same time that application studies pursue the functionality of advanced technologies and their results (products and services) from a user perspective.

Four main sources of funding have been considered, as quantified in the next table. The overall funding level for 2014 was about 2.4 million euros (excluding equipment depreciation and installations), with an increase of about 10% regarding 2013 due to a large effort to attract external funding under competitive processes, as discussed below.

The following paragraphs briefly describe the four main funding sources.

1. **Salaries of Research Staff (50%)**: considers IST Faculty involved in the Center, which are the basis for the continuous and sustainable development of the Center. The total amount represented about 13% of the overall expenditure (excluding equipment depreciation and installations) in 2014, which has been particularly affected by the effective decrease in public salaries.

2. **Research Fellowships and Doctorate Contracts supported directly by FCT, upon competitive funding processes (individual)**: it considers three main types of funding:
   a. Doctorate Contracts, five years in duration, which have been very critical to foster and deepen research activities in the last few years;
   b. Doctorate Fellowships, for post-doctoral researchers, usually up to 3 years, which have also been very critical to foster research activities in the last few years;
   c. PhD Student fellowships, for doctoral students, usually up to 4 years, which have been particularly important to attract young researchers and foster advanced training at a doctoral level.

   The overall funding directly from the Portuguese Science and Technology Foundation, FCT, for research fellowships and individual contracts represented about 13% of the overall IN+ expenditure for 2014 (it was 22% in 2012 and 19% in 2013). The expected contribution for the coming years is decreasing (7% in 2015) and this represents an important threat for deepening new research activities and areas. It should be clear that this type of funding depends on the overall national science policy to foster “institutional funding” of R&D centers and institutions. Since the mid 90s, it has been established through independent assessment exercises every 3 to 4 years. But is should also be
noted that in just two years, the funding for LARSyS that had been agreed by FCT has been cut twice – first by approximately 40% - and, then (despite a written agreement stating that no further cuts would be made), funding was slashed another 15% for 2013.

4. **Competitive Funding for R&D projects, including the following main sources:**
   a. Industry
   b. European Commission (R&D)
   c. Foundation for Science and Technology (FCT - R&D projects)
   d. Others Sources

The overall funding through competitive sources represented about 66% of the overall IN+ expenditure for 2014 (it was 47% in 2012 and 52% in 2014). **For 2015 it is expected to increase to 73%**. This is the result of considerably efforts made over recent years to attract private and public funding from different sources and to diversify the funding structure of IN+. The net result is very positive, although it requires establishing new skills and administrative staff to help managing R&D contracts and contacts with external funding sources. Nevertheless, the expected decrease in the fraction of “institutional funding” is always a threat for sustainable R&D, in terms of keeping a good background for basic research activities.
<table>
<thead>
<tr>
<th>1. Salaries of Research Staff (50%)</th>
<th>IST Faculty</th>
<th>Observations</th>
<th>2012 Executed Values</th>
<th>2013 Executed Values</th>
<th>2014 Executed Values</th>
<th>2015 Expected Budget</th>
</tr>
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<tbody>
<tr>
<td>312</td>
<td>% 16</td>
<td>Full Professors (Manuel Heitor; Paulo Ferro)</td>
<td>393</td>
<td>18%</td>
<td>310</td>
<td>13%</td>
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<tr>
<th>2. Research Fellowships and Grants supported by FCT</th>
<th>PhD and Post Doc Fellowships and Doctoral Contracts</th>
<th>Observations</th>
<th>2012 Executed Values</th>
<th>2013 Executed Values</th>
<th>2014 Executed Values</th>
<th>2015 Expected Budget</th>
</tr>
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<tbody>
<tr>
<td>431</td>
<td>% 22</td>
<td>PhD Fellowships (Anabela Reis; Miguel Amador; Nuno Climaco; António Lorena; Gonçalo Pereira; Gonçalo Cardoso; Vasco Portugal; Michal Monit; Pedro Fazenda; Hana Gerbelová; Vasco Granadeiros)</td>
<td>404</td>
<td>19%</td>
<td>313</td>
<td>13%</td>
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<tr>
<td>300</td>
<td>% 15</td>
<td>Covers Doctoral Contracts (Hugo Horta; Carlos Silva), Research Fellowships (João Dias; Helena Reis; João Rodrigues; Muriela Pádua; Samuel Nisa)</td>
<td>243</td>
<td>11%</td>
<td>207</td>
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<tr>
<td>943</td>
<td>% 47</td>
<td>1.122</td>
<td>52%</td>
<td>1.592</td>
<td>66%</td>
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<tr>
<th>4.1. Industry</th>
<th>Observations</th>
<th>2012 Executed Values</th>
<th>2013 Executed Values</th>
<th>2014 Executed Values</th>
<th>2015 Expected Budget</th>
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<tbody>
<tr>
<td>211</td>
<td>% 11</td>
<td>(EIDA; RAES; Smart Galp; Intel; Green Campus; GALP Centro de ID; REN; OCDE - Carbon Prices; EDP; EcoAgro; EcoProgresso)</td>
<td>331</td>
<td>15%</td>
<td>167</td>
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<tr>
<td>242</td>
<td>% 12</td>
<td>(INSCAN; Energy Wars; Life Engineering; PIRSES-GA; Agreeem. 12/0034-1/AG850; CitySDK; Smart Campus; KIC Innenergy; KIC Explore)</td>
<td>342</td>
<td>16%</td>
<td>473</td>
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<tr>
<th>4.3. Foundation for Science and Technology (FCT)</th>
<th>Observations</th>
<th>2012 Executed Values</th>
<th>2013 Executed Values</th>
<th>2014 Executed Values</th>
<th>2015 Expected Budget</th>
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<tbody>
<tr>
<td>226</td>
<td>% 11</td>
<td>(IGEnergum; Intergem; Netzero; Rest; MM6; Mesur; IRGC; Portug; EnTuCap; Minorias; Ext; CRNHEH; MUST; MUR; SURWIT-COOLs)</td>
<td>373</td>
<td>17%</td>
<td>812</td>
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<th>4.4. Others Sources</th>
<th>Observations</th>
<th>2012 Executed Values</th>
<th>2013 Executed Values</th>
<th>2014 Executed Values</th>
<th>2015 Expected Budget</th>
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<tbody>
<tr>
<td>263</td>
<td>% 13</td>
<td>(MA - Aval. PRODER 2007-2012; 24 th Eur. Conf. on Liquid Tomization and Spray Systems; 16 th LASER)</td>
<td>75</td>
<td>3%</td>
<td>141</td>
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<th>5. Total</th>
<th>Observations</th>
<th>2012 Executed Values</th>
<th>2013 Executed Values</th>
<th>2014 Executed Values</th>
<th>2015 Expected Budget</th>
</tr>
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<tbody>
<tr>
<td>1.987</td>
<td>% 100</td>
<td>2.161</td>
<td>100%</td>
<td>2.423</td>
<td>100%</td>
</tr>
</tbody>
</table>
ANNEX: List of publications
List of publications, 2014

1. **BOOKS**
   **Published:**


2. **CHAPTERS IN BOOKS**
   **Published:**


3. Research papers in International, peer-reviewed, journals Published:


D Neves, CA Silva, S Connors, Design and implementation of hybrid renewable energy systems on micro-communities: A review on case studies, *Renewable and Sustainable Energy Reviews*, 31, pp. 935-946, 2014 [Scopus: 3] [ISI: 1] [GS: 3] [IP: 5.51]


M. Heitor (2015), “How far university global partnerships may facilitate a new era of international affairs and foster political and economic relations?”, *Technological Forecasting and Social Change*, 95, pp. 276-293.


Accepted:


M. Heitor and H. Horta (2014), “Reforming higher education in times of uncertainty: are illities important?”, Technological Forecasting and Social Change, accepted for publication.


Submitted:


Sample published papers:


Pádua, M., Santos J., Horta H., Can improved education levels, risk perception and knowledge be related with reduced risk of getting diabetes in the elderly? submitted


4. Sample Conference presentations


Horta, H. and Jisun J. Higher Education research in Asia: seas of disjuncture, archipelagos and thematic navigation. Comparative Education Society of Hong Kong (CESHK) Annual Conference. Hong Kong SAR, China, 28th February to 1st March 2014.

Horta, H. and Jung J. Higher Education Research in Asia: Moving at Different Speeds and Looking at Different Issues? The 7th World Universities Forum, Lisbon, Portugal, 9th-10th January 2014.


Horta, H. Bringing science and academia to the population: activities to raise questions and make people think in vulnerable urban contexts XVIII ISA World Congress of Sociology, Yokohama, Japan, July 13th -19th July 2014.


5. Studies and reports


do ProDeR. Instituto Superior Técnico, Instituto de Estudos Sociais e Económicos e Instituto Politécnico de Bragança, Lisboa e Bragança.


6. ADVANCED TRAINING

Doctoral Thesis:


Master Thesis:

Supervisor: Edgar Fernandes


Supervisor: Tiago Domingos


Supervisor: Edgar Fernandes


Co-supervisor: André Pina


Supervisor: Tiago Domingos


Supervisor: Edgar Fernandes


Supervisor: Fernanda Margarido


Supervisor: Edgar Fernandes


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Report 2014
and
Plan 2015-2016

Lisboa, May 2015