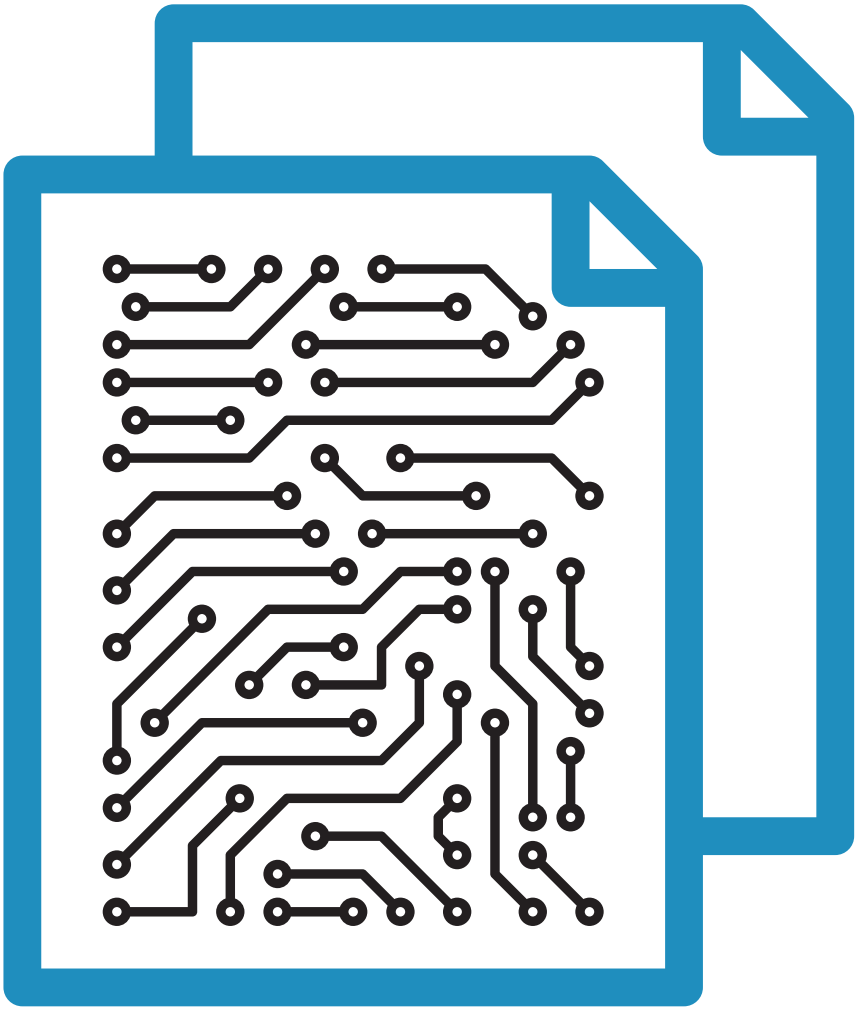
INESCTEC

INSTITUTE FOR SYSTEMS
AND COMPUTER ENGINEERING,
TECHNOLOGY AND SCIENCE



ACTIVITY REPORT 2016

GLOBAL ACTIVITY REPORT 2016

1 INTRODUCTION

This Global Activity Report presents INESC TEC reality, as well as the institute most relevant undertakings in 2016. Specific indicators portraying the institution and its activity are published and a selection of the tangible results obtained is presented. Furthermore, the most important achievements of the year are highlighted.

Section 2 offers a summarized presentation of INESC TEC, including its scope, mission, vision, strategy and organisational model. Section 3 presents the main activity indicators for 2016, those regarding Human Resources, Activity in Projects and Publications.

The research at INESC TEC is developed in 13 Research Centres, aggregated in four structures denoted as Clusters: Computer Science (CS), Industry and Innovation (II), Networked Intelligent Systems (NIS), and Power and Energy (PE). Section 4 presents these four Clusters, their objectives for the short and medium term and the main achievements during 2016.

Section 5 presents the Scientific and Technological Activities developed during 2016 by the 13 Research Centres, including their objectives, main achievements and activity indicators, following the same order of the Clusters in Section 4.

Section 6 focus on the TEC4 initiatives, plataforms that articulate INESC TEC's activity towards the market and details the objectives and achievements of two of them: TEC4Sea and TEC4Media.

Section 7 introduces two "special" projects that run at INESC TEC: the Carnegie Mellon Portugal Program and the Digital Competence Initiative.

Finally, Section 8 presents INESC TEC Support Services, including the Business Development Services, the Management and Organisation Services and the Technical Support Services.

2 INESC TEC PRESENTATION

2.1 Scope and Mission

INESC TEC is a private non-profit research institution, dedicated to scientific research and technological development, technology transfer, advanced consulting and training, and pre-incubation of new technology-based companies.

INESC TEC's associates are the University of Porto, INESC and the Polytechnic Institute of Porto, and the institute also has as privileged partners the University of Minho and the University of Trás-os-Montes e Alto Douro. Presently, its main sites are located in the cities of Porto, Braga and Vila Real.

The 13 R&D Centres of INESC TEC are structured in four thematic domains - Computer Science, Industry and Innovation, Networked Intelligent Systems, and Power and Energy – and at the end of 2016 hosted 711 integrated researchers (332PhDs), including contracted researchers who are staff, faculty of Higher Education Institutions, grant holders and affiliated researchers. INESC TEC's team also includes trainees, and technical and administrative support staff.

As an institution operating at the interface of the academic and business worlds, bringing closer together academia, companies, public administration, and society, INESC TEC typically seeks to apply knowledge and results generated by its research in technology transfer projects, pursuing value creation and social relevance.

The mission of INESC TEC is to achieve advancement in science and technology and to enable science-based innovation through the transfer of new knowledge and technologies to industry, services and public administration.

2.2 Vision

INESC TEC vision is to be a leading Science and Technology Institution at international level, perceived as an important world player, in the domains of Computer Science, Industry and Innovation, Networked Intelligent Systems, and Power and Energy.

The strategic motto for 2015-2020 was defined as THE CHALLENGE OF PERVASIVE INTELLIGENCE. It reflects the view of INESC TEC researchers on the broad lines of development of Science and Technology (S&T) in the four above-mentioned domains, and their application to real life.

The continuous pursuit of excellence by INESC TEC is driven by a bold response to S&T daring challenges and the originality and strength of the management model in S&T.

The S&T driver is decomposed in four perspectives, coherent with the definition of the four INESC TEC Clusters:

POWER AND ENERGY SYSTEMS

The cities in the future will become places of intense energy exchanges with strong distributed generation and storage (home and electric cars) and not only consumption. The generalization of the concept of Smart Grid demands original solutions with massive integration of renewable energy with telecommunications, control and new devices. INESC TEC will work for the power system of the future, with highly decentralized control loops and distributed intelligence taking care of local decisions, with a huge challenge in massive data flows in an environment of augmented uncertainty.

INDUSTRY AND INNOVATION

Modern supply chains and collaborative networks are based on increasingly complex and dynamic flows of materials and information, integrating the delivery of customized products and services. INESC TEC will develop innovative tools, based on massive data mining, simulation and optimization, to provide the pervasive intelligence required for their design and management. Collaborative robots and advanced automation will support further improvements in efficiency and flexibility and will enable a higher level of integration and data capture supporting the concepts of Industry 4.0. These results will be guided by research in innovation processes, thus building strong bridges to economics and management.

NETWORKED INTELLIGENT SYSTEMS

The pervasive ambient intelligence will constitute the fabric of the daily life in the future cities and rural areas. INESC TEC envisions a lively and sustainable world where networked intelligence enables ubiquitous interaction with sensory-rich content, with interoperability of a diversity of technologies. New sensors and devices based on optical technology will be developed to build interfaces of the communication fabric with the real world. INESC TEC will also be at the forefront of the exploration of a new frontier - the deep sea. Distributed intelligence will combine fleets of autonomous robots with an augmented environment perception, bringing challenging requirements for underwater sensors, equipment and broadband wireless communications. Biologic optic-based sensors, coupling physics with chemistry, will be another challenge met by INESC TEC and will also serve the biomedical engineering domain, where strong advancement in signal and image processing will be coupled with pervasive knowledge extraction.

COMPUTER SCIENCE

INESC TEC aims at excelling in the control of the chain data>information>knowledge for pervasive and massive data repositories and data flows. This includes the components of new high-level languages, distributed computing, critical software, privacy protection, pervasive cyber security and generalized knowledge extraction, namely from massive spatio-temporal distributed and geo-referenced databases possibly lodged in moving media.

2.3 Strategy

INESC TEC's strategy is driven by the following axes:

- Excellence in: science, talent development, technology transfer and collaboration with industry;
- Full coverage of the knowledge-to-value chain;
- Multi-disciplinarity;
- Scale, density, critical mass and integration;
- International visibility and presence.

2.3.1 Excellence in science

Without excellence, all aspiration to world recognition and relevant impact in leading companies is void of hope. Therefore, the resolve in making robust a culture of demanding responsibility, quality, accountability, productivity of advanced science must be sustained at all cost. Most of all, incentives and recognition to high level science and researchers must be present. At INESC TEC, the classical indicator of quality (papers in international journals) has witnessed a steady growth that has moved the ratio papers/researcher to a reference value at international level for the areas of activity covered. A continued effort in pursuing and valuing excellence as the trade mark of INESC TEC is one of the fundations of the institution.

2.3.2 Excellence in talent development

The deep involvement in Doctoral Programmes is an underlying condition to have acess to human resources for conducting research and publishing results. INESC TEC must be able to add value to Doctoral Programmes in the several institutions that are in one way or another associates. In particular, the MAP (Minho-Aveiro-Porto) programmes in computer science and in telecommunications, as they join the strongest schools in the north of Portugal, should be viewed as possible models to be extended to other areas. A requirement to take this step forward is the strengthening of the strategy alliances between INESC TEC and the Schools/Universities in reinforcing these programmes.

2.3.3 Excellence in technology transfer and collaboration with industry

The other side of the coin - INESC TEC as an interface organization in Engineering - must be the capacity to produce socially relevant results and to transfer them to the economic fabric. The relations with industry are crucial and INESC TEC must be perceived as a partner of excellence able to provide unique knowledge and relevant technology for product, process service and business model innovation in companies. The

requirement here is that all Research Centres of INESC TEC may contribute to this objective – either autonomously or by integrating a process of knowledge transfer with other Centres.

2.3.4 Managed Science Model

INESC TEC's management and operational model implements the concept of the knowledge-to-value production chain, driving the knowledge generation research activities to their valorisation through a mix of processes of technology transfer, from technology licensing to collaborative development, advanced consulting and training and spin-off launching.

This concept is illustrated in a very simplified manner in the figure below, which depicts the division into four stages: basic knowledge production; applied research; development; and technology transfer and valorisation.

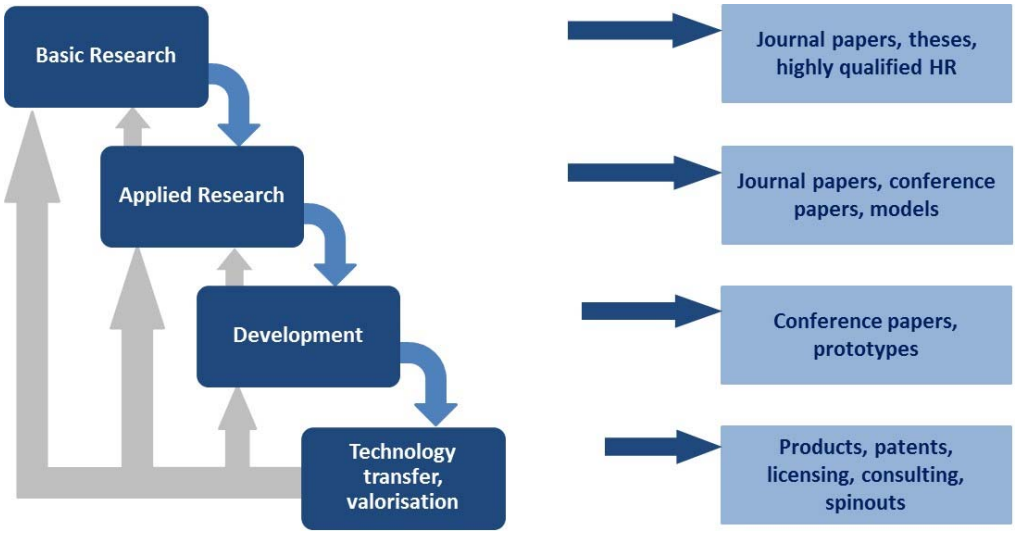


Figure 1 - Knowledge production and valorisation chain concept

The figure also shows some relevant outputs produced at each stage and the feedback links from downstream to upstream activities. The outputs at each stage also serve as performance indicators for the corresponding activity. As with any model depicting a complex reality, the divisions between the stages are fluid and not rigid.

The valorisation of research results through technology transfer and advanced consulting activities is essential to the economic sustainability of the institute and the interaction and collaboration with industry is essential for the identification of new research lines.

INESC TEC Centres present distinct coverage of this chain. Some are more research oriented and are therefore more positioned in the early stages, while others are more market oriented and thus their activity has a higher share in the later stages. The aim is not that each Centre encompasses the whole chain; but their organisation must allow for knowledge flow, not only within each Centre but also between Centres, so that INESC TEC as a whole and its four Clusters area able to perform socially relevant research. This means that INESC TEC focus on both science and technology transfer.

The success of this model relies on the ability to allow or ensure an easy flow from top to bottom and a feedback in the reverse direction. In order to achieve this, one does not require that each researcher should act on every stage of the chain – however, there is a definite incentive for the Centres to have a large enough dimension so that they can accommodate a broad spectrum of activities.

2.3.5 Multi-disciplinarity

In alignment with its focus on real-world applications, INESC TEC seeks to facilitate the multi-disciplinary work that those applications typically require.

A special emphasis is placed on generating and supporting interaction among the several Centres. While the Clusters and the TEC4 initiatives, described below in the Managed Science Model section, play a key infrastructural role towards this purpose, other measures have been implemented, which include, among others: incentive for research projects bringing together more than one Centre; encouragement of cooperation in co-authorship of papers with authors from different Centres; special actions called LAI (Inter-Centre Action Lines), put in place to allow cross-centre fertilization; support to contract research with industry by teams constituted by members from several Centres; management and accounting procedures allowing a Centre to use resources (including researchers) from other Centres.

2.3.6 Scale, density, critical mass

The recent years have been devoted to growth and densification of the coverage of important areas of knowledge.

A few examples may be put forward: (1) the area of computer science, seen for years as a weakness in INESC TEC, benefited in the recent past with aggregation of new research groups (LIAAD, CRACS and HASLab) from the Schools of Sciences and Economics of UP and Minho University; (2) the area of control and robotics has been reinforced with the integration of an external group from the School of Engineering and another from the Polytechnic Institute of Porto (IPP); (3) the area of Industrial Management has been reinforced with the association of a new Centre (CEGI) formerly external to INESC TEC; (4) the programs run by FCT (Foundation for Science and Technology, Government of Portugal) supporting the contracting of scientists have been used to reinforce fragile areas where excellence should be maintained, such as the case of photonics (CAP), very much depending on the School of Sciences faculty in scarce number.

The challenge for the future will be a consistent effort to focus the activities and attract leading researchers to further reinforce INESC TEC's critical mass.

2.3.7 Integration

INESC TEC cannot become a loose federation of nearly independent Centres or its potential will be put in jeopardy. Some Centres at present have more than 100 researchers and therefore the risk of self-containment in each private universe is real.

The Clusters and the TEC4 initiatives are key instruments in INESC TEC's policy for achieving institutional cohesion. Overall, this policy seeks to strengthen the ties among Centres, by deepening cross-border fertilization, originating new science by fusion of knowledge and skills, and conducting multi-disciplinary research by involving multi-disciplinary teams.

2.3.8 International visibility and presence

One only exists when one is seen. Moreover, one is only valued when one is measured. The importance of international projects and activities is crucial to achieve the status of international player. The long-term objective is to guarantee that the international activity of INESC TEC may be accounted as a significant part of the total activity, measured through scientific output as well as financial indicators. To reach excellence in science and technology, it is essential to collaborate and develop strong partnerships with leading international research institutions.

The most important undertaking is the consolidation of the massive presence in European research.

A second step is the constitution of a base of operations outside Portugal, to gain access to projects, funding, human resources and ultimately to conquer the status of multi-national organization. The operation in Brazil, with the constitution of INESC P&D Brasil and its recognition by the Brazilian S&T agencies as a Brazilian ICT (Institution of Science and Technology) must be understood under this light.

2.4 Managed Science Model

2.4.1 Management

The management of INESC TEC is undertaken by a Board of Directors, composed of nine individuals. The Board acts in coordination with the Council of the Coordinators of R&D Centres, Clusters and Support Services, meeting every other week. This ensures cross-centre coherency in vision and policy and joint responsibility and commitment, both in strategic and ordinary management decisions.

The International Scientific Advisory Board is another important body, whose composition reflects the diversity of areas and interests within INESC TEC. It has always had a relevant role in permanently auditing the institute scientific activity and counselling the Board. Its highly valued recommendations have been appreciated and implemented. The Business Advisory Board supports the Board in business development and industrial relations issues.

A group of advisors on specific scientific areas and business development, completes the management team.

Performance is assessed at the end of each quarter, considering both economic and scientific perspectives. The deployment of the annual Plan of Activities is equally monitored. Each researcher is subject to an evaluation process every year and grant holders every three months. In order to provide the appropriate incentives, INESC TEC has in place a set of rewards from complementary remunerations to publication prizes.

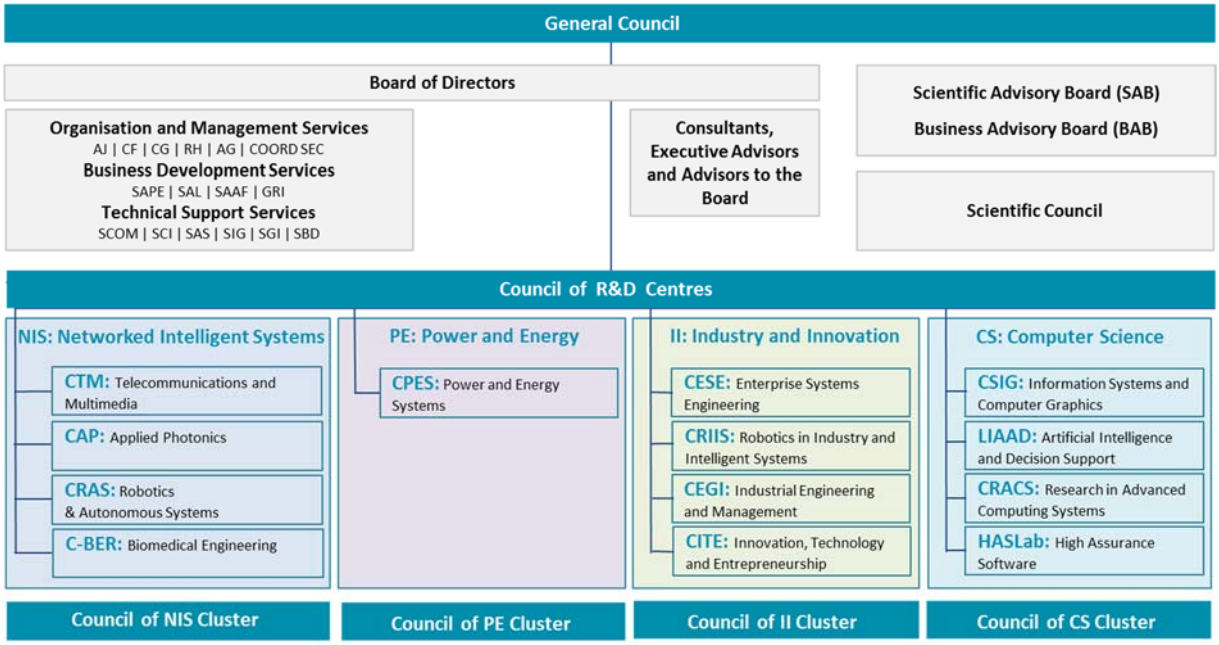


Figure 2 - INESC TEC Organisational Structure

2.4.2 Clusters

The research at INESC TEC is developed under 13 Research Centres, organised in four stable structures denoted of Clusters (see the organisational chart above): Networked Intelligent Systems (NIS), Power and Energy (PE), Industry and Innovation (II) and Computer Science (CS).

The Clusters are responsible for the research and development strategy and long term planning of each thematic domain. They gather their "core" Centres in their specific domain and articulate and interface with other relevant Centres, denoted "associated" Centres. The strategy in a Cluster is designed in collaboration between the Core and associated Centres. Each Cluster is coordinated by a Cluster leader and a Cluster Council. Performance indicators are consolidated at Cluster level to enable the proper planning for the next periods.

Each Centre is responsible for its own planning and strategy and answers to the Board regarding its budget and performance indicators. Each Cluster is followed closely by two Members of the Board.

2.4.3 The TEC4 initiatives

The TEC4 initiatives articulate INESC TEC's activity towards the market, defining the market strategy and planning INESC TEC's interaction with its main markets or application areas. A TEC4 must not be mistaken for a Cluster: it is a process implementing a market pull vision and does not have a rigid core of Research Centres. Instead, a TEC4 initiative provides coherency to the cross-Cluster intervention of all Centres in specific markets, or economy target areas.

A TEC4 is not driven by science but rather by a market of application domain perspective, where multidisciplinary interventions are usually important. A TEC4 initiative establishes an extensive network of contacts and close dialogue with industrial partners and brings back to the several INESC TEC Centres major trends, challenges and the identification of opportunities.

The TEC4s are not rigid or permanent structures. They are flexible, evolving and adaptive to external conditions and internal response. Examples of TEC4 initiatives being developed are: TEC4Sea, TEC4Health, TEC4Agro-food, TEC4Media, TEC4Industry or TEC4Energy.

2.4.4 Support services

A streamlined and dynamic team of highly qualified technical and administrative personnel provides support to INESC TEC's activities. Much of the capacity and excellence of these Support services derive from the continued internal policy of permanently qualifying human resources. Several of the administrative staff hold MSc degrees and three have a PhD degree.

The Support services are organized and managed under the principle that they must aim to alleviate the researchers from all administrative and bureaucratic burdens. One member of the staff has also been a National Contact Point of an EU R&D programme, bringing in a highly valuable experience. The set of services is organized to serve the researchers over the following domains: juridical, project management, accounting, information management, human resources, computing and communications, media, IP management and business development. Furthermore, each research Centre has its autonomous administrative support, with staff also qualified at the same high level.

Table 2.1 – INESC TEC Support Services

Area	Service Name
Business Development Services	Industrial Partnerships Technology Licencing Funding Opportunities International Relations
Management and Organisation Services	Finance and Accounting Management Control Human Resources Legal Support Management Support Secretarial Coordination
Technical Support Services	Communication Management Information Systems Networks and Informatics Systems Administration Infrastructure Management

3 RESULTS ACHIEVED IN 2016

This section presents a short summary of INESC TEC results achieved during 2016, including the main indicators for human resources, activity in projects and scientific publications. The presentation of each Cluster and R&D Centre and the detailed discussion of its objectives, activities and results are carried out in Sections 4 and 5, respectively for Clusters and Centres. Section 6 presents the multidisciplinary initiatives TEC4, Section 7 presents special projects and Section 8 the Support Services.

3.1 Context and Strategic Lines of the 2016 Activity Plan

At the beginning of 2016, INESC TEC evolution paths were limited by a set of strong constraints, some arising internally but most of them of an exogenous nature. These constraints were setting up clear institutional challenges.

From the financing side, the perspective was that of an abrupt activity increase, estimated around 30-40%, leading to an unbalanced financing model (heavier weight of the upstream more fundamental research), to the demand for high levels of self funding and to increased levels of bureaucracy, specially in the regional programs.

The recent changes in S&T policies were paving the way to potential cash flow constraints, due to the hurry for high levels of equipment investment combined with significant delays of FCT and Compete in the processing of payment requests and reimbursing of expenses.

In the institutional framework side, an emerging liability was growing, due to the uncertainty of the financial impact resulting from the expected revision of the protocols for assignment of the university/schools human resources and infrastructures to their affiliated institutes.

With regard to the institute internal organisation, the evolving governance model was on the agenda, with the cluster implementation and the deployment of new management tools, such as the IP Regulation and the Policy for the Management of Conflict of Interests.

In the external strand, the urgent need for new communication media, transversal CRM services and tools for upfront evaluation of new engagements was evident, specially in a scenario of shortage of both lab space and high quality young talent.

From the presentation and discussions held at the January 2016 General Council Meeting, the following 2016 strategic lines have emerged:

- To keep a balanced financing model;
- To ensure sustainable growth, controlling structural costs and further improving the governance model;
- To reinforce policies promoting scientific excellence;
- To reinforce the links with and the tangible impacts near international companies and organisations;
- To actively contribute for the construction of a new relationship framework between UP and Schools and their institutes;
- To consolidate the relationship with the privileged partners, namely UM, UTAD and others;
- To intervene near the regional authorities, together with universities, the polytechnic school and the major R&D institutes for the Norte 2020 Program rules to be changed in favour of the sustainability of the R&D and TT in the region.

3.2 Highlights in 2016

Following the strategic lines above, it became possible to reach, or even surpass, the objectives established for the different sides of INESC TEC. The 2016 highlights presented below are the evidence:

1. Organic growth of the different R&D Centres organised in four clusters, reaching in total 715 integrated researchers, including 347 members with a Ph.D and 200 academic staff.

2. Slight increase in activity of about 6%, consolidating previous year's growths of 14% in 2014 and 26% in 2015 and giving evidence of resilience and capability for compensating the often strong oscillations brought in by cyclic nature of national and international financing programs.
3. A 15% increase in the number of integrated researchers, this being partly due to the increase in activity in projects but also as a result of the increased attractiveness of the institute organisation and governance model (the number of faculty has increased by 2%).
4. A steady increase in financing from European Programs, that continued to be the largest financing source of INESC TEC (about 48% of the total financing in projects in 2016), this resulting mainly from the very large and professional investment put in the H2020 calls and from the good success rate attained.
5. The financing level of the Integrated R&D Projects financed by Norte 2020 has raised considerably, following to their slow start in 2015, while the financing from FCT Projects has decreased following to the end of many projects before the start of new ones, this being expected to happen in 2017.
6. The activity in Consortia R&D projects with companies has decreased in 2016 for two main reasons: the end of all QREN projects in 2015 and the absence of new projects that resulted from the slow start of the Portugal 2020 Program. This trend is expected to change in the second semester of 2017, with the start of new Consortia R&D projects as well as of large scale Mobilizing projects.
7. The slow start of Portugal 2020 Program, putting companies on hold expecting public support to their R&D activities, also explains the strong decrease (26%) of the 2016 financing from contract research and consulting with Portuguese companies. This has been partly compensated by the 66% increased in contract research and consulting with international companies.
8. The support to more upstream research activities and other expenses through the FCT Plurianual Financing Program, highly relevant for the financing rates, the flexibility and the effectiveness of the payment cycles, has reached in 2016 about 19% of all INESC TEC income.
9. The increase in financing of more upstream research has already led to a significant growth of INESC TEC scientific production. The number of papers in indexed journals has increased 26% (reaching 311) and the number of selected conference papers has increased 8% (reaching 476), with just an increase of 5% in the number of integrated Ph.Ds. These results have been obtained using different indexing sources (ISI, SCOPUS and DBLP) and have been gathered with the help of the Authenticus and CORE Platforms. Regarding quality and impact of the research, one should emphasize that the large majority (65%) of the papers have been published in first quartile (Q1) journals (according with SCOPUS).
10. Regarding IP protection and valorisation, it is important to highlight the outcome of the researcher's activities but also of the structuring work under development by SAL (Technology Licensing Office). During 2016, five patents were submited and a patent has been granted to INESC TEC, UP and Honda by the US Patent Office.
11. Inasmuch, as non EU international relations are concerned, the Brazil Office has worked industriously to keep up with the increase of projects with INESC P&D Brazil and a new office has been created to support attracting high quality researchers and promoting new projects with Indian institutions.
12. Considerable effort has been put in the increase of institutional visibility and recognition, by communicating the social and economic impacts of the results of the research undertaken. In the annual event, INESC TEC October Forum, near 250 attendants gathered together to discuss the theme "Factories of the Future: which paths for the industry in the 21st century?". Besides the active participation in multiple events, such as: Ocean Business Week, CTM Open Day, International Conference on the European Energy Market (EEM2016), TechDays, Agroglobal, Business2Sea and EMAF, INESC TEC researchers have participated in the organisation of 75 international conferences and in 236 Program Committees of international events.

3.3 Human Resources

3.3.1 Global Indicators

Table 3.1 and Figure 3.1 show the breakdown of INESC TEC Human Resources by type of contractual relation with INESC TEC and its evolution since 2014. The number of PhDs is also shown (347 at the end of 2016).

Table 3.1 – Evolution of INESC TEC Human Resources

Type of Human Resources			2014	2015	2016	Δ 2015-2016	
Integrated HR	Core Research Team	Employees	49	56	56	0	0%
		Academic Staff	183	196	200	4	2%
		Grant Holders and Trainees	332	307	400	93	30%
		Total Core Researchers	**564**	**559**	**656**	**97**	**17%**
	Affiliated Researchers		26	62	59	-3	-5%
	Management, Administrative and Technical	Employees	52	53	59	6	11%
		Academic Staff	5	8	8	0	0%
		Grant Holders and Trainees	6	17	25	8	47%
		Total Manag, Admin and Tech	**63**	**78**	**92**	**14**	**18%**
	Total Integrated HR		**653**	**699**	**807**	**108**	**15%**
	Total Integrated PhD		**253**	**329**	**347**	18	5%
Curricular Trainees			56	70	36	-34	-49%
External Research Collaborators			112	75	102	27	36%
External Administrative and Technical Staff			6	9	8	-1	-11%
External Students			36	60	71	11	18%
Total			**863**	**913**	**1.024**	**111**	**12%**

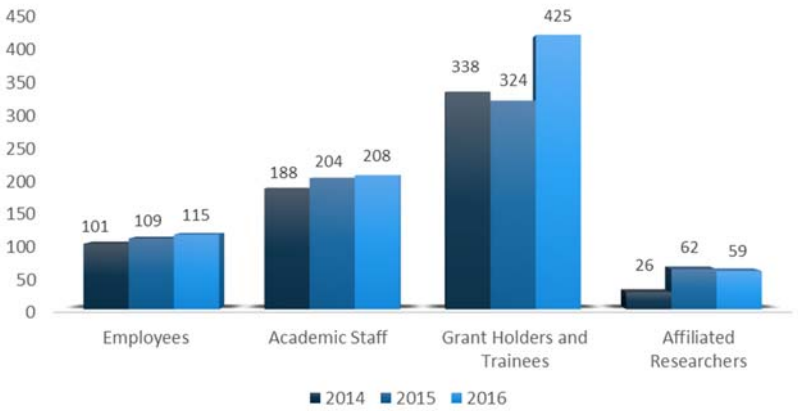


Figure 3.1 – Evolution of INESC TEC Human Resources

It can be seen in Figure 3.2 that grant holders and trainees for the largest group of human resources (53%).

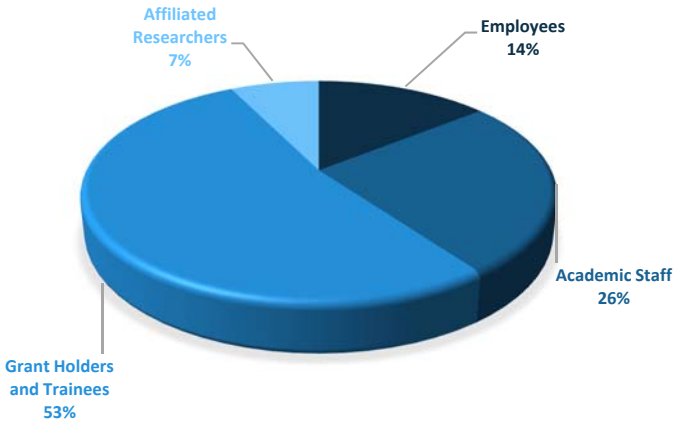


Figure 3.2 – Distribution of Human Resources

The core research team increased 17% to support the higher activity level, reflecting the institute capability to design successful new projects and seize the funding opportunities both at national and European levels. There is also an increase in the number of human resources of the Support services to respond to the increased activity level.

Curricular trainees and external collaborators allocate to INESC TEC activities a small percentage of their time, thus having a negligible financial impact.

3.3.2 R&D Centres Indicators

The number of Human Resources of each R&D Centre is detailed by type in Table 3.2.

Table 3.2 – Human Resources by type and R&D Centre

Type of Human Resources			Total R&D Centres	R&D Centres														Special Projects
				CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB	
Integrated HR	Core Research Team	Employees	56	7	5	5	1	12	12	3	0	2	7	0	2	0	0
		Academic Staff	200	21	9	10	6	12	11	21	19	1	26	29	14	21	0
		Grant Holders and Trainees	398	46	15	25	15	51	33	15	34	4	35	38	41	46	2
		Total Core Researchers	**654**	**74**	**29**	**40**	**22**	**75**	**56**	**39**	**53**	**7**	**68**	**67**	**57**	**67**	**2**
	Affiliated Researchers		57	8	7	0	3	3	4	0	3	6	15	5	2	1	0
	Administrative and Technical	Employees	13	1	2	2	0	2	2	2	0	0	1	0	1	0	3
		Grant Holders and Trainees	4	0	0	1	0	0	0	1	0	0	0	0	1	1	6
	Total Integrated HR		**728**	**83**	**38**	**43**	**25**	**80**	**62**	**42**	**56**	**13**	**84**	**72**	**61**	**69**	**11**
	Total Integrated PhD		**332**	**43**	**22**	**7**	**11**	**25**	**19**	**26**	**32**	**6**	**45**	**41**	**23**	**32**	**2**
Curricular Trainees			**36**	**2**	**0**	**3**	**3**	**2**	**7**	**1**	**5**	**1**	**4**	**5**	**1**	**2**	**0**
External Research Collaborators			**95**	**8**	**2**	**1**	**2**	**9**	**8**	**5**	**8**	**6**	**10**	**15**	**11**	**10**	**4**
External Administrative and Technical Staff			**7**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**4**	**0**
External Students			**70**	**6**	**13**	**2**	**2**	**1**	**1**	**4**	**3**	**6**	**4**	**10**	**1**	**17**	**0**
Total			**936**	**99**	**53**	**49**	**32**	**92**	**78**	**53**	**74**	**26**	**102**	**102**	**74**	**102**	**15**

R&D Centres:

CTM	Centre for Telecommunications and Multimedia
CAP	Centre for Applied Photonics
CRAS	Centre for Robotics and Autonomous Systems
CBER	Centre for Biomedical Engineering Research
CPES	Centre for Power and Energy Systems
CESE	Centre for Enterprise Systems Engineering
CRIIS	Centre for Robotics in Industry and Intelligent Systems
CEGI	Centre for Industrial Engineering and Management
CITE	Centre for Innovation, Technology and Entrepreneurship
CSIG	Centre for Information Systems and Computer Graphics
LIAAD	Laboratory of Artificial Intelligence and Decision Support
CRACS	Centre for Research in Advanced Computing Systems
HASLAB	High-Assurance Software Laboratory

3.3.3 Support Services Indicators

Table 3.3 presents the number of Human Resources for the Management Board and each Support Service (decimal values apply to signify shared resources between Services).

Table 3.3 – Human Resources by type and Service

Type of Human Resources		Total	Board and Advisors	Support Services													
				Operations and Management Services					Business Development Services				Technical Supporting Services				
				AG	AJ	CF	CG	RH	SAAF	SAPE	SAL	GRI	SCOM	SCI	SIG	SAS	SGI
Integrated HR	Employees	43	5	1,2	0,7	3,8	7,8	3,3	0,2	4	1		3	2	3	3	5,1
	Academic Staff	8	8														
	Grant Holders and Trainees	15			2	3	1		1	1	1	1	3		2		
	Affiliated Researchers	2	2														
	Total Integrated HR	**68**	**15**	**1,2**	**2,7**	**6,8**	**8,8**	**3,3**	**1,2**	**5**	**2**	**1**	**6**	**2**	**5**	**3**	**5,1**
	Total Integrated PhD	**13**	**10**			**1**				**2**							
External Collaborators		5								2		3					
Total		**73**	**15**	**1,2**	**2,7**	**6,8**	**8,8**	**3,3**	**1,2**	**7**	**2**	**4**	**6**	**2**	**5**	**3**	**5,1**

Support Services:

AJ	Legal Support
CF	Finance and Accounting
CG	Management Control
RH	Human Resources
AG	Management Support [1]
SAAF	Funding Opportunities
SAPE	Industrial Partnerships
SAL	Technology Licensing
GRI	International Affairs
SCOM	Communication
SCI	Networks and Informatics
SIG	Management Information Systems
SAS	Systems Administration
SGI	Infrastructure Management

[1] Includes Secretarial Coordination

3.4 Activity in Projects

3.4.1 Global Indicators

Table 3.4 shows the breakdown of INESC TEC funding sources and its evolution between 2013 and 2016.

Table 3.4 - Funding sources and evolution

Sources			Value (k€)				Δ (k€ / %)	
			2013	2014	2015	2016	2015-16	
Active Projects	PN-FCT	National R&D Programmes - FCT	985	867	775	490	-284	-37%
	PN-PICT	National R&D Programmes - S&T Integrated Projects	657	1.170	785	1.464	679	86%
	PN-COOP	National Cooperation Programmes with Industry	610	551	316	263	-53	-17%
	PUE-FP	EU Framework Programmes	1.868	2.751	4.040	4.494	454	11%
	PUE-DIV	EU Cooperation Programmes - Other	117	114	290	632	342	118%
	SERV-NAC	R&D Services and Consulting - National	1.322	2.672	3.033	2.259	-774	-26%
	SERV-INT	R&D Services and Consulting - International	410	259	173	287	115	66%
	OP	Other Funding Programmes	735	531	802	703	-99	-12%
		Total Active Projects	**6.705**	**8.914**	**10.214**	**10.592**	**379**	**4%**
Closed Projects			77	34	229	418	189	83%
National Strategic Programme - Pluriannual			1.654	881	2.191	2.615	424	19%
National Strategic Programmes - Other			339	125	140	112	-27	-19%
Other Revenues			371	491	411	270	-141	-34%
		Total Revenues	**9.147**	**10.445**	**13.184**	**14.008**	**823**	**6%**

Figure 3.3 illustrates the funding distribution from projects in 2016 and the comparison with 2015.

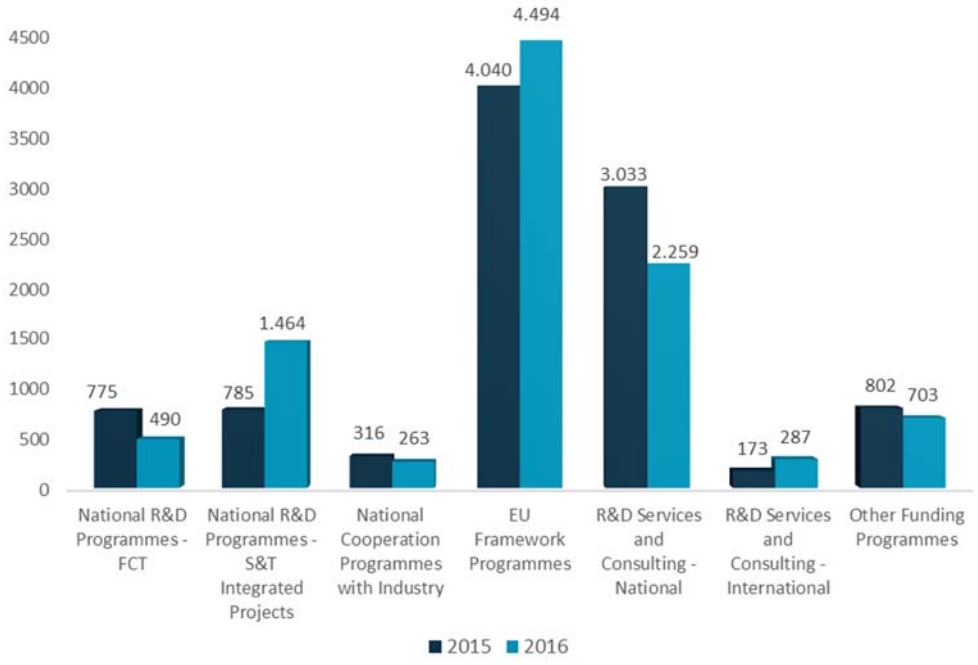


Figure 3.3 – Evolution of Funding Sources from Projects (k Euros)

Figure 3.4 shows the correspondent distribution from funding sources of projects, and the comparison with the previous year.

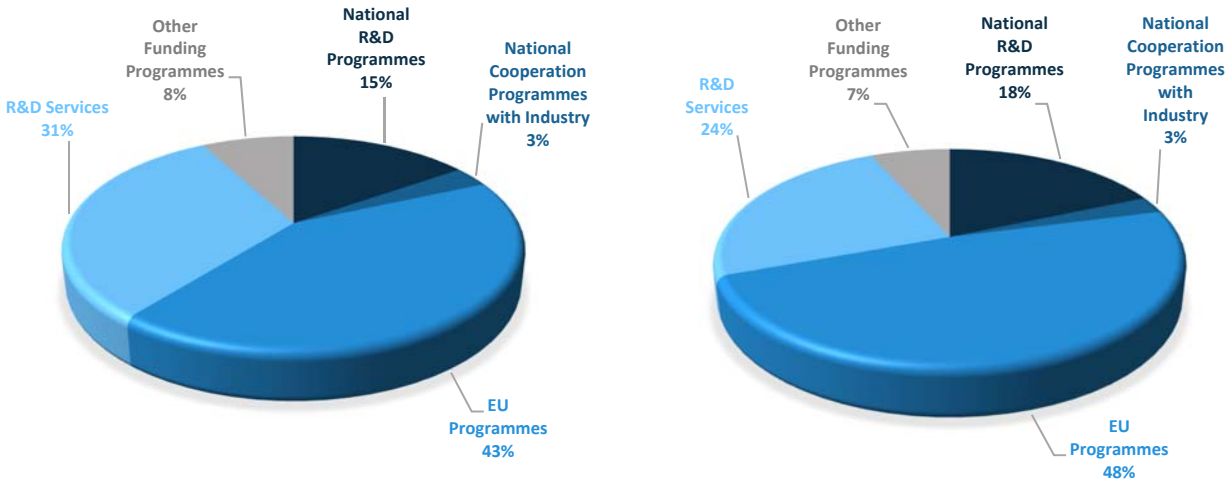


Figure 3.4 – Distribution of Funding Sources from Projects - 2015 (left) and 2016 (right)

The insight into the number of active projects per source and the average funding per project is also of interest, and is shown in Table 3.5.

Table 3.5 - Number of Projects by Type and Average Funding

Type of Project		Number of Active Projects				Δ 2015-16	Average Funding 2016 (k€)
		2013	2014	2015	2016		
PN-FCT	National R&D Programmes - FCT	56	41	32	22	-10	22
PN-PICT	National R&D Programmes - S&T Integrated Projects	6	6	10	10	0	146
PN-COOP	National Cooperation Programmes with Industry	13	11	13	13	0	20
PUE-FP	EU Framework Programmes	31	26	35	37	2	121
PUE-DIV	EU Cooperation Programmes - Other	4	4	9	12	3	53
SERV-NAC	R&D Services and Consulting - National	67	71	72	67	-5	34
SERV-INT	R&D Services and Consulting - International	13	8	6	11	5	26
OP	Other Funding Programmes	10	11	13	19	6	37
	Total	**200**	**178**	**190**	**191**	**1**	**55**

The main conclusions that can be drawn from the previous tables and graphs are the following:

- Funding from EU Programmes continues a steady grow and continues to be the largest funding source (48% in 2016), reflecting a high effort and success rate in the calls lauched within the H2020 programme. Projects funded by Interrreg and several ERA-NETs are included in this group, but represent only 6% of the total project funding.

- The funding from the Integrated Projects shows a large increase after its start in 2015, while the funding from FCT projects shows a decrease due to the ending of several projects before new ones started, which will take place during 2017.
- The funding from R&D projects in cooperation with companies decreased due to the slow start of new projects under P2020, after the end of all QREN projects (from the previous funding programme) at the end of the first semester of 2015. The start of new projects in cooperation with companies and the start of the Mobilization projects (large R&D projects in cooperation with companies) expected for the second semester 2017 will invert this negative trend.
- Partialy due to a slow start of P2020 R&D projects promoted by individual companies, the income from national R&D and consulting services presents a decrease of 26%. This was partially compensated by an increase of 66% in the R&D Services and Consulting to international companies.
- Support from the FCT National Strategic Programme "Plurianual" is an important source of funding due to its flexibility and funding rates, representing 19% of the total funding sources.
- The largest projects in terms of funding are indeed Integrated Projects and EU Framework Projects; on the opposite end, other EU Cooperation Programmes usually fund small projects (with complicated and often very specific rules); R&D Services and Consulting are expected to be under the global average of funding per project.
- Overall, the institute was able to grow its activity level by 6%, demonstrating a large capability to react to the nomal cycles in the funding programes. During 2016, the reduction of funding from national R&D programmes and R&D Services and Consulting (that were reduced partially because of the starting phase of some national programes) was more than compensated by new European projects, national research integrated projects and international R&D Services and Consulting.

3.4.2 R&D Centres Indicators

A detailed view of the total funding sources per R&D Centre is given in Table 3.6 and Figure 3.5.

Table 3.6 - Project Funding per R&D Centre

Funding Source			Total (k€)	R&D Centre													
				CTM	CAP	CRAS	CBER	CPES	CESE	CRIIS	CEGI	CITE	CSIG	LIAAD	CRACS	HASLAB	Special Projects
Firm Projects	PN-FCT	National R&D Programmes - FCT	**490**	28	0	0	85	62	76	4	24	0	46	24	141	0	0
	PN-PICT	National R&D Programmes - S&T Integrated Projects	**1.464**	333	155	33	76	8	101	63	65	12	189	127	172	132	0
	PN-COOP	National Cooperation Programmes with Industry	**263**	70	0	19	0	0	118	54	0	0	0	1	0	0	0
	PUE-FP	EU Framework Programmes	**4.494**	431	117	1.143	0	1.279	391	313	43	46	226	100	67	340	0
	PUE-DIV	EU Cooperation Programmes - Other	**632**	104	27	103	0	62	108	0	0	34	178	16	0	0	0
	SERV-NAC	R&D Services and Consulting - National	**2.259**	120	0	95	20	631	259	169	181	3	541	20	114	99	7
	SERV-INT	R&D Services and Consulting - International	**287**	75	40	0	0	114	58	0	0	0	0	0	0	0	0
	OP	Other Funding Programmes	**703**	18	7	19	0	57	37	0	0	17	16	41	0	0	493
		Active Projects	**10.592**	**1.179**	**346**	**1.412**	**181**	**2.212**	**1.147**	**603**	**313**	**112**	**1.196**	**329**	**494**	**571**	**500**
		Closed Projects	**418**	46	23	0	6	106	41	54	55	12	71	0	2	0	2
		Total	**11.010**	**1.225**	**369**	**1.412**	**187**	**2.318**	**1.187**	**657**	**367**	**123**	**1.267**	**329**	**497**	**571**	**501**

Legend:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programmes
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	R&D Services and Consulting - National
SERV-INT	R&D Services and Consulting - International
OP	Other Funding Programmes

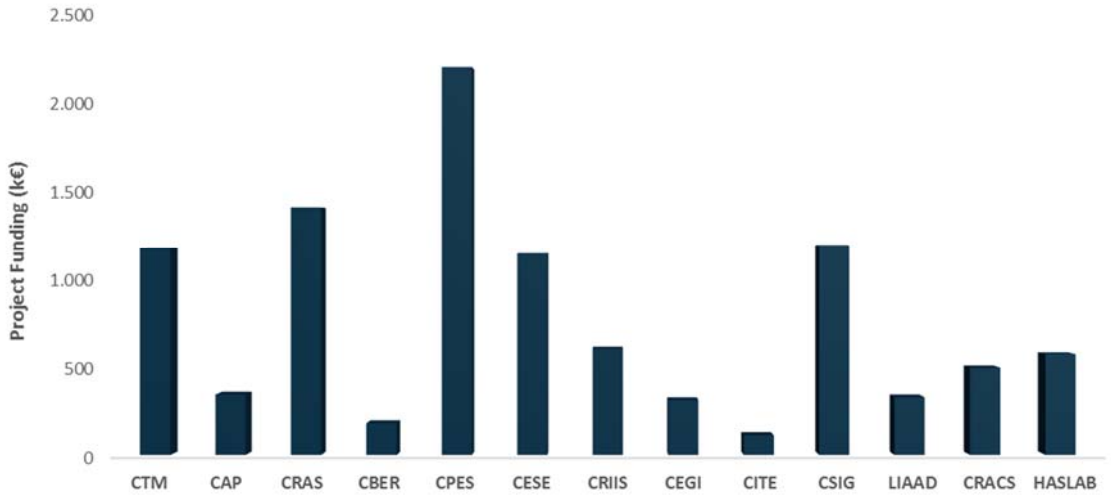


Figure 3.5 – Project Funding by R&D Centre

3.5 Publications

3.5.1 Global Indicators

Table 3.7 and Figure 3.6 show the number of INESC TEC publications in 2016 and its evolution since 2014.

The number of publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia). Publications with authors from different Centres are counted individually in each Centre of the authors, but the institutional total removes repetitions of the same publication in more than one Centre whenever it occurs.

It is important to highlight a clear and steady increase in the number of indexed publications over the last years, both in journals and conferences, reflecting the quality and relevance of the research work at INESC TEC. The increase in the number of indexed jounal papers in 2016 was 26%, significantly higher than the increase in PhD researchers (5%).

Table 3.7 – Number of INESC TEC Publications

Publication Type	2014	2015	2016
Indexed Journals	234	247	311
Indexed Conferences	393	440	476
Books	5	5	1
Book Chapters	50	40	37
PhD Theses - Members	45	26	38
PhD Theses - Supervised	56	66	56

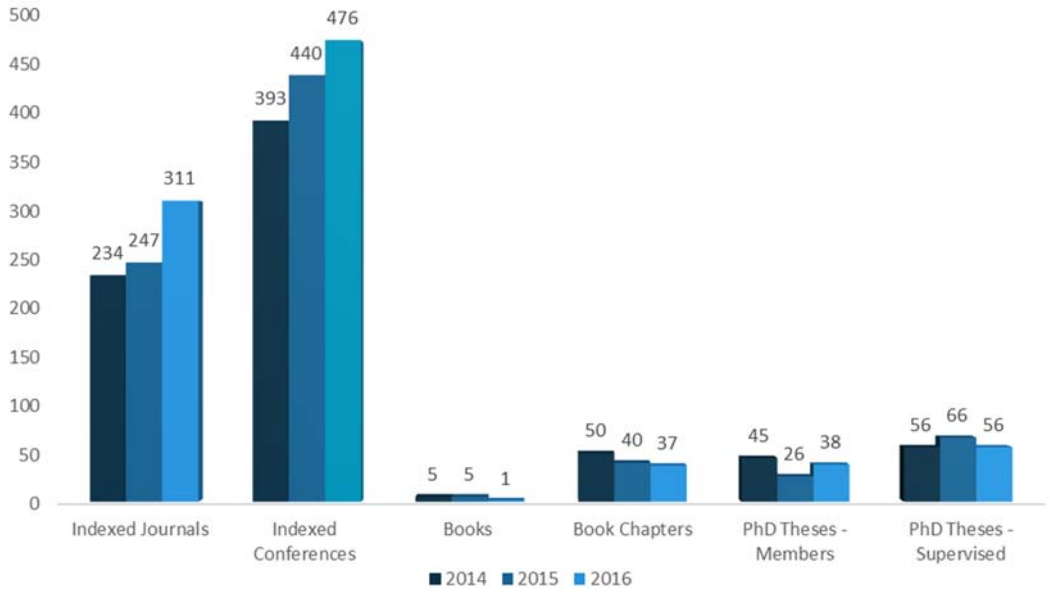


Figure 3.6 – Evolution of INESC TEC Publications

3.5.2 R&D Centres Indicators

Figure 3.7 presents the number of indexed publications in journals and conferences per R&D Centre. The analysis of the evolution of the publications per R&D Centre in presented in later sections in the context of each Centre.

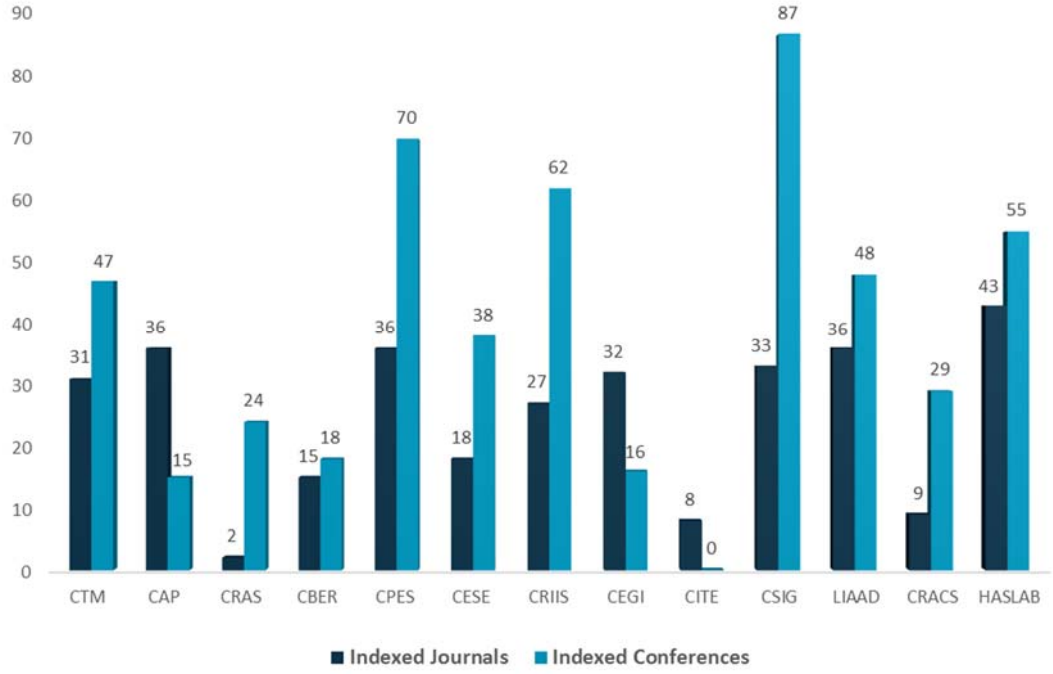


Figure 3.7 - Indexed Publications in Journals and Conferences per R&D Centre

For publications in journals indexed by Scopus (279), Figure 3.8 shows the distribution of the number of publications in each impact factor quartile. As it can be seen, almost two thirds of INESC TEC publications are ranked in the first quartile and only a small proportion (14%) are ranked below the second quartile.

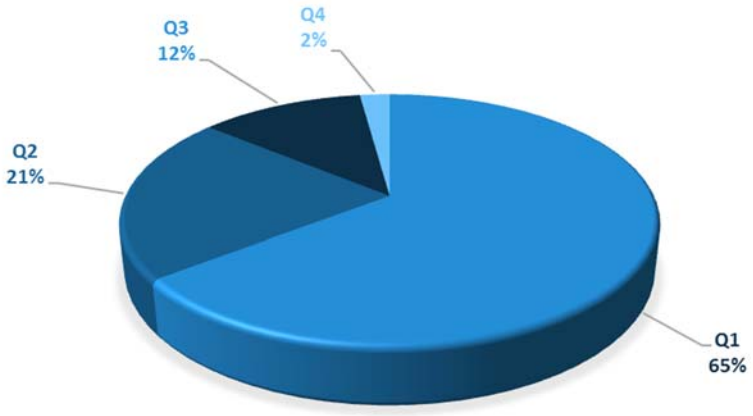


Figure 3.8 – Journal Impact Factor Quartile Distribution (Scopus)

3.6 IP Protection, Exploitation and Technology Transfer

Table 3.8 – Results related with IP Protection, Exploitation and Technology Transfer

Type of Result	2016
Invention disclosures	16
Software copyright registrations	1
Patent applications	5
Licence agreements	5

3.7 Dissemination Activities

Table 3.9 – Results related with Dissemination activities

Type of Activity	2016
Participation as principal editor, editor or associated editor in journals	48
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	75
International events in which INESC TEC members participate in the program committees	236
Participation in events such as fairs, exhibitions or similar	83
Advanced training courses	19

4 INESC TEC CLUSTERS

As mentioned in Section 2, research at INESC TEC is structured in four Clusters - Networked Intelligent Systems (NIS), Power and Energy (PE), Industry and Innovation (II) and Computer Science (CS). Next sections present those four Clusters, their objectives and results during 2016.

4.1 NETWORKED INTELLIGENT SYSTEMS

Coordinator: Manuel Ricardo
Core Centres: Centre for Applied Photonics (CAP), Centre for Biomedical Engineering Research (C-BER), Centre for Robotics Autonomous Systems (CRAS), and Centre for Telecommunications and Multimedia (CTM).

4.1.1 Presentation of the Cluster

The Cluster on Networked Intelligent Systems (NIS) consists of 4 INESC TEC Centres addressing complementary scientific and technological domains:

- CAP, addressing optical sensing and imaging, and microfabrication.
- C-BER, addressing bioinstrumentation, biomedical imaging, and neuro-engineering.
- CRAS, addressing robotics and autonomous systems operating in complex environments for data gathering, inspection, mapping, surveillance and intervention.
- CTM, addressing radio and optical communications, electronics, communications networks, multimedia technologies, computer vision, and intelligent information processing.

The Cluster NIS carries out activities aligned with the following vision:

"We aim to create autonomous networked intelligent hybrid systems enabled by ubiquitous sensing and processing of information."

These systems should be able to operate also in extreme environments such as the deep sea or inside the human body. Examples of networked intelligent systems we aim to create include the following: underwater robotics for environment protection and resource exploitation, flying or terrestrial robotics for surveillance of borders, distributed robotics for monitoring intelligent cities, micro-robotics for monitoring human health, distributed robotics for provisioning of adaptive telecom infrastructures. The development of such systems will probably lead to new results in the NIS Centres, including chemical and bio-sensors, bio instrumentation, high bitrate underwater communications systems, or positioning and navigation systems at deep sea.

4.1.2 Objectives

The NIS cluster aims to develop key enabling technologies for localized and distributed sensing and their deployment in critical and complex environment conditions. The main research lines of this cluster include the following:

- **Sensing technologies**, including physical sensors, chemical sensors, biosensors, optical sensors, RF antennas including planar and arrays of antennas, and acoustic sensors. The adaptation or improvement of multimedia sensors, including video cameras or microphones is also considered.
- **Electronics**, both analogue and digital, which will be required to help implementing the sensors, harvesting or transferring energy, process data, and provide adequate integration means.
- **Information processing,** including signal processing, pattern recognition and machine learning techniques, which are used to process the information provided by generic sensors and extract relevant information including recognizing complex patterns, by using techniques that include machine learning.
- **Robots and autonomous systems**, which carry out the sensors, the processing units, the communications modules and are able to operate in complex environments, including underwater or in human bodies, individually or in groups.

- **Communications**, mainly focused on wireless communications technologies and networks, which will enable the transference of large volumes of information, possibly in real-time, between autonomous vehicles and the Internet operating in complex environments.

4.1.3 Main Achievements in 2016

Sensing technologies

- Microfluidic and optofluidic devices fabricated in pure silica.
- Detection of volatile organic compounds using zinc coated optical fiber gratings.
- Detection of thrombin using an Aptamer-based grating sensor.
- Optical sensor for monitoring solvents in high refractive index oils based on hybrid FBG/titanium dioxide coated LPFG.
- Polymer fiber sensor.
- Sensing of Hydrogen by using configuration of metamaterials.
- Incorporation of low cost optoelectronics dCO2 sensor in an oceanographic platform.
- Medical Device with Rotational Flexible Electrodes.
- Acquisition of dense 3D visual information in underwater environments.

Electronics

- Multiparametric microfluidic chip.
- In-situ stimulator implant in a 180 nm CMOS technology.
- Low-power UWB transmitter, including the digital control on chip, in a 130nm technology.
- Underwater laser scanner.
- Wireless underwater power transfer system.

Information Processing

- Face recognition from RGBD data.
- Modules for automatic fingerprint recognition.
- Re-synthesis of environmental audio information.
- Person identification from an electrocardiogram.
- Quantification of Epileptic Seizure Motion from 3D video-EEG.
- Segmentation of 3D lung nodule using Hessian approaches.
- Lumen detection on ultrasound images of the carotid.
- Content based image retrieval from radiology reports of interstitial lung diseases.
- Visual motion perception through dense optical flow fields for mobile robots.
- Hyperspectral imaging for real-time target detection application.

Robots and autonomous systems

- Small-sized autonomous underwater vehicle.
- Underwater docking station, for support of data transfer and battery recharging of underwater vehicles.
- Laser triangulation system for measuring underwater structures with high definition.
- Portable acoustic beacon for AUV navigation.
- Vision-based localization algorithm for hovering AUVs.
- Control and guidance algorithms for positioning and manoeuvring of AUVs.
- Path planner for a visual navigation under observation constraints.
- Robot localization and mapping in dynamic underwater environments.
- Cooperative perception for UAVs teams.

Communications

- Satellite cognitive radio algorithms implemented in testbed demonstrator.
- Experimental measurement of radiation patterns of radio-frequency antennas in an underwater medium.
- Topology control algorithm for flying communications networks.
- Broadband, long-range maritime communications solution using tethered helium balloons.
- ns-3 computer models for flying networks, maritime networks, and green networks.
- ns-3 computer modules for enabling the fast deployment of communications protocols in real prototypes.

4.2 POWER AND ENERGY

Coordinator: Manuel Matos
Core Centres: CPES
Associated Centres (potential): Centre for Industrial Engineering and Management (CEGI), Centre for Telecommunications and Multimedia (CTM), Artificial Intelligence and Decision Support Laboratory (LIAAD), Centre for Robotics and Autonomous Systems (CRAS), Centre for Information and Computer Graphics Systems (CSIG), High-Assurance Software Laboratory (HASLab), Centre for Applied Photonics (CAP), Centre for Enterprise Systems Engineering (CESE).

4.2.1 Presentation of the Cluster

The cluster is focused on traditional and emergent areas of Power and Energy Systems, for planning and operation purposes, with an emphasis on renewable energy sources (RES) integration, electric vehicles deployment, distributed energy resources (DER) management, demand response (DR), smart grids and energy analytics, through steady state and dynamic network analysis, reliability models and tools, optimization and soft computing and forecasting.

CPES is the core Centre of the cluster but many of the emergent areas benefit from the involvement of associated Centres (CEGI, CTM, LIAAD, CRAS, CSIG, HASLab, CAP and CESE), due to their areas of expertise and of the multidisciplinary nature of the problems to address. There are already examples of this collaboration and joint projects, in the areas of communications (CTM), data mining (LIAAD), cybersecurity and data hub platforms (HASLab). However, rather than just sharing projects, the goal is to deepen and extend this kind of partnership to create new knowledge at low TRL and favour new developments and tools at higher TRL.

The cluster council is presently composed by: Carlos Moreira, Jorge Pereira, Luís Seca, Manuel Matos, Ricardo Bessa (all from CPES) and followed by Luís Carneiro and João Peças Lopes (both from the Board). Representatives of the associated clusters will be invited to participate in the future meetings of the cluster.

4.2.2 Objectives

Structural objectives

The consolidation of the cluster structure is a short-term objective, namely regarding the discussion with the foreseen associated Centres, as mentioned in other part of this plan.

Following a suggestion from the Board, the cluster will develop efforts in the middle term to promote two new Centres, one resulting of the autonomisation and extension of the power electronics area, another in the area of Oil and Gas.

Strategic areas

The cluster identified a list of strategic areas for present and future activity. These areas result from a preliminary analysis of the European Union's R&D agenda (European Strategic Energy Technology Plan, Horizon 2020 work programme, Grid+Storage R&I Roadmap 2017-2026, etc.) and the National Research and Innovation Strategies for Smart Specialisation (RIS3 strategies) and includes the vision of CPES and associated Centres researchers:

Co-simulation in Electrical Networks

Simulation of the joint operation of telecommunication and electrical networks, including the transmission-distribution grids coordination and protection systems coordination.

Multi-energy networks

Joint modelling of electricity, gas and heat networks considering active demand-side management (residential and building level), energy storage and renewable energy sources. This also includes the joint modelling of transmission and distribution electrical networks.

Large-scale modelling of energy systems

- Modelling spatial-temporal dependency structures of time-series with two goals: uncertainty modelling; forecasting.
- Definition of methods and strategies for real-time monitoring and support the operation of networks by considering DER (renewable energy, storage and flexible loads) and the types of information available, at HV, MV and LV level independently or integrated. This includes knowledge extraction from synchro-phasors units installed in electric power transmission and distribution systems.
- Solve large-scale non-convex optimization and learning problems with decomposition techniques and distributed computing. Definition of methods and strategies for operation distributed energy resources (DER) locally or globally.
- Renew the concepts of load profile for analysis at LV, MV and HV levels by using different sources of information, including human behaviour, and using techniques of classification and clustering, that will be used on planning, in operation, and in reliability studies.

Weather Intelligence Applied to Power Systems

Integrate information generated from numerical weather prediction systems in power system operation and management tasks, electricity markets and demand response actions.

Stochastic Optimization of Energy Systems

Integration of uncertainty forecasting information in grid operational tools that aim to evaluate the future network conditions and derive a set of optimal control actions.

Predictive Maintenance and Asset Management

Multi-disciplinary approach that combines big data management structures, statistical learning and power systems theory (reliability, electric modelling, etc.) to design a probabilistic framework to support the decision-making process of asset management and renew of electrical power systems and power plants.

Towards 100% RES integration and Massive integration of power electronic-based interfaces

- Identification of challenges resulting from the massive connection of power electronic based generators in electric power systems and development of new operational methodologies for assuring system stability.
- Development of predictive algorithms for enabling the participation of renewable generation in synthetic inertia provision and frequency containment control (it requires the development of on-line tools to estimate the available inertia and primary reserve levels).

Smart-grid hardware

- Development of intelligent and autonomous control devices for smart grids network, including lab tests of integration with different components in the network and substation automation.
- Explore the hardware and software in the loop capability for testing hardware devices and software control modules for future smart grids. Take advantage of the OPAL system to perform RTDS. Enhancing RTDS through connection with similar simulators.
- Specific developments for enhancing system behaviour (inverters, protections).

New marketplaces for energy services

New solutions for network operation and planning in an active market environment with several players and rules considering data transmission, data privacy and data security issues, including market hubs. Development and test of new tariff options, namely associated to dynamic tariffs, and peer-to-peer trading mechanisms for prosumers (renewable energy, flexibility from controllable resources).

Cybersecurity of the grid

Cybersecurity is a current concern for several electrical utilities and a critical barrier for advanced functionalities at the smart grid level and emergent business models. The research goal in this topic is to analyse the internet threats for the power systems and means to avoid, early detect and combat cyber-attacks.

System resilience

Procedures for black-start, self-healing and islanding operations in systems dominated by grid inverter generation.

Power system planning

- Development of algorithms for intelligent planning considering the smart grid implementation, operation and management costs, the benefits of using smart grids (flatter diagrams, the option of investment deferral, etc.) and the potential drawbacks (higher losses, higher risk, etc.);
- Development of tools for reliability analysis, namely for security of supply evaluation and reserves adequacy evaluation.

Energy efficiency

Integrate the internet-of-things (IoT) technology with data-driven energy optimization functions to achieve higher energy efficiency gains in energy-intensive consumers (e.g., manufacturing, water distribution, buildings). Identification of the synergies between the traditional energy efficiency area and smart grid developments, originating new tools and opportunities for consulting.

4.2.3 Main Achievements in 2016

Due to the specificity of this cluster, with only one core Centre (CPES), efforts have been developed in order to increase the synergies with other Clusters/Centres, in the framework of the definition of the strategic lines for the cluster. The first stage was internal, with the identification of an initial list of strategic lines (see previous section). An invitation was then made to all the other centres of INESC TEC to make proposals of cooperation in the initial lines or in additional lines. The process is on-going, with foreseen meetings to set a final list of strategic lines. Meanwhile, the process has already generated new projects where CPES and other centres collaborate in multidisciplinary approaches to complex problems. These are important achievements.

During 2016, we saw already a participation of CPES and other centres of INESC TEC in some important projects, in the framework of previous partnerships, leading to the following achievements:

- Development of new market services to handle local constraints in electric distribution grids through the use of flexibility of DSO resources and DR services. This work was made in the framework of the Horizon 2020 EU project smarterEMC2. [CPES, CTM]
- Development of a data and market hub platform to enable exchange of information regarding retailing market data, such as flexibility from the Home Energy Management System (HEMS) and smart meter measurements. This work combined knowledge in power systems management and big data and it was made in the framework of the Horizon 2020 project UPGRID. [CPES, HASLab]
- Design of new energy services boosted by smart grid technologies, supported by consumer segmentation methods, to engage residential consumers in demand-side management technology. This work followed a multi-disciplinary approach that combined knowledge in smart grid technology, services engineering and business analytics. This work was made in the framework of the Horizon 2020 project UPGRID. [CPES, CEGI]
- DevelopCentrement of a home energy management system including the supporting hardware and software modules; optimization algorithms embedded in single board computing platforms. This work was made in the framework of the Horizon2020 project AnyPlace. [CPES, CTM, LIAAD]

- Development of algorithms and implementation of a platform (R Project language) for the detection of non-technical losses and anomalous consumption behaviour. These activities were developed under the scope of contract with EDP Distribuição. [CPES, LIAAD]
- Implementation of a sub-metering system in INESC TEC main building with ca. 170 metering points. The meters' frequency is configurable (maximum of 5 measurements per second) and the collected data will be stored in real-time in an online database. The data gathered will be used to feed a gamification platform which main objective is to foster behaviour change to increase overall energy efficiency in the building. (GReSBAS ERA-NET project) [CPES, CSIG]

These specific achievements are highlighted because they reflect the interaction with Centres outside the cluster, but we considered replicated here the other main achievements reported by CPES.

4.3 INDUSTRY AND INNOVATION

Coordinator: António Lucas Soares
Core Centres: Centre for Enterprise Systems Engineering (CESE), Centre for Robotics in Industry and Intelligent Systems (CRIIS), Centre for Industrial Engineering and Management (CEGI), Centre for Innovation, Technology and Entrepreneurship (CITE)
Associated Centres: Laboratory of Artificial Intelligence and Decision Support (LIAAD)

4.3.1 Presentation of the Cluster

The Cluster Industry and Innovation at INESCTEC (c_I+I@INESCTEC) aims to research and innovate in systems and services applied to the management of value streams, from the individual organisation to networks and chains. The activities of the c_I+I@INESCTEC result in high impact systems for decision support, operations automation, management and intelligence and in the provision of technology transfer and innovative consultancy services for applications in Industry, Retail, Healthcare, Energy, Mobility and Transports, and Agriculture.

The c_I+I@INESCTEC wants to make INESC TEC internationally recognised as a leading research Centre in the industry and innovation area and as a first choice for supporting organisations to achieve high-levels of sustainable innovation and performance.

The Cluster Industry and Innovation (I+I) consists of 4 INESC TEC Centres addressing complementary scientific and technological domains:

- CESE, addressing Manufacturing and Services Operations Management, Enterprise and Industrial ICT, Collaborative Networks and Supply Chains, Manufacturing Intelligence;
- CRIIS, addressing industrial Robotics, Collaborative Robots and Intelligent Sensors and Dynamical Systems;
- CEGI, addressing Service Design, Decision Support, Performance Assessment, Asset Management, Prescriptive and Prescriptive Analytics;
- CITE, addressing Innovation Management, Fuzzy Front End of Innovation, Technology Management, Technology Entrepreneurship.

The four core Centres of c_I+I@INESCTEC undertake research, knowledge/technology transfer, and consultancy services in complementary research domains (see Figure 4.1) strongly coupled and coordinated through the following collaboration axis: Innovation and Development of New Product/Services; Information Management and Knowledge Discovery; Robotics, Automation, Internet of Things and Cyber-Physical Systems; Design, Planning, Control and Improvement of Operations; Transportation and Mobility.

The cluster uses a range of research approaches to fulfil its mission, namely: Systems Design, Modelling, Mathematical Programming, Optimization, Simulation, Analytics, Information Management, Data Mining, Knowledge Discovery, Machine Learning, Model Based Predictive Control, 3D and Active Perception, Multimodal Sensor Fusion, Design Science and Explanatory Research, Creative Thinking and Problem Structuring.

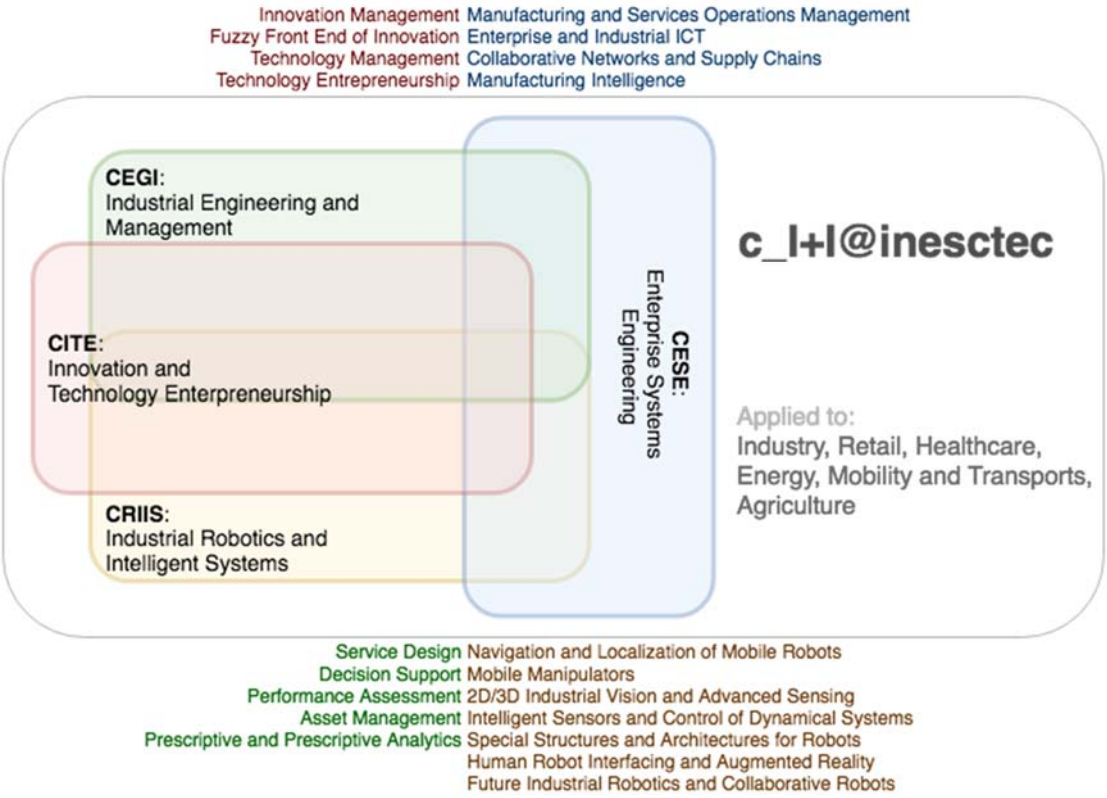


Figure 4.1: c_ I+I@INESCTEC research domains

4.3.2 Objectives

The c_I+I@INESCTEC core Centres have a good track record of joint projects, publications and consultancy services, as well as established collaboration practices. Still, there is room for improvement. In the second semester of 2016, the cluster undertook an internal project — "Shape the future" — involving five inter-centre teams that analysed the as-is situation regarding the axis of collaboration and proposed a set actions to substantially improve the cluster performance. The bellow described objectives already reflect the results of this project.

The following objectives intend to address further integration of practices, improve and balance the scientific production and rationalise consultancy:

- Continue to improve the alignment between basic research, applied research and consultancy;
- To implement joint strategies to attract high quality PhD students and scholarship holders;
- To define a strategy for the technology transfer and consultancy projects portfolio;
- Evaluate the potential of new technology transfer and consultancy areas;
- Develop a roadmap for existing and new high-value services to offer;
- Consolidation of a strategic communication plan that includes the establishment of the Cluster's web presence, including a youtube channel, in articulation with the communication strategy of INESC TEC.

4.3.3 Main Achievements in 2016

In the research and technology development area, the following achievements must be highlighted:

- The completion of the first year of the research programme — SmartSL — with KYAIA, a company in the footwear sector. Under this programme, research results such as new sequencing and production balancing techniques were achieved and used to develop an innovative system for the management of stitching departments. This solution takes the production of footwear to a next step, managing efficiently resources, increasing the production, reducing the lot and producing faster. INESC TEC with KYAIA owns the property rights and in 2016 already sold 3 licenses;
- The organization of the 17th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2016, Porto, Portugal, October 3-5. This is the main international conference in the area of collaborative networks. This scientific event gathered approximately 70 international specialists from several disciplines;
- In the Robotics for Agriculture and Forestry application field, the cluster has proposed eleven projects and got four projects approved (two national SmartFarming, ROMOVI and two international Agrisensus and Water4Ever). This will allow to reach the first goal of our Agriculture and Forestry robotics roadmap, propose advanced solutions for agricultural monitoring systems;
- The dynamics of the cluster and quality of its research has been distinguished, both at the national and international level, with nominations for prizes and relevant positions, including: two Certified Analytics Professionals; one deputy at the Health Parliament Portugal; one coordinator of a European working group on Retail Operations; a prize for the most influential paper published at Transport Policy; a nomination for non-executive board member of A3ES - The National Agency for Accreditation in High Education. One team member is now President of the Portuguese Association for Operations Research. Furthermore, four team members are with the Editorial Board of prestigious international journals: International Transactions in Operations Research, European Journal of Operations Research, Advanced Tutorials in Operational Research, and TRPRO.

In the technology transfer area, the following were the main achievements:

- The consolidation of simulation-centered advanced consulting services. Levered on the IKEA service contracts, INESCTEC was able to build a highly qualified team and develop a specific methodology for factory layout design. With this team and approach, INESC TEC become the main partner of IKEA for layout design and planning;
- The visibility achieved by the participation in AUTOMATICA trade fair and the EMAF. The AUTOMATICA trade fair is held each two years in Munich, and is the main event in the world in terms of Industrial and Service Robotics. In 2016 INESC TEC had a strong presence at AUTOMATICA, with robots in 3 booths, showing results from 3 FP7 European Projects: CARLoS, STAMINA and SMERobotics. In November 2016, the biggest national industrial trade fair took place at Exponor, EMAF, and the CRIIS robots have been shown in 3 different booths: (1) The STAMINA robot at the INESC TEC booth, the LeanAGV at the PRODUTECH booth in partnership with ANTIPODA and finally the CoopWeld Robot was shown at SARKKIS Robotics. Two of these robots were awarded the 1st and 2nd prize in the EMAF/Robotica innovation award;
- INESC TEC received a special invitation for the participation on the agricultural fair AgroGlobal 2016 (The biggest technology fair in Portugal) and got more than a dozen of articles on the main national media (referring the Agrob V14 and Agrob V16 platforms). This type of news will make INESC TEC a national reference on robotics R&D for Agriculture and Forestry application;
- Approval of a grant for three different accelerator programmes that include mentorship and educational components: IN&OUT – an early stage start-ups accelerator for everyone who wants to

develop a technological based entrepreneurial project; BIP – Business Ignition Programme: a programme design to researchers in order to improve their capacities to be part of the process of the technology exploitation; LET IN Catalyst – implement an internal entrepreneurship programme to support INESC TEC researchers in their entrepreneurship initiatives;

- Consolidation of partnership with EDP Group was achieved with one new project in "Asset Management";
- In the healthcare domain, partnership with Glintt Healthcare in a co-promotion project is also an important achievement for 2016, strengthening the activity within the Cluster.

4.4 COMPUTER SCIENCE

Coordinator: António Gaspar
Core Centres: Centre for Information Systems and Computer Graphics (CSIG), Laboratory of Artificial Intelligence and Decision Support (LIAAD), Centre for Research in Advanced Computing Systems (CRACS), High-Assurance Software Laboratory (HASLab)

4.4.1 Presentation of the Cluster

INESC TEC aims at excelling in the control of the chain data>information>knowledge for pervasive and massive data repositories and data flows. This includes the components of new high-level languages, distributed computing, critical software, privacy protection, pervasive cyber security and generalized knowledge extraction, namely from massive spatio-temporal distributed and geo-referenced databases possibly lodged in moving media.

The Computer Science Cluster mission is to achieve excellence in both fundamental and applied research, with international impact, with a strong emphasis on technology innovation and transfer that benefits society at large. Our strong commitment encompasses many core areas from programming languages and rigorous software development, data processing and large scale computing to security and usability, to newer challenges of bringing better intelligence into everything.

The Computer Science (CS) Cluster is composed by four Centres, namely:

- CRACS - Centre for Research in Advanced Computing Systems
- CSIG - Centre for Information and Computer Graphics Systems
- HASLab - High-Assurance Software Laboratory
- LIAAD - Artificial Intelligence and Decision Support Laboratory

The CS Cluster Centres address diversified, heterogeneous and yet complementary research areas. The main research areas are:

- Accessibility and Assistive Technologies
- Big Data Applications
- Computer Graphics and Virtual Environments
- Cryptography, Information Security and Privacy
- Distributed Systems
- Information Management and Information Systems
- Intelligent and Adaptive Systems
- Languages and Distributed Computing
- Machine Learning and Data Mining
- Mathematical Modelling in Decision Support
- Software Engineering
- Special Purpose Computing Systems

The Cluster is also strongly involved in Technology Transfer activities, either as Advanced ICT Consulting or Innovative Systems Development in areas such as Agriculture, Electronic Government, Energy, Healthcare, Industry, Telecommunications, Transport and Services. Major examples of these activities are:

- vCardID - Development and implementation on smartcard of a fingerprint match-on-card algorithm for the next version of the Portuguese citizen card. This project involved three CS Cluster Centres (and CTM): CRACS, CSIG and HASLab.
- WiderMoS - Implementation of a prototype of a Logistics Single Window, for multimodal cargo transport.
- DRIW2020 - Consultancy for the design of new e-infrastructures supporting navigation in river Douro.
- SIGAMP - Implementation of a Spatial Data Infrastructure (SDI) for the Porto Metropolitan Area.

- Esporão - Design and implementation of data mining solutions for increased efficiency in different stages of agricultural processes.

Additionally, several spin-off and start-up companies have been launched in the period 2015-2016, namely:

- ADYTA - a start-up company of the University of Porto with its core business in mobile security, created with 2 collaborators.
- LEANXCALE – a start-up in the area of real time analytics, producing an ultra-scalable transactional database, created in the sequence of the CumuloNimbo (EU FP7), CoherentPaaS (EU FP7) e LeanBigData projects (EU FP7). It has 10 collaborators (7 PhDs).
- MITMYNID – a spin-off in the area of e-logistics for multimodal cargo transport, resulting from MIELE (EU TEN-T) and WIDERMOS (EU TEN-T) projects, launched with 8 collaborators (1 PhD).

The Cluster is served by significant laboratory infrastructures, namely cluster and cloud computing resources located in Porto and Braga, and a multi sensorial immersive virtual reality laboratory based in Vila Real.

The computing infrastructure at Porto comprises a reliable OpenStack cloud setup implemented in the model of infrastructure-as-a-service. It is a cluster comprising 280 Intel Xeon cores with 1.5TB of memory distributed among 12 compute nodes. The architecture includes a 16TB of usable storage, a 40-Gb- Infiniband to interconnect the compute nodes and 10-Gbs copper Ethernet to connect the nodes and storage, all built to be fully redundant and fault tolerant from the network to service layers. The computing infrastructure at Braga is broken into 3 distinct components: one cluster composed of server grade machines, providing a total of 192 cores and sharing a 16TB DAS connected via 8Gb fiber; one cluster with 104 commodity machines, providing 4 cores each; one private OpenStack cloud currently providing 50 cores.

The multisensorial immersive virtual reality laboratory (MASSIVE Laboratory) has 150m2 and is organized in 7 spaces: waiting area, experimental room, multisensory experimental room, control room, survey room, researcher's workspace and maintenance area. Its main equipment is composed by omnidirectional treadmills and a VirtuSphere, sound proofed facilities, optical tracking systems, smell capture and delivery, wind blower, temperature control, eye trackers and bio sensors (EEG and ECG).

4.4.2 Objectives

- Increase the level of consultancy and R&D services.
- Increase the number of publications.
- Increase the participation in European projects and networks.
- Reinforce the partnership with other INESC TEC Centres that require the use of our competences in their target domains.
- Create a joint OpenDay.
- Organise small events among Cluster Centre's researchers to promote collaboration.
- Create a web streaming infrastructure to support remote access and archive of Cluster events.

4.4.3 Main Achievements in 2016

The publication level has increased from 2015 roughly 10%, both in terms of indexed journals and indexed conferences.
FCT funded research was strongly reinforced in 2016, with three new projects: TAIL, CONTEXTWA and iCare4Depression.

The research supported by European funds was also successful:

- The FP7 projects Maestra, PRACTICE and CoherentPaaS were successfully concluded;
- The BEACONING H2020 project started in January 2016;
- The Digi-NewB H2020 project started in March 2016;
- And 3 new H2020 projects were approved in 2016: RECAP, LightKone and CloudDBAppliance.

Additionally, new funding lines were opened in 2016:

- HDR4RTT, HDR for Real Time Tracking, was the first INESC TEC's project funded by US Navy (ONRG);
- AV360, was the first INESC TEC's project funded by Google DNI.

In 2016 several distinctions and awards were received:

- João Gama, nominated "Distinguished Speaker" by the Association for Computing Machinery;
- Carla Teixeira Lopes, Honorable Mention Award ,CLEF'16;
- Manuel Barbosa and José Bacelar Almeida, Best Paper Award, Fast Software Encryption 2016;
- Álvaro Figueira and Luciana Oliveira, Best Paper Award, CSEdu 2016;
- Ana Paiva e Nuno Flores, Best Paper Award, HEAD'16;
- José Creissac Campos and Michael Harrison, Honorable Mention Award, EICS '16;
- Álvaro Figueira and Luciana Oliveira, Best Poster Award, WEBIST'16;
- Diana Carvalho e Maximino Bessa. Jesús Lorés Best Paper Award, INTERACCIÓN 2016;
- Vinícius Souza, Best PhD Thesis, Computational and Artificial Intelligence Thesis and Dissertations Contest;
- Carlos Afonso, Multicert School Prize 2014/2015;
- Ricardo Campos, invited to the Editorial Board of the Information Processing and Management Journal;
- Ricardo Queirós, invited to the jury of IEEE Mobile Application Development Contest (IEEEmadC);
- Cristina Ribeiro, invited to the Open Science National Policy Working Group, created by the Ministry of Science, Technology and Higher Education;
- José Creissac Campos, elected chairman of IFIP WG 2.7/13.4;
- Two different projects led by João Barroso and Tânia Rocha received the two "Inclusion and Digital Literacy Prizes" awarded in 2016 by FCT.

Significant laboratory infrastructures were concluded in 2016, namely cluster and cloud computing labs and a laboratory dedicated to research in multisensorial immersive virtual reality.

The spin-off company MITMYNID, previously referred, was also launched in 2016.

4.5 Main Indicators by Cluster

In this section, we include the Cluster main indicators which allow obtaining an overview of their relative size and expected results planned for 2017.

4.5.1 Human Resources

Table 4.1 – Human Resources indicators by Cluster

Type of Human Resources			Clusters			
			NIS	PE	II	CS
Integrated HR	Core Research Team	Employees	18	12	17	9
		Academic Staff	46	12	52	90
		Grant Holders and Trainees	101	51	86	160
		Total Core Researchers	**165**	**75**	**155**	**259**
	Affiliated Researchers		18	3	13	23
	Administrative and Technical	Employees	5	2	4	2
		Grant Holders and Trainees	1	0	1	2
		Total Integrated HR	**189**	**80**	**173**	**286**
		Total Integrated PhD	**83**	**25**	**83**	**141**
Curricular Trainees			8	2	14	12
External Research Collaborators			13	9	27	46
External Administrative and Technical Staff			0	0	3	4
External Students			23	1	14	32
		Total	**233**	**92**	**231**	**380**

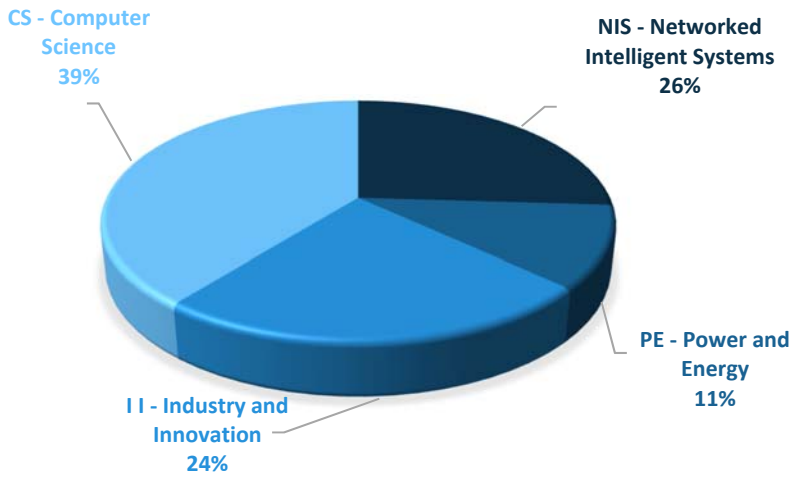


Figure 4.2 – Human Resources by Cluster

4.5.2 Activity in Projects

Table 4.2 – Activity in Projects by Cluster

Funding Source			Clusters			
			NIS	PE	II	CS
Firm Projects	PN-FCT	National R&D Programmes - FCT	113	62	104	211
	PN-PICT	National R&D Programmes - S&T Integrated Projects	596	8	240	619
	PN-COOP	National Cooperation Programmes with Industry	89	0	172	1
	PUE-FP	EU Framework Programmes	1.690	1.279	792	733
	PUE-DIV	EU Cooperation Programmes - Other	235	62	141	194
	SERV-NAC	R&D Services and Consulting - National	235	631	612	775
	SERV-INT	R&D Services and Consulting - International	115	114	58	0
	OP	Other Funding Programmes	44	57	54	56
		Active Projects	3.117	2.212	2.174	2.590
		Closed Projects	76	106	161	74
		Total	**3.192**	**2.318**	**2.335**	**2.663**

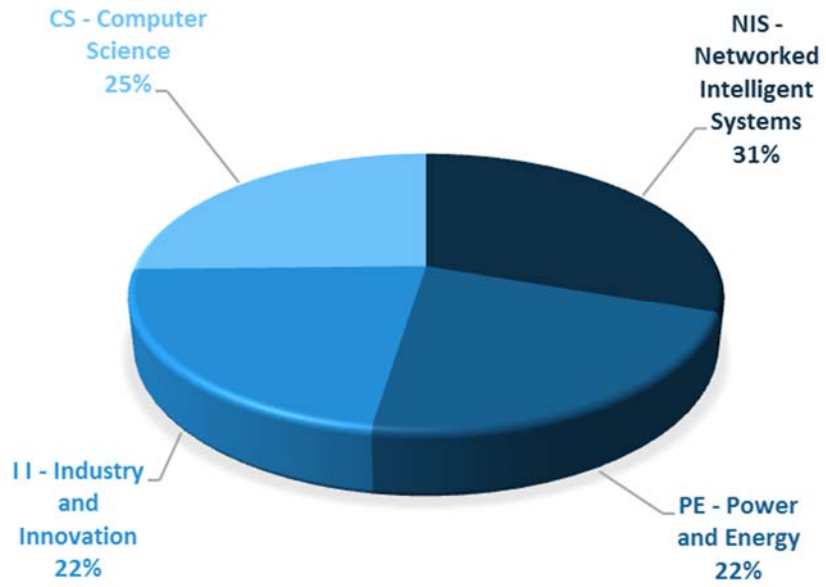


Figure 4.3 – Project Funding by Cluster

4.5.3 Publications

The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 4.3 – Summary of Publications by Cluster

Funding Source	Clusters			
	NIS	PE	II	CS
Indexed Journals	84	36	85	121
Indexed Conferences	104	70	116	219
Books	0	0	1	0
Book Chapters	6	3	16	15
PhD Theses - Members	11	3	9	15
PhD Theses - Supervised	15	5	16	23

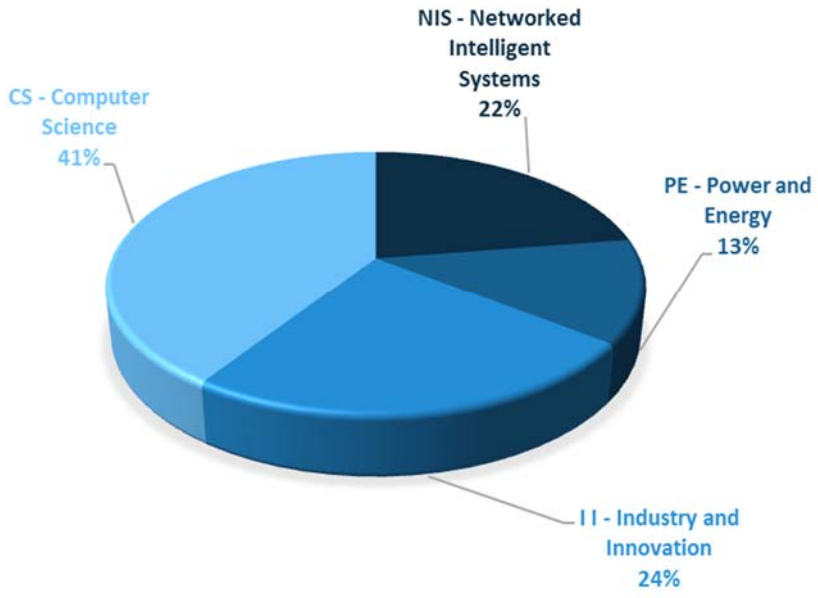


Figure 4.4 – Indexed Articles by Cluster

5 RESEARCH AND DEVELOPMENT CENTRES

5.1 CTM - CENTRE FOR TELECOMMUNICATIONS AND MULTIMEDIA

Coordinator: Manuel Ricardo

5.1.1 Presentation of the Centre

The Centre for Telecommunications and Multimedia (CTM) consists of 100+ researchers addressing scientific and technologic topics related to the fields of telecommunications and multimedia. CTM is fully committed and aligned with the vision and mission of INESC TEC and specializes them as follows:

- **Vision:** A lively and sustainable world where networked intelligence enables ubiquitous interaction with sensory-rich content.
- **Mission:** Development of advanced systems and technologies enabling high capacity, efficient, and secure communications, media knowledge extraction, and immersive ubiquitous multimedia applications.

CTM accomplishes its mission, within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards 4 main areas of research: Optical and Electronic Technologies; Wireless Networks; Multimedia and Communications Technologies; Information Processing and Pattern Recognition.

5.1.2 Research and Technology Development

OET – Optical and Electronic Technologies

The main goal of this area is to technologically devise solutions for communications and intelligent systems of the future, based on the integration of advanced skills in optical communications and microwaves, signal processing, microelectronics and programmable logic. Research activities in optical communications and microwaves addresses the development of optical and wireless communication systems, including the convergence between both wireless and optical systems, targeting future high-speed wired and wireless communication systems, in both terrestrial and maritime environments, supported in advanced modulation formats and signal processing techniques as well as on R&D of novel radio devices and antennas. Research in microelectronics and programmable logic addresses design, testability, characterization and adaptive correction of performance, RF design and transparent electronics, A/D and D/A conversion, dedicated computing applications in reconfigurable logic and adaptive transparent acceleration, and VLSI design.

WiN – Wireless Networks

The main goal of this area is to design and evaluate new networking solutions suitable for next generation communication networks. The focus is on wireless networks and mobile communications, extending infrastructure networks and enabling the Internet of Everything in terrestrial and maritime environments. This requires theoretical and simulation modelling, implementation, and experimental evaluation of communications networks and their elements. The main research topics include medium access control, radio resource management, context-aware optimization using cross-layer techniques, and self-configuration of static and mobile multi-hop wireless networks.

MCT - Multimedia and Communications Technologies

The main goal of this area is to devise solutions for capturing, producing, sharing and accessing multimedia information from users' own perspectives and experiences, over the Internet, in social media, through on demand services, or even in large spaces like a theatre or a football stadium. This includes the integration of different media formats, the ways of constructing different narratives, human-media interaction mechanisms or the possibility of delivering and accessing distributed multimedia resources in heterogeneous environments to any user in a seamless and adaptable way. The main research topics include the following: technologies to enable personalized access and consumption of multimedia content through context awareness; immersive multi-view experiences; content description approaches and metadata model and tools for sensing,

representing and reproducing multi-sensorial real-life experiences; efficient search and content analysis methods; image, video, sound and music content analysis and knowledge extraction; pattern recognition.

IPPR - Information Processing and Pattern Recognition

IPPR pursues a never ending audiovisual information learning system, to empower the next generation of intelligent systems with the capability of reasoning from audiovisual data. On the shorter-term IPPR aims to develop computer based algorithms and systems by proposing computer vision and machine learning architectures that attempt to explain the input data from the world by exploiting prior experience with similar data. The new advances are being validated in key applications on the areas of biometry, medical image analysis, human sensing, and network information processing, contributing to a more enjoyable, secure and healthy environment.

5.1.3 Technology transfer

OET – Optical and Electronic Technologies

In the optical and electronics area, CTM is able to transfer technology and provide consulting services on:

- Design and characterisation of Optical and Microwave Communication Systems. Telecommunication solutions based on wireless technology, research and development in compact multi-band/integrated antennas for mobile networks, developing, testing and characterisation of RF/microwave devices, antennas and waveguides. Simultaneously we address aspects dealing with technological solutions for optical/RF communications and wireless power transfer in underwater environments. CTM holds an advanced laboratory for optical and microwave communications where researchers can test and characterise optoelectronic devices, RF/microwave circuits and waveguides. This laboratory makes it possible to develop and test optical and wireless communication systems and develop optical fibre based solutions for present and future broadband wireless applications.
- Design of (Micro)electronic Systems for Communications. Semi/full-custom designing and testing of analogue, digital and mixed (A/D) circuits and digital systems based on microprocessors and reconfigurable logic. CTM has specialised in the design of analogue and digital electronic circuits in silicon-monolithic substrates, printed circuits and reconfigurable platforms, as well as on the development of analogue or mixed-signal circuits for low and radio frequency applications, namely in the biomedical domain. Testing and built-in self-testing solutions for integrated circuits and systems, design for dependability of wearable systems, reconfigurable logic processing and computing solutions and/or embedded systems and implementing adaptive systems based on dynamic reconfiguration, are also some of the areas we focus on for technology transfer.

WiN - Wireless Networks

In the wireless networks area, CTM is able to transfer technology and provide consulting services on:

- Planning and design of broadband networks capable of supporting multimedia applications and services, including video.
- Planning and design of wireless mesh networks for network infrastructure extension.
- Planning and design of communications networks for autonomous vehicles (aerial, surface, and underwater).

MCT - Multimedia and Communications Technologies

In the Multimedia Systems area, CTM is able to transfer technology and provide consulting services on:

- Context-aware multimedia applications in heterogeneous environments, metadata and content description approaches, content management, adaptation and personalization.
- Image, video, sound and music analysis, including cross-media knowledge extraction.

IPPR - Information Processing and Pattern Recognition

In the sound and vision area, CTM is able to transfer technology and provide consulting services on:

- Intelligent Recognition Products and Systems based on Vision.
- Solutions to automatically process manuscript documents, medical decision support systems, automatic surveillance systems, and biometrics.

5.1.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CTM – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)								
	Status (2)	Optical and Microwave Systems	(Micro)electronic Systems	Wireless Mesh Networks	Networks for robotics	Multimedia applications	Video and music analysis	Recognition Systems based on Vision	Medical and biometrics solutions
Optical and Electronic Technologies	I	H	H						
Wireless Networks	I			H	H				
Multimedia and Communications Technologies	I					H	H	H	
Information Processing and Pattern Recognition	I							H	H

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer

(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership

(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.1.5 Main Achievements in 2016

OET – Optical and Electronic Technologies

- Evaluation and validation of the satellite cognitive radio algorithms developed in the SCREEN project, using a laboratory testbed demonstrator;
- Demonstration of novel method for designing maximum efficiency underwater wireless power transfer inductors through an optimization across the full range of battery charge state;
- First reported experimental measurement of a radiation pattern for a radio-frequency antenna placed in an underwater medium, including demonstration of the effect of water conductivity in the shape of the radiation pattern;
- Development and design of a very low-power UWB transmitter, including the full digital control on chip, in a 130nm technology (almost ready for tape-out);
- Development of an externally powered and programmable cruciate ligament in-situ stimulator implant in a 180 nm CMOS technology.

WiN – Wireless Networks

- Network topology control algorithm for flying backhaul mesh networks using a potential-fields approach;
- Broadband, long-range maritime communications solution using tethered helium balloons, whose prototype was successfully validated in three sea trials;
- Novel ns-3 simulation models for evaluating flying networks, maritime networks, and green networks.
- Novel ns-3 modules enabling optimized fast prototyping of networking protocols;
- Deepened collaboration with the CRAS INESC TEC Centre by means of multiple joint R&D projects, including EEA Grants BLUECOM+, EEA Grants ENDURE, FP7 SUNNY, Norte 2020 CORAL, H2020 RAWFIE – FLEXUS, and H2020 STRONGMAR.

MCT - Multimedia and Communications Technologies

- Large Scale Pilot in real environment for the validation of research results for the integrated management of retail environments;
- Novel modules for the video annotation tool to include social network platforms integration;
- A web-based system for interactive experimentation with musical temperament (Beatings);
- A sound-design system for environmental audio resynthesis (SEED);
- CTM researcher awarded "Investigador FCT Development Grant" (ranked 1st in Engineering and Technology).

IPPR - Information Processing and Pattern Recognition

- Pilot for face recognition from RGBD data;
- Modules for automatic fingerprint recognition;
- Novel methods for dealing with imbalanced learning problems;
- New classifier for directional data;
- Pilot for breast cancer surgery planning;
- 3rd place in the first round of the international DREAM challenge in breast cancer screening.

5.1.6 Centre Organizational Structure and Research Team

The Centre for Telecommunications and Multimedia is coordinated by Prof. Manuel Ricardo and is organized in the following research Areas:

- OET - Optical and Electronics Technologies - Responsible: Henrique Salgado
- WiN - Wireless Networks - Responsible: Rui Campos
- MCT - Multimedia Communications Technologies - Responsible: Paula Viana
- IPPR - Information Processing and Pattern Recognition – Responsible: Jaime Cardoso

The Centre has two councils: **CTM Coordination Council** and **CTM Scientific Council**. CTM Coordination Council meets every 2 weeks and it is composed by CTM Coordinator, 4 Area Leaders, the Advisor to CTM Coordinator and CTM secretary - in these meetings strategic and management decisions are made. CTM Scientific Council meets every 2 months and it is composed by the senior CTM researchers, mostly PhD researchers - this is a consultative council and strategic topics are discussed in the meetings.

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CTM – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	6	5	7	2
		Academic Staff	21	22	21	-1
		Grant Holders and Trainees	55	44	46	2
		Total Core Researchers	**82**	**71**	**74**	**3**
	Affiliated Researchers		9	11	8	-3
	Admin. & Tech	Employees	1	1	1	
		Grant Holders and Trainees				
	Total Integrated HR		**92**	**83**	**83**	
	Total Integrated PhD		**40**	**43**	**43**	
Curricular Trainees			9	12	2	-10
External Research Collaborators			13	7	8	1
External Administrative and Technical Staff						
External Students			8	6	6	
Total			**122**	**108**	**99**	**-9**

5.1.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CTM – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	178	73	28	-45
PN-PICT	National R&D Programmes - S&T Integrated Projects	236	162	333	171
PN-COOP	National Cooperation Programmes with Industry	60	14	70	56
PUE-FP	EU Framework Programmes	342	662	431	-231
PUE-DIV	EU Cooperation Programmes - Other		27	104	77
SERV-NAC	R&D Services and Consulting - National	338	288	120	-168
SERV-INT	R&D Services and Consulting - International	15	25	75	50
OP	Other Funding Programmes	2	22	18	-4
Closed Projects			17	46	29
Total Funding		**1.170**	**1.291**	**1.225**	**-66**

Table 5.4 - CTM – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	27	32	31
International conference proceedings indexed by ISI, Scopus or DBLP	63	51	47
Books (author)			
Chapter/paper in books	5	5	1
PhD theses concluded by members of the Centre	5	7	6
Concluded PhD theses supervised by members of the Centre		10	9

Table 5.5 - CTM – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	9
Software copyright registrations	0
Patent applications	1

Table 5.6 - CTM – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	8
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	12
International events in which INESC TEC members participate in the program committees	37
Participation in events such as fairs, exhibitions or similar	29
Advanced training courses	4

5.1.8 List of projects

Type of Project	Short Name	Leader	Starting date	Ending date
PN-FCT	Creation	João Canas Ferreira	01-05-2013	30-04-2016
PN-FCT	WISE	Manuel Ricardo	01-06-2016	31-05-2019
PUE-DIV	BLUECOM+	Rui Lopes Campos	17-07-2015	30-04-2017
PUE-DIV	ENDURE	Luís Pessoa	17-07-2015	31-03-2017
PN-COOP	MareCom	Rui Lopes Campos	01-03-2016	31-08-2018
PN-PICT	FOUREYES	Paula Viana	01-07-2015	30-06-2018
PN-PICT	SMILES-6	Manuel Ricardo	01-07-2015	30-06-2018
PN-PICT	CORAL-TOOLS	Rui Lopes Campos	01-01-2016	31-12-2018
PN-PICT	NanoStima-RL1-3	Henrique Salgado	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL5	Jaime Cardoso	01-07-2015	30-06-2018
PN-COOP	WI-GREEN	Rui Lopes Campos	01-10-2016	30-09-2018
PN-COOP	BCCT.Plan	Hélder Filipe Oliveira	01-11-2016	31-10-2019
PN-COOP	Cloud-Setup	Maria Teresa Andrade	01-07-2016	31-12-2018
PUE-FP	PICTURE	Jaime Cardoso	01-02-2013	31-01-2016
PUE-FP	SUNNY-1	Manuel Ricardo	01-01-2014	30-06-2017
PUE-FP	iBROW	Luís Pessoa	01-01-2015	31-12-2017
PUE-FP	SCREEN	Henrique Salgado	01-01-2015	31-12-2016
PUE-FP	SmarterEMC2-1	José Ruela	01-02-2015	31-01-2018
PUE-FP	AnyPLACE-1	Rui Lopes Campos	01-02-2015	31-01-2018
SERV-NAC	vCardID-1	Jaime Cardoso	01-01-2014	30-06-2017
SERV-INT	MDX	Pedro Guedes de Oliveira	01-07-2014	31-12-2016
SERV-NAC	Consultoria	Manuel Ricardo	01-01-2010	
OP	WBMv9	Filipe Borges Teixeira	01-03-2016	31-12-2016
OP	VISUM_2016	Ana Maria Rebelo	01-04-2016	31-12-2016

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.1.9 List of Publications

International Journals with Scientific Referees

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3. Bahubalindrun, P, Tavares, V, Barquinha, P, de Oliveira, PG, Martins, R, Fortunato, E, "InGaZnO TFT behavioral model for IC design", Analog Integrated Circuits and Signal Processing, vol.87, no.1, pp.73-80, Apr
4. Bahubalindruni, PG, Kiazadeh, A, Sacchetti, A, Martins, J, Rovisco, A, Tavares, VG, Martins, R, Fortunato, E, Barquinha, P, "Influence of Channel Length Scaling on InGaZnO TFTs Characteristics: Unity Current-Gain Cutoff Frequency, Intrinsic Voltage-Gain, and On-Resistance", Journal Of Display Technology, vol.12, no.6, pp.515-518, Jun
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15. Gebhardt, RB, Davies, MEP, Seeber, BU, "Psychoacoustic approaches for harmonic music mixing", Applied Sciences, vol.6, no.5, pp.123
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Books

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Chapter/Paper in Books

1. Rodrigues, A, Marcal, ARS, Cunha, M, "PhenoSat – A Tool for Remote Sensing Based Analysis of Vegetation Dynamics", Remote Sensing and Digital Image Processing, vol.20, pp.195-215

Publications (Editor)

Blank

Dissertations (PhD)

1. Azad, M., "Towards mitigating unwanted calls in voice over IP";
2. Kandasamy, S., "Utilizing Directional Antennas and Graph based Interference Models to Improve the Performance of Wireless Mesh Networks";
3. Kandaswamy, C., "Contributions on Deep Transfer Learning";
4. Oliveira, C., "Exploring sensors fusion on the design of dependable wearable medical electronic systems";
5. Pereira, E., "Humans in Action at Different Levels: the group, the whole, and the parts";
6. Pereira, F., "Positioning Systems for Underground Tunnel Environments".

5.2 CAP - CENTRE FOR APPLIED PHOTONICS

Coordinators: Paulo Marques and Ireneu Dias

5.2.1 Presentation of the Centre

CAP accomplishes its mission within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards 3 main areas of research: optical sensors; integrated optics and microfabrication; advanced optical imaging. In this arrangement, optical sensors comprise Chemical/Biosensors and Physical sensors.

This organization of the activities understands sustained inter-activities and support within the different fields of expertise, sharing researchers whose activities touch the different areas of research.

A good example is the Microfabrication section which will explore traditional top-down microfabrication techniques and non-traditional based on laser direct writing processes to support the activities of other areas. For example, microfluidics chips will be produced to implement biosensors and micro and nanostructures; Bragg gratings will be made by laser direct writing to implement new sensing heads that will lead to the development of better and more reliable sensing heads.

CAP has a task force devoted to R&D outreach activities which deals with all the news related to the CAP research activities, the organization of scientific meetings, the collaboration with the Department of Physics and Astronomy (DFA) of the Faculty of Sciences of University of Porto, the scientific dissemination to the general public, etc.

Of particular importance is the insertion of the Group and the dissemination within the universe of the DFA that hosts the Research Group. In the past, the CAP Group set up a lab which provides advanced optics experiments available to both CAP researchers and also for advanced laboratory lectures of MSc and PhD teaching programs. These activities lead to better prepared students in these topics and an enhancement and widespread interest on many related subjects.

5.2.2 Research and Technology Development

Integrated optics and microfabrication

- Implementation of a tri-dimensional laser direct writing station based on a femtosecond fiber laser system (second and third harmonics). Improvement of third axis and software control of the apparatus;
- Monolithic integrated optic devices in pure silica mainly for integrated sensors and communications. In addition, other materials, such as chalcogenide glasses, Lithium Niobate, etc. and applications such as astronomical interferometry, quantum cryptography, etc. are areas of possible work;
- Hybrid devices that combine optical layers will fluids handling capabilities (opto-fluidics made by femtoetching) for sensing. The fabrication of tri-dimensional structures using multi-photon polymerization or suspended cores within channels will be investigated;
- Structures supporting whispery gallery modes are very interesting for sensing but coupling to these structures is typically based on fragile fiber tapers or similar. Alternative robust solutions based on integrated optics for excitation of whispery gallery modes will be developed;
- Implementation of a second apparatus for specialized Bragg grating fabrication mainly on optical fibers, including possibility of handling special fibers;
- Fabrication of Bragg and long period gratings and also explore “fiber-integrated optics”, i.e., using the fiber cladding as the media to write waveguides and devices. Explore multi-core fibers.

Advanced optical imaging

- Compressive sensing based imaging based in single-pixel cameras, targeting applications such as Security and defence, Quality control: spectroscopic/hyperspectral imaging, 3D LIDAR imaging, Pharmaceutics, Astronomical imaging;

- Reinforce local capabilities in high precision optical imaging, grounded on the knowledge acquired in white light interferometry imaging;
- Explore medical and bio-sciences using techniques such as Narrow Band Imaging;
- Development of simulation tools based on Physical Ray-tracing for complex optical media based on gpgpu supercomputing.

OPTICAL SENSORS

Physical sensors

The new strategic plan in nanosensors field is proposed for the next five years, targeting ultra-high sensitivity sensors. In this part, active devices will be designed in order to improve the precision of physical parameters measurement and to apply in new platforms for new areas of research.

- Fabrication of nano/microfibers through different fabrication techniques. The CO2 laser is one of the techniques to be explored during the next years;
- Study and development of nanostructures (Bragg gratings and Fabry-Perot interferometer) fabricated through FIB technique;
- Development arc-electric source for long period grating;
- Development of Microfiber Knot Resonators sensor for simultaneous measurement of physical parameters;
- Metamaterials on fibre optics platforms;
- Development of nano-active and nano tapers targeting very high resolution and accuracy employing metamaterials and SPR;
- Study and development of sensors based on polymer fiber;
- Study of Raman Effect for future applications in reactors for pharmaceutics;
- Expand the application of ionizing radiation dosimeters from the radiotherapy scenario to the monitoring of radiation in industrial facilities and reinforce medical physics capabilities and sensing;
- Study of optical sensor for thermal conductivity in solids.

Chemical/biosensors

Applications in new areas using already consolidated optical of Biosensors technologies were tested. New developments in the area of optical tweezers and micromanipulations were carried out. And the establishment of activity in the area of plasma spectroscopy was initiated.

- New applications of long period grating refractometric sensors platforms, were explored in specific applications (genomic sensors for identification of species – vitis vinifera, marine species -, corrosion monitoring, detection of chemical analytes with differential detection methods);
- Low cost robust prototype platforms for colorimetric based sensing (PWM LED based), were optimized for dCO2 sensing and modified for incorporation in oceanographic observatory prototype. Tests for allowing the detection of new analytes (nitrites, phosphates, heavy metals) using the same platforms were investigated;
- New Ionic Liquid fluorescent and colorimetric indicators as marking agents for bacterial identification were developed and tested;
- Improvement of developed e-tongues, e-eyes and e-noses platforms for bacterial and toxin detection, was carried out. Also, implementation of algorithms for the treatment of the sensor data, and its remote web access with secure access were carried out.

Efforts were also focused on the consolidation of emerging areas in the group:

- Optofluidics: development of monolithic optofluidic platforms combining waveguides and microfluidic channels fabricated by 3D fs laser microfabrication, in fiber tips and in planar platforms. Use of

advanced sensing techniques in these platforms such as micro resonators, interferometers and plasmonic sensors.

- Improvement of fiber tip microstructures targeting single cell diagnostic and manipulation (analytical tweezers) using in fiber photopolymerization and focused ion beam fabrication techniques.
- A new experimental setup for the real time composition analysis determination by Laser induced breakdown spectroscopy was established. Test of new configurations using fiber lasers were investigated. Advanced algorithms for robust pattern recognition strategies enabling identification and quantification in trace analysis were tested, particularly focusing on mineral identification aiming autonomous mining activities.

Simulation tools for Optic and Photonic Systems based on GP-GPU supercomputing

- Develop a simulation tool based in physical ray tracing to model light propagation and image formation through complex optical systems (anisotropic and inhomogeneous media);
- Development of a simulation tool using in a particle in cell algorithm to solve the Maxwell-Lorentz-Vlasov equations to model plasmonics in ionized gases and nanoplasmonic systems;
- Development of a simulation tool using in a particle in cell algorithm to solve the Maxwell-Bloch equations to model n-level atomic systems;
- Development of a simulation tool to solve the Gravitoelectromagnetic Einstein-Vlasov equations to model the many-body dynamics in a general relativity context.
- Improvement of current solver of Generalized Nonlinear Schrödinger equation.

DISSEMINATION & INTERNATIONALIZATION

The participation in doctoral programmes, namely MAP-FIS.
Continue to support the 200m2 cleanroom (ISO6/ISO7) of CEMUP-MNTEC.

However, internationalization is where the Group will make the strongest effort since our international relations have to be enhanced in order to increase the participation in European international consortiums. Participation in short term visits, sponsored by bilateral collaboration projects and others, such as COST projects, will be the key aspects leading to more European projects under the Horizon 2020 programme.

5.2.3 Technology transfer

Electronics and Photonics Integration

In the electronics and photonics area, CAP is able to transfer technology and provide consulting services on:

- Electronic PCB design, implementation, test and characterization;
- Micro and nanofabrication techniques;
- Optoelectronics assembly and packaging;
- Photonic systems implementation, test and characterization;
- Signal processing.

5.2.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CAP – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3) Electronics and Photonics Integration
Integrated optics and Microfabrication	I	H
Advanced Optical Imaging	I	M
Physical Sensors	I	M
Biosensors	I	M

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.2.5 Main Achievements in 2016

- Fabrication of microfluidic devices in pure silica by femtosecond laser exposure and wet-etching (FLICE)
- Fabrication of optofluidic devices in pure silica for sensing
- Fabrication of an integrated add-drop for WDM systems working at 100GHz, including fiber pigtailing
- Demonstration of first order Bragg gratings in standard SMF-28 fibres written by point-by-point technique
- Development of an Arduino/Raspberry Pi potentiometer for electrical signal acquisition of e-tongues/e-noses
- Detection of volatile organic compounds using zinc coated optical fiber long period gratings Detection of thrombin using an Aptamer-based long period grating sensor
- Demonstration of optical sensor based on hybrid FBG/titanium dioxide coated LPFG for monitoring solvents in high refractive index oils
- Optimization of wavelength shift sensitivity of long period grating sensor by over coating with metal oxides
- Development of multiple potentiometric sensors for quantification of:
  - quaternary ammonium compounds in water;
  - monocrotalin, a toxin from milk or honey bee, in water and milk;
  - cereulide, toxin from Bacillus cereus;
  - bacillus anthracis.
- Implementation of several R scripts for calculating a novel Information Theory similarity index to be use to compare sensor behaviour
- Implementation of a Fourier Domain – Optical Coherence Tomography system, with 3D optical scanning capability, and GPU-based signal processing and visualization
- Development of a methodology for differentiating monocrotalin from other amine compounds using UV-Vis spectroscopy and several dyes
- Development of a solver of Generalized Nonlinear Schrödinger equation based on GP-GPU supercomputing
- Fabrication of LPG in SMF 28 using an arc-electric technique with a period less 200um (turn-point)
- New advances of Fabry-Perot Interferometry

- Polymer fiber for sensing applications
- New design and signal processing for fiber cavity ring down
- Knot Configuration in nano/microfibers´
- Validation of LPG based sensor prototype in medical (detection of thrombin) and food industry (genomic identification of Vitis vinifera) application.
- Demonstration of new Hydrogen sensing configuration using metamaterials.
- Demonstration of new multiparametric microfluidic chip
- Demonstration of new probe configuration for fiber based optical tweezers (vortices, Fresnel lens, manipulation and rotation of microalgae)
- Validation of electric current sensor prototype for industrial applications.
- Incorporation of low cost optoelectronics dCO2 sensor in multitrophic oceanographic platform prototype

5.2.6 Centre Organizational Structure and Research Team

The researchers responsible for the Areas and Sub-Areas within CAP are:

- Integrated optics and microfabrication - Paulo Marques
- Advanced optical imaging - Carla Rosa
- Sensors: physical sensors - Orlando Frazão; biosensors - Pedro Jorge
- Dissemination & internationalization - Manuel Joaquim Marques

The internal organization of the Centre follows the general model adopted at INESC TEC. It is governed by a Coordinator and a Coordinating Council (CC). The CC is composed of 3 to 5 PhDs with responsibilities over areas of work and research. The project leaders respond to the Coordinating Council in what refers to the execution of projects and meeting financial sustainability goals, as well as scientific productivity targets.

Each of the research areas has an appointed leader. Ordinary management meetings are held every fortnight to discuss matters related to the research Group daily issues, which include acquisitions, travel, staff and student movements, and project management. The regular attendants to these meetings are the Research Group leader and co-leader together with the leaders of the research areas. Depending on the subjects to be evaluated during the meetings, other research group members could be present.

The CAP has a scientific council, which is composed of all researchers holding a PhD. The scientific council meet quarterly to analyse the progress made on the different areas of research and to discuss future work. It is also incumbency of the scientific council to propose new strategic actions.

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CAP – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	5	5	5	
		Academic Staff	9	9	9	
		Grant Holders and Trainees	17	12	15	3
		Total Core Researchers	**31**	**26**	**29**	**3**
	Affiliated Researchers		6	8	7	-1
	Admin. & Tech	Employees	3	2	2	
		Grant Holders and Trainees				
	Total Integrated HR		**40**	**36**	**38**	**2**
	Total Integrated PhD		**20**	**22**	**22**	**0**
Curricular Trainees			3	3		-3
External Research Collaborators			5	2	2	
External Administrative and Technical Staff						
External Students			8	15	13	-2
Total			**56**	**56**	**53**	**-3**

5.2.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CAP – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	84	52		-52
PN-PICT	National R&D Programmes - S&T Integrated Projects	119	62	155	93
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	108	28	117	89
PUE-DIV	EU Cooperation Programmes - Other	45	24	27	3
SERV-NAC	R&D Services and Consulting - National	204	30		-30
SERV-INT	R&D Services and Consulting - International			40	40
OP	Other Funding Programmes	-6	28	7	-21
Closed Projects		14	28	23	-5
Total Funding		**568**	**252**	**369**	**117**

Table 5.4 - CAP – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	27	30	36
International conference proceedings indexed by ISI, Scopus or DBLP	46	29	15
Books (author)			
Chapter/paper in books	1		1
PhD theses concluded by members of the Centre	2	1	4
Concluded PhD theses supervised by members of the Centre		2	4

Table 5.5 - CAP – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6 - CAP – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	0
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	3
International events in which INESC TEC members participate in the program committees	3
Participation in events such as fairs, exhibitions or similar	1
Advanced training courses	0

5.2.8 List of Projects

Table 5.7 - CAP – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PUE-DIV	MarineEye-2	Pedro Jorge	30-07-2015	30-04-2017
PN-PICT	CORAL-SENSORS	Pedro Jorge	01-01-2016	31-12-2018
PN-PICT	CORAL-TOOLS-2	Pedro Jorge	01-01-2016	31-12-2018
PN-PICT	NanoStima-RL1-1	Carla Carmelo Rosa	01-07-2015	30-06-2018
PUE-FP	SNIFFER	Gerardo Aguilar	01-05-2013	30-04-2016
PUE-FP	VAMOS-1	Pedro Jorge	01-02-2015	31-07-2018
SERV-INT	TECCON2	Pedro Jorge	01-01-2016	31-12-2018
OP	Femto3D	Paulo Vicente Marques	01-01-2016	30-06-2017

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.2.9 List of Publications

International Journals with Scientific Referees

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2. Coelho, L, Marques Martins de Almeida, JMM, Santos, JL, da Silva Jorge, PAD, Martins, MCL, Viegas, D, Queiros, RB, "Aptamer-based fiber sensor for thrombin detection", Journal of Biomedical Optics, vol.21, no.8, pp.087005, Aug
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4. Coelho, L, Viegas, D, Santos, JL, de Almeida, JMMM, "Characterization of zinc oxide coated optical fiber long period gratings with improved refractive index sensing properties", Sensors and Actuators B-Chemical, vol.223, pp.45-51, Feb
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Books

Blank

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2. Darbrazi, S., "GPU- Accelerated Optical Coherence Tomography Signal Processing and Visualization";
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4. Nascimento, I., "Optical fiber sensors technology for supervision, control and protection of high power systems".

5.3 CRAS - CENTRE FOR ROBOTICS AND AUTONOMOUS SYSTEMS

Coordinators: Eduardo Silva and Aníbal Matos

5.3.1 Presentation of the Centre

The Centre for Robotics and Autonomous Systems (CRAS) aggregates more than 40 researchers addressing scientific and technological topics associated to field robotics and autonomous systems. Its mission addresses the development of innovative robotic solutions for operation in complex environments for multiple operations, including data gathering, inspection, mapping, surveillance, or intervention.

CRAS accomplishes its mission within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards 4 main areas of research: autonomous navigation; long term deployments; sensing, mapping, and intervention; multiple platform operations.

5.3.2 Research and Technology Development

The activities of the Centre are organized along the following major research areas:

Autonomous navigation

The major goal of this area is related to the development of solutions that allow autonomous robots to operate in dynamic and complex environments or where global positioning aiding systems are not available. Research activities address advanced navigation algorithms based on data fusion techniques, algorithms for simultaneous navigation and mapping, underwater acoustic positioning systems, situation awareness systems, obstacle detection algorithms, obstacle avoidance systems, path planning algorithms, obstacle avoidance systems, close range operations in maritime robotics, and safety behaviours.

Long term deployments

The main goal of these lines is the development of technologies and solutions that enable the long-term deployment of robotic platforms. Research activities include design of efficient propulsion systems for underwater or surface vehicles, development of long range navigation algorithms, development of energy harvesting systems for robotic platforms, and development of auxiliary systems for long term deployments (e.g. docking stations, energy transfer systems).

Sensing, mapping, and intervention

This area addresses the use of autonomous robotic systems in sensing, mapping, and intervention operations. Research activities include computer vision techniques and algorithms, sensing strategies for single or multiple robotic systems, adaptive sampling techniques, multi sensor data fusing for underwater or overwater mapping, hyperspectral, electro-optic and acoustic image processing, autonomous intervention for robotic platforms.

Multiple platform operations

This area addresses the development of technologies and solutions that take advance of the use of multiple robotics platforms that cooperate in the accomplishment of a given tasks. Activities in this area include the development of command and control solution for the coordinated operation of multiple (possibly heterogeneous) platforms, development of mobile beacons for underwater positioning and communication networks, and coordinated operations of underwater, surface, and aerial platforms.

5.3.3 Technology transfer

Autonomous navigation

In this area, CRAS is able to transfer technology and provide consulting services on:

- Design, development, and implementation of navigation systems for autonomous systems (aerial, land, surface, or underwater);
- Design, development, and implementation of underwater acoustic positioning systems;
- Design, development, and implementation of obstacle detection and avoidance systems.

Long term deployments

In this area, CRAS is able to transfer technology and provide consulting services on:

- Design and development of robotic platforms or subsystems for long term deployments;
- Design, development, and implementation of efficient propulsion systems for marine platforms.

Sensing, mapping, and intervention

In this area, CRAS is able to transfer technology and provide consulting services on:

- Implement a multi-trophic sensor;
- Design, development, and implementation of computer vision algorithms for robotics and robotic based sensing applications;
- Design, development and implement 3D acoustic image processing system;
- Design, development, and implementation of data processing and fusion strategies and algorithms for single or multiple cooperating robots;
- Design, development, and implementation of adaptive sampling algorithms;
- Design, development, and implementation of multi sensor data fusion systems for inspection and mapping.

Multiple platform operations

In this area, CRAS is able to transfer technology and provide consulting services on:

- Design and development of command and control systems for coordinated robotic platforms;
- Design, development, and implementation of mobile beacons for underwater positioning;
- Design, development, and implementation of mobile beacon for communication networks.

5.3.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CRAS – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)											
	Status (2)	Navigation	Acoustic positioning	Obstacle detection & avoidance	Robotic platforms	Underwater propulsion	Computer vision	Data fusion	Adaptive sampling	Inspection and mapping	Command and control	Mobile beacons
Autonomous navigation	I	H	H	H	H	L	H	H	L	H	M	M
Long term deployments	I	H	H	H	H	H			M	L	M	L
Sensing, mapping, and intervention	I	H	H		H		H	H	H	H	L	L
Multiple platform operations	I	L	H	H	L			L	L	L	H	H

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.3.5 Main Achievements in 2016

The main achievements of the Centre for Robotics and Autonomous Systems are listed below:

- Small-sized surface robotic platform to conduct experiments for the Internet of Moving Things
- SHAD – Small-sized autonomous underwater vehicle
- Underwater docking station, for data transfer and battery recharging of underwater vehicles
- Laser triangulation system for measuring underwater structures with high definition
- Portable acoustic beacon for AUV navigation
- Lightweight surface buoy composed by a mechanical structure with a small footprint for transportation
- System for acquisition of dense 3D visual information for underwater environments
- System for passive acoustic tracking of moving underwater targets
- Underwater optical communication system
- Vision-based relative localization algorithm for hovering AUVs
- Control and guidance algorithms for precise positioning of AUVs
- Control and guidance algorithms for AUV docking manoeuvres
- Algorithm for stitching sequential images for underwater scenarios
- Algorithm for 3D acquisition from a camera-laser triangulation: high precision, small range and multiple beams
- Path planner for a visual relative navigation under observation constraints
- Simultaneous navigation and tracking algorithms for multiple AUVs
- Application for streaming pairs of images to a base-station with small integrity loss
- Application for live video streaming
- Implementation of a visual SLAM algorithm for outdoors 3D localization
- Application for vision-based relative pose estimator and beacon tracker for an AUV
- Hyperspectral Imaging for Real-Time Unmanned Aerial Vehicle Maritime Target Detection application
- Robot Localization and Mapping algorithm for Dynamic Underwater Environments
- OTUS-1 unnamed aerial vehicle for aerial inspection
- Active Cooperative Perception for UAVs Teams
- Underwater Robot prototype for mapping flooded mines
- Underwater satellite prototype AUV/ROV for underwater mine operations
- Multitrophic sensing system for remote maritime applications
- Underwater Laser scanner system prototype
- Awarded at MTS/IEEE Oceans'16 Conference: Received a 2nd place award at the Students Poster Competition of the Oceans'16 Conference, in Shanghai, with an article entitled "Towards LBL Positioning Systems for Multiple Vehicles"
- Remote supervision system for aquaculture platforms
- Remote monitoring and control system for ecosystem replication experiments
- Experiments in open sea leading to an Internet connection of an AUV (BLUECOM+) at several tens of kilometres from shore
- Co-organization of a special session on “Advanced Visual Perception in Robotics” at the conference ICIAR – International Conference on Image Analysis and Recognition, Póvoa do Varzim, 2016
- Co-organization with the University of Porto, Faculty of Engineering of the 9th World Robotic Sailing Championship / International Robotic Sailing Conference (WRSC/IRSC), Viana do Castelo, Portugal, September 5-10, 2016
- Organization of the 2016 STRONGMAR conference, A sea of science, Porto, Portugal, 17 November 2016

5.3.6 Centre Organizational Structure and Research Team

The Centre for Robotics and Autonomous Systems is coordinated by Eduardo Silva and Aníbal Matos. The Centre has a coordination council (CRAS Coordination Council) composed by the Centre coordinators and by 4 other senior researchers: Alfredo Martins, José Carlos Alves, José Miguel Almeida, and Nuno Cruz. This council is responsible for the discussion, definition, and implementation of the Centre research, development and innovation strategy.

The Centre research team present composition and evolution is presented in Table 5.2. The Centre was established in 2016 as a split from the previous Centre CROB (Centre for Robotics and Intelligent Systems) – figures for 2015 apply for the group within CROB that emerged as CRAS.

Table 5.2 - CRAS – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees		3	5	2
		Academic Staff		10	10	
		Grant Holders and Trainees		17	25	8
		Total Core Researchers		**30**	**40**	**10**
	Affiliated Researchers					
	Admin. & Tech	Employees		1	2	1
		Grant Holders and Trainees			1	1
		Total Integrated HR		**31**	**43**	**12**
		Total Integrated PhD		**8**	**7**	**-1**
Curricular Trainees				2	3	1
External Research Collaborators					1	1
External Administrative and Technical Staff						
External Students					2	2
Total				**33**	**49**	**16**

5.3.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CRAS – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT				
PN-PICT	National R&D Programmes - S&T Integrated Projects			33	33
PN-COOP	National Cooperation Programmes with Industry			19	19
PUE-FP	EU Framework Programmes			1.143	1.143
PUE-DIV	EU Cooperation Programmes - Other			103	103
SERV-NAC	R&D Services and Consulting - National			95	95
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes			19	19
Closed Projects					
	Total Funding			**1.412**	**1.412**

Table 5.4 - CRAS – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP		9	2
International conference proceedings indexed by ISI, Scopus or DBLP		30	24
Books (author)		1	
Chapter/paper in books		1	3
PhD theses concluded by members of the Centre		1	1
Concluded PhD theses supervised by members of the Centre		1	1

Table 5.5 - CRAS – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	1
Software copyright registrations	
Patent applications	1

Table 5.6 - CRAS – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	5
Participation in events such as fairs, exhibitions or similar	1
Advanced training courses	2

5.3.8 List of Projects

Table 5.7 - CRAS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	MyTag	Eduardo Silva	01-06-2016	31-05-2019
PUE-DIV	ENDURE-1	Eduardo Silva	17-07-2015	31-03-2017
PUE-DIV	BLUECOM+-1	Eduardo Silva	17-07-2015	30-04-2017
PUE-DIV	MarineEye	Eduardo Silva	30-07-2015	30-04-2017
PN-PICT	CORAL-SENSORS-1	Eduardo Silva	01-01-2016	31-12-2018
PN-PICT	CORAL-TOOLS-1	Eduardo Silva	01-01-2016	31-12-2018
PN-COOP	DeepFloat	Eduardo Silva	09-03-2016	30-03-2018
PUE-FP	ICARUS	Aníbal Matos	01-02-2012	31-01-2016
PUE-FP	SUNNY	Eduardo Silva	01-01-2014	30-06-2017
PUE-FP	VAMOS	Eduardo Silva	01-02-2015	31-07-2018
PUE-FP	STRONGMAR	Eduardo Silva	01-01-2016	31-12-2018
PUE-FP	UNEXMIN	Eduardo Silva	01-02-2016	31-10-2019
PUE-FP	EMSODEV	Aníbal Matos	01-09-2015	31-08-2018
SERV-NAC	Demo_Drone	José Miguel Almeida	01-05-2015	30-04-2017
SERV-NAC	Fmanagement	Aníbal Matos	10-05-2016	09-05-2017
SERV-INT	RAWFIE	Aníbal Matos	01-09-2016	28-02-2019
SERV-INT	HAIFA	Nuno Cruz	01-09-2016	01-03-2017
OP	CINMarS	Eduardo Silva	12-03-2015	11-03-2017
OP	WRSC2016	Eduardo Silva	01-07-2016	31-12-2016

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.3.9 List of Publications

International Journals with Scientific Referees

1. Ferreira, BM, Matos, AC, Cruz, NA, Moreira, AP, "Coordination of Marine Robots Under Tracking Errors and Communication Constraints", IEEE Journal of Oceanic Engineering, vol.41, no.1, pp.27-39, Jan
2. Pinto, AM, Moreira, AP, Costa, PG, "WirelessSyncroVision: Wireless synchronization for industrial stereoscopic systems", International Journal of Advanced Manufacturing Technology, vol.82, no.5-8, pp.909-919, Feb

International Conference Proceedings with Scientific Referees

1. Aguiar, J, Pinto, AM, Cruz, NA, Matos, AC, "The Impact of Convergence Cameras in a Stereoscopic System for AUVs", Image Analysis And Recognition (ICIAR 2016), vol.9730, pp.521-529
2. Almeida, J, Ferreira, A, Matias, B, Dias, A, Martins, A, Silva, F, Oliveira, J, Sousa, P, Moreira, M, Miranda, T, Almeida, C, Silva, E, "Air and underwater survey of water enclosed spaces for Vamos! Project", OCEANS 2016 MTS/IEEE Monterey, OCE
3. Almeida, R, Cruz, N, Matos, A, "Man Portable Acoustic Navigation Buoys", OCEANS 2016 - Shanghai
4. Almeida, R, Melo, J, Cruz, N, "Characterization of Measurement Errors in a LBL Positioning System", OCEANS, Shanghai
5. Balbaert, Joppe, Park, Jaehyun, Marimon, Ramon, Serfozo, Akos, Cazelles, Marine, Domenic, StancelConstantin, Speckstadt, Arne, Skonieczna, Klaudia, Rajnai, Gergely, Daza, JairoPerez, Barb, BogdanMarius, Duarte, AbelJ., Malheiro, Benedita, Ribeiro, Cristina, Ferreira, Fernando, Silva, M, "Design of sustainable domes in the context of EPS@ISEP", Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality, Salamanca, Spain, November 02 - 04, pp.105-112
6. Borzecka, A, Fagerstroem, A, Costa, A, Gasull, MD, Malheiro, B, Ribeiro, C, Silva, MF, Caetano, N, Ferreira, P, Guedes, P, "Educating Global Engineers with EPS@ISEP The "Pet Tracker" Project Experience", 2016 2nd International Conference Of The Portuguese Society For Engineering Education (CISPEE)
7. Campos, R, Oliveira, T, Cruz, N, Matos, A, Almeida, JM, "BLUECOM plus: Cost-effective Broadband Communications at Remote Ocean Areas", OCEANS 2016 - Shanghai
8. Costa, P, Lima, J, Pereira, AI, Costa, P, Pinto, A, "An Optimization Approach for the Inverse Kinematics of a Highly Redundant Robot", Proceedings of the Second International Afro-European Conference for Industrial Advancement (AECIA 2015), vol.427, pp.433-442
9. Ferreira, A, Silva, G, Dias, A, Martins, A, Campilho, A, "Motion Descriptor for Human Gesture Recognition in Low Resolution Images", ROBOT 2015: Second Iberian Robotics Conference: Advances In Robotics, Vol 1, vol.417, pp.297-308
10. Ferreira, BM, Matos, AC, Alves, JC, "Water-jet Propelled Autonomous Surface Vehicle UCAP: System Description and Control", OCEANS 2016 - Shanghai
11. Figueiredo, AB, Ferreira, BM, Matos, AC, "Vision-based Localization and Positioning of an AUV", OCEANS 2016 - Shanghai

12. Leal, F, Dias, JM, Malheiro, B, Burguillo, JC, "Analysis and Visualisation of Crowd-sourced Tourism Data", Proceedings of the 9th International C* Conference on Computer Science & Software Engineering, C3S2E '16, Porto, Portugal, July 20-22, 2016, pp.98-101

13. Marques, MM, Parreira, R, Lobo, V, Martins, A, Matos, A, Cruz, N, Almeida, JM, Alves, JC, Silva, E, Bedkowski, J, Majek, K, Pelka, M, Musialik, P, Ferreira, H, Dias, A, Ferreira, B, Amaral, G, Figueiredo, A, Almeida, R, Silva, F, Serrano, D, Moreno, G, De Cubber, G, Balta, H, Beglerovic, H, "Use of multi-domain robots in search and rescue operations - contributions of the ICARUS team to the euRathlon 2015 challenge", OCEANS 2016 - Shanghai

14. Martins, A, Dias, A, Silva, E, Ferreira, H, Dias, I, Almeida, JM, Torgo, L, Goncalves, M, Guedes, M, Dias, N, Jorge, P, Mucha, AP, Magalhaes, C, Carvalho, MDF, Ribeiro, H, Almeida, CMR, Azevedo, I, Ramos, S, Borges, T, Leandro, SM, Maranhao, P, Mouga, T, Gamboa, R, Lemos, M, dos Santos, A, Silva, A, Frazao, "MarinEye - A tool for marine monitoring", OCEANS 2016 - Shanghai

15. Matos, A, Martins, A, Dias, A, Ferreira, B, Almeida, JM, Ferreira, H, Amaral, G, Figueiredo, A, Almeida, R, Silva, F, "Multiple robot operations for maritime search and rescue in euRathlon 2015 competition", OCEANS 2016 - Shanghai

16. Melo, J, Matos, A, "Towards LBL Positioning Systems for Multiple Vehicles", OCEANS 2016 - Shanghai

17. Pinto, AM, Pinto, H, Matos, AC, "A Mosaicking Approach for Visual Mapping of Large-Scale Environments", 2016 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC 2016), pp.87-93

18. Rodrigues, B, Cruz, E, Dias, A, Silva, MF, "LSA Portraiture Robot", ROBOT 2015: Second Iberian Robotics Conference: Advances in Robotics, VOL 2, vol.418, pp.341-352

19. Silva, E, Martins, A, Almeida, JM, Ferreira, H, Valente, A, Camilo, M, Figueiredo, A, Pinheiro, C, "TURTLE - A robotic autonomous deep sea lander", OCEANS 2016 MTS/IEEE Monterey, OCE

20. Silva, E, Martins, A, Dias, A, Matos, A, Olivier, A, Pinho, C, De Sa, FA, Ferreira, H, Silva, H, Alves, JC, Almeida, JM, Pessoa, L, Ricardo, M, Cruz, N, Dias, N, Monica, P, Jorge, P, Campos, R, "Strengthening marine and maritime research and technology", OCEANS 2016 MTS/IEEE Monterey, OCE

21. Silva, H, Almeida, JM, Lopes, F, Ribeiro, JP, Freitas, S, Amaral, G, Almeida, C, Martins, A, Silva, E, "UAV trials for multi-spectral imaging target detection and recognition in maritime environment", OCEANS 2016 MTS/IEEE Monterey, OCE 2016

22. Sousa, P, Ferreira, A, Moreira, M, Santos, T, Martins, A, Dias, A, Almeida, J, Silva, E, "ISEP/INESC TEC Aerial Robotics Team for Search and Rescue Operations at the EuRathlon Challenge 2015", 2016 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC 2016), pp.156-161

23. Veloso, B, Malheiro, B, Burguillo, JC, "Collaborative Filtering with Semantic Neighbour Discovery", Advances in Artificial Intelligence - Iberamia 2016, vol.10022, pp.273-284

24. Veloso, B, Malheiro, B, Carlos Burguillo, JC, "CloudAnchor: Agent-Based Brokerage of Federated Cloud Resources", Advances in Practical Applications of Scalable Multi-Agent Systems: The Paams Collection, vol.9662, pp.207-218

Books

Blank

Chapter/Paper in Books

1. Sousa, JP, Palop, CG, Moreira, E, Pinto, AM, Lima, J, Costa, P, Costa, P, Veiga, G, Paulo Moreira, A, "Erratum to: The SPIDERobot: A Cable-Robot System for On-site Construction in Architecture", Robotic Fabrication in Architecture, Art and Design 2016, pp.E1-E2

2. Sousa, JP, Palop, CG, Moreira, E, Pinto, AM, Lima, J, Costa, P, Costa, P, Veiga, G, Paulo Moreira, A, "The SPIDERobot: A Cable-Robot System for On-site Construction in Architecture", Robotic Fabrication in Architecture, Art and Design 2016, pp.230-239

3. Veloso, B, Meireles, F, Malheiro, B, Burguillo, JC, "Federated IaaS Resource Brokerage", Developing Interoperable and Federated Cloud Architecture, pp.252-280

Publications (Editor)

Blank

Dissertations (PhD)

1. Melo, J., "Navigation Algorithms for Sensor-limited Autonomous Underwater Vehicles".

5.4 C-BER - CENTRE FOR BIOMEDICAL ENGINEERING RESEARCH

Coordinators: Aurélio Campilho and João Paulo Cunha

5.4.1 Presentation of the Centre

The Centre for Biomedical Engineering Research (C-BER) aggregates researchers and research activity under a mission and is guided by specific goals.

Mission:
To promote knowledge through applied research, advanced training and innovation in Biomedical Engineering.

Goals:

- To create interdisciplinary knowledge enabling the innovation and technology transfer with economic impact;
- To develop products, tools and methods for the prevention and early detection of different types of diseases, aging related impairments, or for human rehabilitation, physiotherapy or functional assessment;
- To contribute to the development of advanced neuro-technologies at the frontier of engineering and neurology;
- To promote strategic partnerships with other Centres of INESC TEC, clinical partners, research institutes and foster international cooperation.

C-BER accomplishes its mission within the Cluster NIS - Networked Intelligent Systems, by directing its activities towards areas of research organized under three Research Labs: Biomedical Imaging Lab, Bioinstrumentation Lab and Neuroengineering Lab.

5.4.2 Research and Technology Development

Biomedical Imaging Lab

Coordinator: Aurélio Campilho

The main focus of the Biomedical Imaging Lab is the development of advanced image processing and analysis methodologies, particularly medical and biological images, with the aim of creating computer-aided diagnosis tools to support medical decision making. The research activities at the Lab use several imaging modalities addressing different clinical departments including in Ophthalmology, Neurology, Radiology, Gynaecology and Obstetrics and Gastroenterology.

The Biomedical Imaging Lab is organized in three main lines of research: Ophthalmology CAD, Lung CAD and Ultrasound CAD.

Ophthalmology CAD

The research activities under this line are:

- Screening of Diabetic Retinopathy, including the automatic detection of image quality, the automatic detection of images with pathology and the grading of retinopathy. Advanced image analysis and machine learning methodologies, including generic approaches are/will be used. The input data are retinograms.
- Analysis of eye fundus images for early detection of prevalent eye pathologies, including diabetics and hypertension. This involves the detection and segmentation of main anatomical structures and its characterization in order to derive image-based biomarkers. Advanced image analysis methodologies, including generic approaches are/will be used. The input data are retinograms.
- To determine choroid thickness and changes in the layer's structure in Optical Coherence Tomography (OCT) images and to correlate with clinical status.

Lung CAD

- Segmentation of lung structures, as lung lobes, airways and vasculature network.
- Early detection of lung pathologies in chest CT scans, with a reduced number of false positives.
- Segmentation and characterization of lung lesions.
- Computer-aided diagnosis of lung cancer and prediction of malignancy likelihood.

Ultrasound CAD

- Measurement of macro vascular characteristics, as calibers, layer thicknesses (as IMT - Intima-to-media Thickness), plaque burden and other markers in ultrasound images of the carotid.
- Characterization of Ultrasound Images in 2D, 3D and 4D and its application in Gynaecology and Obstetrics.

The modular design will allow to set-up web-based and cloud-based solutions in the research areas defined above. This will enable innovation and facilitate tech-transfer to the high-tech clinical market, either in hospital environment or business companies in medical devices.

NeuroEngineering Lab

Coordinator: João Paulo Cunha

The main goal of the NeuroEngineering lab is to perform high-level interdisciplinary R&D in engineering and computational approaches applied to basic and clinical neuroscience, namely crossing several areas, such as Physics; Engineering (Electronics; Computation; etc.); Neurology; Neurosurgery; Neurophysiology; Neuroradiology; Neuropsychology and Neurobiology.

Furthermore, we also aim to innovate and facilitate tech-transfer to the high-tech market.

The main research activity lines in the lab are:

- Brain imaging (&signals)
- Man-computer symbiosis (e.g. Brain-Computer Interfaces)
- Movement analysis in neurological diseases
- Neurosurgery Aiding Systems

BioInstrumentation lab

Coordinator: Miguel Velhote Correia

The main goal of the BioInstrumentation lab is to perform high-level interdisciplinary R&D in engineering and computational approaches applied to health, well-being, sports performance and rehabilitation namely crossing several areas, such as Physics; Engineering (Electronics; Computation; etc.); Physiology, Physiotherapy, Psychology, Psychophysics and Sports sciences.

Furthermore, there is also the aim to innovate and facilitate tech-transfer to the high-tech market.

The main research activity lines in the lab are:

- Sensing and biosignal acquisition technologies
- Medical electronics and devices
- Wearable monitoring systems
- Human movement analysis

5.4.3 Technology transfer

Biomedical Imaging Lab

In order to ease the technology transfer our approaches are organized in modules of direct applicability in specific clinical or general purpose domains. The researchers are asked to fill in a module lab chart, identifying the module (name, input and output), give a 3-line description and application targeted. In Biomedical Imaging C-BER is able to transfer technology and provide consulting services in:

- Planning and design Ophthalmology CAD, particularly involving image analysis of eye images, as eye fundus images and Optical Coherence Tomography eye images.
- Ultrasound (US) image analysis techniques in order to develop tools for image enhancement, lesion detection, biomarkers measurements from 2D, 3D and 4D US images.
- Planning and design Lung CAD for early detection and characterization of lung pathologies in chest CT scans.

NeuroEngineering Lab

- The TRL of the current projects in this lab did not allow tech transfer during 2016. We will continue to provide several advanced neuroimaging services to clinical partners from Porto and Munich.

BioInstrumentation Lab

We have been following the tech-transfer methodology by:

- Establish R&D collaborations with companies and industry clusters.
- File for patents or other exploitation paths of higher TRL developments.
- Actively search for opportunities for exploitation of the achieved patents and developments.

In recent years, we have been active in producing several patents requests, namely:

- “Medical Device with Rotational Flexible Electrodes”, Pedido Provisório de Patente 20161000064607, 25.08.2016, INPI (This patent is the first IP result from the R&D Program Contract with Biodevices SA)
- “Biometric Method ad Device For Identifying A Person Through An Electrocardiogram (ECG)”, Pedido Provisório de Patente 20161000028874, 29.04.2016, INPI
- Mixed-signal test and measurement framework for monitoring systems, pedido provisório de patente 20131000012338, 2013/02/15, INPI
- Imager with compressive sensing capability, pedido provisório de patente 20131000012300, 2013/02/15, INPI
- Control module for multiple mixed-signal resources management, pedido de patente PT107537; PCT/IB2015/052141; WO/2015/145347A1, Pub date 2015/10/01

During 2017, we intend to start the spin-off process of the achieved patents looking for different possible paths (licensing, selling, etc.).

We are also open to provide consulting services in the Biomedical Engineering area, although we do not yet sense a large demand for this type of services in the Portuguese market.

5.4.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CBER – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3)								
		Ophthalmology	Neurology/Neurosurgery	Vascular Medicine	Radiology	Obstetrics/Gynecology	Geriatrics	Rehabilitation	Health and Well-being	Sports technology
Biomedical Imaging Lab	I	H	L	H	M	L				
BioInstrumentation Lab	I		M				L	H	H	H
NeuroEngineering Lab	I		H		M		L		H	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer

(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership

(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.4.5 Main Achievements in 2016

2016 was the third year of activity of C-BER. Naturally, it has an impact on the achievements herein reported, some of them being a result of activities developed in a different environment.

During 2016 the following important achievements can be highlighted in different areas of activity as in publications, in supervision, projects and others.

Patents:

- "Medical Device with Rotational Flexible Electrodes", Pedido Provisório de Patente 20161000064607, 25.08.2016, INPI (This patent is the first IP result from the R&D Program Contract with Biodevices SA)
- "Biometric Method ad Device For Identifying A Person Through An Electrocardiogram (ECG)", Pedido Provisório de Patente 20161000028874, 29.04.2016, INPI

Key 2016 papers:

- Cunha, J. P. S., Choupina, H. M. P., Rocha, A. P., Fernandes, J. M., Achilles, F., Loesch, A. M. and Noachtar, S. (2016). NeuroKinect: A Novel Low-Cost 3Dvideo-EEG System for Epileptic Seizure Motion Quantification. PloS One, 11(1), e0145669.
- http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0145669 [One of the top 5 impact journal in the world: Google Scholar h5-index=166; #4 Life Sciences & Hearth Sciences (General); ISI IF: 3.234]
- L. Gonçalves, J. Novo, A. Campilho, Hessian based approaches for 3D lung nodule segmentation, Expert Systems with Applications, vol. 61, pp 1-15, 2016 [a first quartile (Q1) journal, with an Impact Factor IF: 2.981].
- J. Rouco, E. Azevedo, A. Campilho, Automatic Lumen detection on Longitudinal ultrasound B-mode images of the carotid Using Phase Symmetry, Sensors 2016, 16(3), 350, pp 1-21, 2016. [IF: 2.033, Q1].
- J. Ramos, T. Kockelkorn, I. Ramos, R. Ramos, J. Grutters, B. Ginneken, M. Viergever, A. Campilho, Content Based Image Retrieval by Metric Learning from Radiology Reports: Application to Interstitial Lung Diseases, IEEE J. Biomedical and Health Informatics, vol. 20, pp. 281-292, 2016. [IF: 2.093, Q1].
- A. M. Pinto, P. G. Costa, M. V. Correia, A. C. Matos, A. P. Moreira, Visual motion perception for mobile robots through dense optical flow fields, Robotics and Autonomous Systems, Vol. 27 (1), DOI: 10.1016/j.robot.2016.08.014

Projects: C-BER started in 2016 two new projects, with Aurélio Campilho as PI:

- SCREEN-DR: Image Analysis and Machine Learning Platform for Innovation in Diabetic Retinopathy Screening, CMUP-ERI/TIC/0028/2014, April 2016 – March 2020, (552.044 Euros).
- LNDetector - Automatic Detection, Segmentation and Classification of Pulmonary Nodules System in Computed Tomography Images, Project nº 016673 - PTDC/EEI-SII/6599/2014, Jun 2016 – May 2019 (198.189 Euros).

Others:

- João Paulo Cunha was member of the external evaluation committee for the Biomedical Engineering area of the National Agency for Higher Education Accreditation (A3ES) that evaluated most of the degrees in the area in Portugal.
- By appointment of the Innovation Agency (AdI), João Paulo Cunha was nominated by the Ministry of Economy to be member of the "Agency for Biomedical Research and Innovation" working group of experts.
- Aurélio Campilho was Co-chair and Co-organizer of the Session Machine Learning for Medical Applications of the 24th European Symposium on Artificial Neural Networks, Computational Intelligence and Machine Learning, 2016.
- Aurélio Campilho was Publicity and Sponsorship Chair and Area Chair of Biomedical Image Analysis and Applications track for ICPR 2016, the International Conference on Pattern Recognition, the major conference in the field.

5.4.6 Centre Organizational Structure and Research Team

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CBER – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	2	1	1	
		Academic Staff	5	6	6	
		Grant Holders and Trainees	8	5	15	10
		Total Core Researchers	**15**	**12**	**22**	**10**
	Affiliated Researchers		3	4	3	-1
	Admin & Tech	Employees				
		Grant Holders and Trainees				
	Total Integrated HR		**18**	**16**	**25**	**9**
	Total Integrated PhD		**10**	**11**	**11**	
Curricular Trainees			4	5	3	-2
External Research Collaborators			4	3	2	-1
External Administrative and Technical Staff						
External Students			8	5	2	-3
Total			**34**	**29**	**32**	**3**

5.4.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - C-BER – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	60	126	85	-41
PN-PICT	National R&D Programmes - S&T Integrated Projects			76	76
PN-COOP	National Cooperation Programmes with Industry	58	44		-44
PUE-FP	EU Framework Programmes				
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	18	41	20	-21
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	15	17		-17
Closed Projects				6	6
Total Funding		**151**	**227**	**187**	**-40**

Table 5.4 - C-BER – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	11	7	15
International conference proceedings indexed by ISI, Scopus or DBLP	20	17	18
Books (author)	1	1	
Chapter/paper in books	2		1
PhD theses concluded by members of the Centre	1		
Concluded PhD theses supervised by members of the Centre		3	1

Table 5.5 – C-BER – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	3
Software copyright registrations	
Patent applications	3

Table 5.6 - C-BER – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	0
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	2
Participation in events such as fairs, exhibitions or similar	4
Advanced training courses	0

5.4.8 List of Projects

Table 5.7 - C-BER – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	VR2Market	João Paulo Cunha	15-07-2014	14-07-2018
PN-FCT	LNDetector	Aurélio Campilho	01-06-2016	31-05-2019
PN-FCT	SCREEN-DR	Aurélio Campilho	01-04-2016	31-03-2020
PN-PICT	NanoStima-RL1	João Paulo Cunha	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL5-1	Aurélio Campilho	01-07-2015	30-06-2018
PN-PICT	SMILES-1	João Paulo Cunha	01-07-2015	30-06-2018
SERV-NAC	Bio-Early	João Paulo Cunha	01-10-2015	30-06-2017

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.4.9 List of Publications

International Journals with Scientific Referees

1. Castro, H, Monteiro, J, Pereira, A, Silva, D, Coelho, G, Carvalho, P, "Cognition inspired format for the expression of computer vision metadata", Multimedia Tools and Applications, vol.75, no.24, pp.17035-17057, Dec
2. Cunha, JPS, Choupina, HMP, Rocha, AP, Fernandes, JM, Achilles, F, Loesch, AM, Vollmar, C, Hartl, E, Noachtar, S, "NeuroKinect: A Novel Low-Cost 3Dvideo-EEG System for Epileptic Seizure Motion Quantification", PLOS ONE, vol.11, no.1, pp.e0145669, 2016

3. Faustino Rocha, AI, Gama, A, Oliveira, PA, Alvarado, A, Fidalgo Goncalves, L, Ferreira, R, Ginja, M, "Ultrasonography as the Gold Standard for In Vivo Volumetric Determination of Chemically-induced Mammary Tumors", IN VIVO, vol.30, no.4, pp.465-472, 2016
4. Goncalves, L, Novo, J, Campilho, A, "Hessian based approaches for 3D lung nodule segmentation", Expert Systems With Applications, vol.61, pp.1-15
5. Oliveira, DR, Goncalves, LF, Reis, AM, Fernandes, RJ, Garrido, ND, Reis, VM, "The Oxygen Uptake Slow Component at Submaximal Intensities in Breaststroke Swimming", Journal of Human Kinetics, vol.50, no.2, pp.165-173, Jun
6. Pereira, T, Paiva, JS, Correia, C, Cardoso, J, "An automatic method for arterial pulse waveform recognition using KNN and SVM classifiers", Medical & Biological Engineering & Computing, vol.54, no.7, pp.1049-1059, Jul
7. Ramos, J, Kockelkorn, TTJP, Ramos, I, Ramos, R, Grutters, J, Viergever, MA, van Ginneken, B, Campilho, A, "Content-Based Image Retrieval by Metric Learning From Radiology Reports: Application to Interstitial Lung Diseases", IEEE Journal of Biomedical and Health Informatics, vol.20, no.1, pp.281-292, Jan
8. Remeseiro, B, Barreira, N, Resúa, CG, Lira, M, Giráldez, MJ, Pimentel, EY, Penedo, MG, "iDEAS: A web-based system for dry eye assessment", Computer Methods and Programs in Biomedicine, vol.130, pp.186-197
9. Remeseiro, B, González, AM, Penedo, MG, "CASDES: A Computer-Aided System to Support Dry Eye Diagnosis Based on Tear Film Maps", IEEE J. Biomedical and Health Informatics, vol.20, no.3, pp.936-943
10. Ribeiro, MJ, Paiva, JS, Castelo Branco, M, "Spontaneous fluctuations in sensory processing predict within-subject reaction time variability", Frontiers in Human Neuroscience, vol.10, no. May
11. Rouco, J, Azevedo, E, Campilho, A, "Automatic Lumen Detection on Longitudinal Ultrasound B-Mode Images of the Carotid Using Phase Symmetry", SENSORS, vol.16, no.3, pp.350, Mar
12. Rozanski, VE, Wick, F, da Silva, NM, Ahmadi, SA, Kammermeier, S, Cunha, JPS, Boetzel, K, Vollmar, C, "A connectivity-based approach to the pathophysiology of hemiballism", BASAL GANGLIA, vol.6, no.2, pp.107-113, Apr
13. Vilas Boas, MDC, Cunha, JPS, "Movement quantification in neurological diseases: Methods and applications", IEEE Reviews in Biomedical Engineering, vol.9, pp.15-31
14. Bereciartua, A, Picon, A, Galdran, A, Iriondo, P, "3D active surfaces for liver segmentation in multisequence MRI images", Computer Methods and Programs in Biomedicine, vol.132, pp.149-160, 2016
15. Costa-Almeida, R, Carvalho, DTO, Ferreira, MJS, Aresta, G, Gomes, ME, van Loon, JJWA, Van der Heiden, K, Granja, PL, "Effects of hypergravity on the angiogenic potential of endothelial cells", Journal of the Royal Society Interface, vol.13, no.124, pp.20160688, 2016

International Conference Proceedings with Scientific Referees

1. Al Rawi, MS, Galdran, A, Yuan, X, Eckert, M, Martinez, JF, Elmgren, F, Curuklu, B, Rodriguez, J, Bastos, J, Pinto, M, "Intensity Normalization of Sidescan Sonar Imagery", 2016 Sixth International Conference on Image Processing Theory, Tools and Applications (IPTA)
2. Assis, S, Costa, P, Rosas, MJ, Vaz, R, Cunha, JPS, "An adaptive model approach for quantitative wrist rigidity evaluation during deep brain stimulation surgery", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, vol.2016-October, pp.5809-5812
3. Bolón Canedo, V, Remeseiro, B, Alonso Betanzos, A, Campilho, A, "Machine learning for medical applications", ESANN 2016 - 24th European Symposium on Artificial Neural Networks, pp.225-234
4. Costa, L, Trigueiros, P, Cunha, A, "Automatic meal intake monitoring using Hidden Markov Models", International Conference on Enterprise Information Systems/International Conference on Project Management/International Conference on Health and Social Care Information Systems and Technologies, Centeris/Projman / HCIST 2016, vol.100, pp.110-117

5. Cunha, A, Cunha, E, Peres, E, Trigueiros, P, "Helping older people: is there an app for that?", International Conference on Enterprise Information Systems/International Conference on Project Management/International Conference on Health and Social Care Information Systems and Technologies, Centeris/Projman / HCIST 2016, vol.100, pp.118-127
6. Cunha, JPS, Rocha, AP, Choupina, HMP, Fernandes, JM, Rosas, MJ, Vaz, R, Achilles, F, Loesch, AM, Vollmar, C, Hartl, E, Noachtar, S, "A novel portable, low-cost kinect-based system for motion analysis in neurological diseases", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, vol.2016-October, pp.2339-2342
7. Domínguez, JG, Remeseiro, B, Martín, MJ, "Acceleration of Tear Film Map Definition on Multicore Systems", International Conference on Computational Science 2016, ICCS 2016, 6-8 June 2016, San Diego, California, USA, vol.80, pp.41-51
8. Ferreira, A, Silva, G, Dias, A, Martins, A, Campilho, A, "Motion Descriptor for Human Gesture Recognition in Low Resolution Images", Robot 2015: Second Iberian Robotics Conference: Advances In Robotics, VOL 1, vol.417, pp.297-308
9. Georgieva, K, Georgieva, P, Georgieva, O, Ribeiro, MJ, Paiva, JS, "Regression Approach for Automatic Detection of Attention Lapses", 2016 IEEE 8th International Conference on Intelligent Systems (IS), pp.370-375
10. Goncalves, L, Novo, J, Campilho, A, "Central Medialness Adaptive Strategy for 3D Lung Nodule Segmentation in Thoracic CT Images", Image Analysis and Recognition (ICIAR 2016), vol.9730, pp.583-590
11. Gonçalves, L., Novo, J., Campilho, A. “Feature definition, analysis and selection for lung nodule classification in chest computerized tomography images”, ESANN 2016 - 24th European Symposium on Artificial Neural Networks, pp. 253-258.
12. Leite, A, Silva, ME, Rocha, AP, "Modeling volatility in heat rate variability", 38th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC 2016, Orlando, FL, USA, August 16-20, 2016, pp.3582-3585
13. Martins, C, Moreira Da Silva, N, Silva, G, Rozanski, VE, Cunha, JPS, "Automated volumetry for unilateral hippocampal sclerosis detection in patients with temporal lobe epilepsy", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, vol.2016-October, pp.6339-6342
14. Moreira, D, Silva, J, Correia, MV, Massada, M, "Classification of knee arthropathy with accelerometer-based vibroarthrography", PHEALTH 2016, vol.224, pp.33-39
15. Paiva, JS, Rodrigues, S, Cunha, JPS, "Changes in ST, QT and RR ECG intervals during acute stress in firefighters: A pilot study", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, vol.2016-October, pp.3378-3381
16. Pavao, J, Bastardo, R, Covelo, M, Pereira, LT, Goncalves, N, Queiros, A, Rocha, NP, Costa, V, "Usability Study of SClinico", 2016 11th Iberian Conference on Information Systems and Technologies (CISTI), vol.2016-July
17. Rocha, AP, Leite, A, Silva, ME, "Volatility leveraging in heart rate: Health vs disease", Computing in Cardiology, vol.43, pp.25-28
18. Rodrigues, S, Paiva, J, Pimentel, G, Cunha, JPS, "Effects of perceived stress and fatigue in Firefighters cognitive performance: a pilot study", SHO2016: International Symposium on Occupational Safety nd Hygiene, pp.278-280

Books

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Chapter/Paper in Books

1. Silva, RM, Sousa, E, Fonseca, P, Pinheiro, AR, Silva, C, Correia, MV, Mouta, S, "Analysis and Quantification of Upper-Limb Movement in Motor Rehabilitation After Stroke", Converging Clinical and Engineering Research on Neurorehabilitation II - Biosystems & Biorobotics, pp.209-213

Publications (Editor)

1. Campilho, A, Karray, F, "Image Analysis and Recognition - 13th International Conference, ICIAR 2016, in Memory of Mohamed Kamel, Póvoa de Varzim, Portugal, July 13-15, 2016, Proceedings", ICIAR, vol.9730

Dissertations (PhD)

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5.5 CPES - CENTRE FOR POWER AND ENERGY SYSTEMS

Coordinators: Manuel Matos and Luís Seca

5.5.1 Presentation of the Centre

The Centre for Power and Energy Systems (CPES) accomplishes its mission within the Cluster PE – Power and Energy. CPES is INESC TEC's main actor in the areas of electrical energy. The Centre is internationally recognised for its expertise in integration of renewable energy in power systems, distributed generation, storage, smart-grids and areas traditionally associated with planning and operation of power systems. The high level of expertise developed has allowed specialists at CPES to take on key roles in important EU projects as part of the successive framework programmes that led to notable scientific and technical advances with considerable impact on industry. This has led to contracts for development and consultancy with manufacturing equipment companies and with generation, transmission and distribution companies, regulators, government agencies and investors in Europe, South America, the United States of America and Africa.

5.5.2 Research and Technology Development

The Centre addresses the following main research areas:

Decision Making, Optimisation and Computational Intelligence
Classic and emerging optimisation methods with applications in energy systems, methodologies for multi-criteria decision support, including risk models and methodologies based on metaheuristics and evolutionary computation for optimisation and decision making. Computational intelligence based models (e.g. fuzzy systems, neural networks, autoencoders) for applications in energy systems.

Forecasting
Statistical learning algorithms for univariate and multivariate time series; forecasting error analysis with probabilistic descriptions of uncertainties; distributed learning and parallel computing; classical data mining algorithms and deep learning techniques for dimension reduction and feature extraction; data-driven power system management, control and planning functions; modelling of energy systems, such as storage, renewable technologies and controllable loads.

Static and Dynamic analysis of Energy Grids
Classic and fuzzy models for steady state analysis of electricity grids, modelling and analysis of the dynamic behaviour in isolated and interconnected networks, dynamic models for energy conversion systems, dynamic simulation models for microgeneration systems and microgrids and the design of advanced system support functions/ancillary services for Distributed Energy Resources integration into electric power systems.

Reliability
Models to analyse reliability in energy systems, reliability in static, spinning and operational capacity power systems looking at renewable and variable energy production, reliability of composite distribution systems (Generation + Transmission), microgeneration and microgrids, models to represent maintenance and the transmission network.

Power Electronics
Research and development activities ranging from the fundamental technology investigation up to advanced demonstration pilot sites related to power electronic energy conversion units, conditioning and control for microgeneration units and energy storage devices with advanced grid support functionalities.

5.5.3 Technology transfer

DMS/EMS & System Operation
The main focus of this area is the specification, development and integration of advanced computational tools for network management systems, such as: topology processors, load allocation, fuzzy state estimation, voltage and reactive power control, fault location with fuzzy inference, isolation and restauration (FDIR), optimal

network reconfiguration, optimal power flow, contingency analysis, economic dispatch, unit commitment, dispatch training system, distribution state estimator including unbalanced networks.

System Planning and Reliability

The technology transfer activities developed in this area are mainly directed to transmission and distribution system planning and reliability analysis, including security of supply and reserves adequacy. Another major topic involves load research, load pattern analysis, classification and management, and the development of load and loss profiles for electricity markets. This area also addresses loss studies, comprising estimation and allocation of technical losses, and strategy scheming for the reduction of technical losses. Finally, it also focusses on the detection of non-technical losses and consumption behaviour anomalies.

Network Studies and RES & DER integration

The central focus of the Network Studies and RES & DER integration Area is the steady state, dynamic and transient modelling, analysis and control of interconnected and isolated electric power systems with increasing shares of Renewable Energy Sources (RES). The mains activities are related to RES integration studies, identification of system support functions/ancillary services from RES and the exploitation of new technologies for increasing the controllability and flexibility of transmission and distribution grids (transmission and distribution FACTS, energy storage and associated power converters, HVDC). These activities are supported by a laboratorial infrastructure where reduced-scale models can be implemented and extensively tested in a power-hardware-in-the-loop set-up. The work developed in this area has been largely carried out in collaboration with the industry through consultancy services and applied research as well as through national and European public research bodies, whose financial support enables the developed of fundamental R&D activities.

Electricity Markets and Regulation

This area addresses the organization, operation and expansion planning of power systems under market conditions as well as the development of tariff schemes to support regulated transmission and distribution activities. On one hand, it aims at developing market structures to bring gate closure closer to real time, to progressively integrate reserve markets in active power markets and to expand them into transnational mechanisms. On the other hand, it applies optimization methods and metaheuristics to develop long term expansion generation and transmission planning under uncertain conditions namely due to the presence of multiple generation agents. Finally, it addresses regulatory issues related to transmission and distribution network activities in order to incorporate dynamic tariff options in the tariff codes and to study the reshaping of network tariffs in view of the expected reduction network usage as local micro and mini generation spread in the systems.

Energy Analytics and Forecasting

This area applies statistical learning and optimization techniques to power system related problems, electricity markets and end-users. The main activities are the development of time series forecasting algorithms for load, renewable energy and electricity prices. These techniques are the basic framework to tackle new problems like distributed and data-driven demand response strategies and knowledge extraction (data mining) from different power system data, such as phase measurement units, smart meter data and other sensors. The final goal is to embed extracted knowledge in decision-aid methods under risk and create new paradigms for power system control and planning. The results from the R&D activities are, in general, transferred to industrial partners (system operators, retailers, consumers) and the operationalization of the computational modules is made by INESC TEC or by the final client.

Advanced Training

Organising lectures and training activities on emerging issues as part of projects with international consortia, European projects or on request from companies.

5.5.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CPES – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Areas of Technology Transfer --> relationships (3)						
		Status (2)	DMS/EMS System Operation	System Planning and Reliability	Network Studies and RES & DER integration	Electricity Markets and Regulation	Energy Analytics and Forecasting	Advanced Training
Decision Making, Optimisation and Computational Intelligence		I	H	H	M	H	M	
Forecasting		I	H	M		H	H	H
Static and Dynamic analysis of Energy Grids		I	M	L	H		L	H
Reliability		I	M	H		M	L	M
Power Electronics		I		L	M			
Other Areas (1)	Communication networks (CTM)	O	H				M	
	Data Mining (LIAAD)	O	L	M			H	
	Service Design and Engineering (CEGI)	O		L			M	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer

(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership

(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.5.5 Main Achievements in 2016

DMS/EMS & System Operation

- Development of a methodology to improve the automation of Faial island by selecting localization of remote control on switching devices for automatic fault location, isolation and restauration;
- Specification of a new DMS module, the Validation of Optimized Solutions application, to determine a feasible switching procedure which will reconfigure the network according to a final topology;
- Development of an autonomous Unbalanced Power Flow application, a generalized approach based on an efficient and robust three-phase branch-oriented backward-forward procedure, and it is able to deal with 4-wire unbalanced LV systems;
- Development of an automatic platform, with an extensive set of validations, to test the new improvements done in the DMS modules implemented in the last two decades;

System Planning and Reliability

- Development of loss profiles for the Portuguese part of the MIBEL (Iberian electricity market) for the year of 2017;
- Specification of the implementation plan of the Project Pump-storage Santiago Island / Cape Verde. Its overall objective is to mobilize investment in Cape Verde's electricity supply sector and to provide

sufficient energy at a fair price benefitting from the country's attractive RE sources and to introduce innovative electricity storage technologies and schemes to manage high RE shares in the electricity supply mix and managing their intermittencies. In the Centre of the analysis will be three identified pump-storage sites on Cape Verde's Santiago Island and the potential impact upon higher RE penetration in the island's electricity supply mix. A preliminary work was developed in 2016, including visits to the candidate hydro reservoir sites and analysis of the Cape Verde distribution system;

- Development and implementation of models to emulate the Brazilian electrical system to estimate the impacts of climate changes on the electricity generation, security of supply, costs and emissions. Another objective of this research is to anticipate the benefits of smart grids under a climate changing environment. These models are now currently integrated in a software platform that simulates a set of climate and power system scenarios. Final results and conclusions expected during the current year;

Network Studies and RES & DER integration

- Development of advanced control algorithms for MV and LV grids using a multi-temporal OPF that is responsible for the management of several DER, namely energy storage devices, as well as the flexibility that can be provided from final costumers. These tools were developed within the framework of the H2020 project SENSIBLE.
- Development of an advanced control algorithm for managing DER in a microgrid during islanding operation and aiming at maximizing the time during which the microgrid is capable of operating in island mode. This algorithm was developed within the framework of the H2020 project SENSIBLE.
- Implementation and experimental validation of the power converter prototype for energy storage applications with advanced grid supporting capabilities, namely voltage control and low voltage fault ride through capability. This prototype was developed within the framework of the H2020 project SENSIBLE.
- Development of a new approach for primary frequency control in future power systems - the Frequency Containment Control - that aims at solving frequency deviation problems generated in a control area by using locally available resources. The novelty of this approach relies on the fact that the power frequency characteristic can be adjusted in the moments subsequent to a disturbance affecting the power-frequency control mechanism, depending on the incident location. This control solution was developed within the framework of the ELECTRA project.
- Within the SusCity project, it was developed an expedite methodology to assess the total flexibility of Low Voltage (LV) clients and aggregate them in a bottom-up approach until reaching the transmission network nodes. The ultimate goal is to provide accurate upward and downward load flexibility per distribution and transmission network node and analyse the impact of different DER integration scenarios in the flexibility availability and in the network operation. Furthermore, an OPF algorithm was developed to activate the available flexibility and solve the technical problems induced by the increasing integration of PV, EV, and charging stations.
- Within the framework of the HYPERBOLE project, it was developed and validated dynamic simulation models for variable speed hydro power plants and specification of advanced system services they can provide to the grid. The value of the identified system services was demonstrated through extensive system simulation based on the Portuguese transmission electric power system.
- Establishment of a research contract for SIEMENS AG on the development of control procedures for handling islanded microgrids development
- Development of consultancy activities for EDA on the evaluation of transient stability of isolated power system with reversible hydro power plants.
- Development of consultancy activities for EEM on the specification of a grid code for all type of generators to be connected in the Madeira and Porto Santo islands.

Electricity Markets and Regulation

- Organization of the 13th International Conference on the European Energy Market, EEM 2016. This Conference was organized by INESC TEC through CPES (chaired by João Tomé Saraiva and co-chaired by José Nuno Fidalgo) and took place from June 6 to June 9, 2016. It had more than 260 participants and it included technical sessions in which 180 papers were presented.
- Development of a Cost Benefit Analysis regarding the possible introduction of Dynamic Options in the Electricity Access Tariffs in Portugal mainland. This study was prepared as a response to a request from EDP Distribution in order to fulfil a requirement issued by ERSE to the Portuguese regulated companies.
- Similar studies to the one mentioned in the previous bullet were also developed to the distribution companies of Azores and Madeira. In these cases, the Cost Benefit Analyses resulted in a negative result that enabled the Portuguese Regulatory Agency to decide not to introduce dynamic tariff options in the electricity tariffs existing in Azores and in Madeira islands.
- Development of models to plan the expansion on the long term of transmission networks using solution space reduction techniques in order to identify more rapidly possible expansion plans;
- Development of a System Dynamic model to plan the expansion of generation systems, focused on the Brazilian power system. This model considers the organization of the Brazilian power system in four submarkets, integrates transmission constraints between these sub markets and internalizes the impact of hydro units and the increasing presence of wind and PV generation, namely in the northeast submarket.
- Development of a model to schedule hydro stations with pumping in market environment, considering them as price makers, as well as the tailwater effect and the variation of the efficiency of the units. This model was tested using the cascade of 9 hydro units installed in the Portuguese section of the Douro river and it produced more accurate results than previous models.
- Development of new market services to handle local constraints in electric distribution grids through the use of flexibility of DSO resources and DR services. This work was made in the framework of the Horizon 2020 EU project smarterEMC2.
- Development of a new market-clearing model that enables market participation of renewables using variable primary resources and flexible loads by accepting probabilistic bids to handle the intrinsic uncertainty of these resources. (SusCity project)

Energy Analytics and Forecasting

- A new methodology combining the alternating direction method of multipliers (ADMM), the least absolute shrinkage and selection operator (LASSO) and vector autoregression models was developed to extract information from geographically distributed wind and solar time series to produce forecasted with high skill. The method was tested in data provided by Vestas (Denmark) and results were disseminated to the industrial partner. This work was made in the framework of the FCT funded project Suscity.
- A wind power probabilistic forecasting method that solves the quantile regression problem in the Reproducing Kernel Hilbert Space (RKHS) was developed to extract information from the European Centre for Medium-Range Weather Forecasts (ECMWF) weather ensembles. The forecasting algorithm was tested for wind farms in Romania and transferred to EDP Renováveis.
- The development of two decision-aid tools for the Portuguese TSO (REN) was concluded during this period. A tool was developed to define the operating reserve requirements based on probabilistic forecasts and another tool defines the maximum value of the import net transfer capacity. Both tools were demonstrated in a real-environment and transferred to REN. Moreover, conditional extreme value theory was also applied to estimate the extreme quantiles of the distribution's tails.
- Integration of load and renewable energy forecasting in two distribution grid optimization tools: a) estimate the active and reactive power flexibility in the TSO-DSO interface; sequential optimal power

flow for HV and MV distribution grids. Models demonstrated for the Portuguese DSO (EDP Distribuição) and French DSO (Enedis). This work was made in the framework of the FP7 EU project evolvDSO.

- Demonstration for the French DSO (Enedis) of a data-driven low voltage state estimator based on extreme learning machines. This work was made in the framework of the FP7 EU project evolvDSO.
- Development of an advanced solar power forecasting method with the following innovative features: a) explores a grid of numerical weather predictions; b) proposes a set of features constructed with domain knowledge that improves the point and probabilistic forecasting skill. This was made in the framework of the national project CORAL.
- Development of an optimization framework (from mid to short-term horizon) to support the participation of variable speed pump storage power, alone or combined with a wind power plant, in the day-ahead energy and frequency restoration reserve markets. This work was made in the framework of the FP7 EU project HYPERBOLE.
- Development of wind power forecasting algorithms based on the combination of machine learning algorithms (e.g., gradient boosting trees) and feature reduction techniques (e.g., time series clustering, PCA). Software transferred to a Spanish company (Meteobit).
- Development of a probabilistic load forecasting algorithm for low voltage networks, based on analog search and kernel density estimation. This work was made in the framework of the Horizon 2020 project UPGRID.
- Development of a stochastic optimal power flow algorithm that encompasses spatial-temporal renewable energy uncertainty. This was a result of a joint work with Technical University of Denmark.
- Started the participation in the IEA Wind Task 36 on Forecasting for Wind Energy, task leader in identifying best practices in the usage and communication of wind power forecasts.
- Development of a home energy management system including the supporting hardware and software modules; optimization algorithms embedded in single board computing platforms. This work was made in the framework of the Horizon2020 project AnyPlace.
- Development of algorithms and implementation of a platform (R Project language) for the detection of non-technical losses and anomalous consumption behaviour. These activities were developed under the scope of contract with EDP Distribuição.
- Implementation of a sub-metering system in INESC TEC main building with ca. 170 metering points. The meters' frequency is configurable (maximum of 5 measurements per second) and the collected data will be stored in real-time in an online database. The data gathered will be used to feed a gamification platform which main objective is to foster behaviour change to increase overall energy efficiency in the building. (GReSBAS ERA-NET project)

5.5.6 Centre Organizational Structure and Research Team

The Centre for Power and Energy Systems is coordinated by Manuel Matos and Luís Seca and is organized in the following Areas:

- DMS/EMS & System Operation - Responsible: Jorge Pereira
- System Planning and Reliability - Responsible: José Nuno Fidalgo
- Network Studies and RES & DER integration - Responsible: Carlos Moreira
- Electricity Markets and Regulation - Responsible: João Tomé Saraiva
- Energy Analytics and Forecasting - Responsible: Ricardo Bessa

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CPES – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	7	13	12	-1
		Academic Staff	11	11	12	1
		Grant Holders and Trainees	34	36	51	15
		Total Core Researchers	**52**	**60**	**75**	**15**
	Affiliated Researchers		3	3	3	
	Admin.& Tech	Employees	2	2	2	
		Grant Holders and Trainees				
	Total Integrated HR		**57**	**65**	**80**	**15**
	Total Integrated PhD		**21**	**24**	**25**	**1**
Curricular Trainees			3	2	2	
External Research Collaborators			9	8	9	1
External Administrative and Technical Staff						
External Students				1	1	
Total			**69**	**76**	**92**	**16**

5.5.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CPES – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	98	79	62	-17
PN-PICT	National R&D Programmes - S&T Integrated Projects	205	93	8	-85
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	707	1.253	1.279	26
PUE-DIV	EU Cooperation Programmes - Other			62	62
SERV-NAC	R&D Services and Consulting - National	461	608	631	23
SERV-INT	R&D Services and Consulting - International	38	68	114	46
OP	Other Funding Programmes	78	23	57	34
Closed Projects			52	106	54
Total Funding		**1.586**	**2.176**	**2.318**	**142**

Table 5.4 - CPES – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	20	13	36
International conference proceedings indexed by ISI, Scopus or DBLP	19	33	70
Books (author)	1		
Chapter/paper in books	4	5	3
PhD theses concluded by members of the Centre	3		3
Concluded PhD theses supervised by members of the Centre		4	5

Table 5.5 – CPES – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	1
Software copyright registrations	0
Patent applications	0

Table 5.6 - CPES – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	6
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	20
Participation in events such as fairs, exhibitions or similar	
Advanced training courses	1

5.5.8 List of Projects

Table 5.7 - CPES – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	SusCity	Manuel Matos	01-01-2015	31-12-2017
PN-FCT	INFUSE	Vladimiro Miranda	01-04-2016	31-03-2019
PN-PICT	iMAN-5	Luís Seca	01-07-2015	30-06-2018
PN-PICT	CORAL-TOOLS-4	Carlos Moreira	01-01-2016	31-12-2018

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PUE-DIV	REStable	Carlos Moreira	01-04-2016	31-03-2019
PUE-DIV	GReSBAS	Filipe Joel Soares	01-04-2016	31-03-2019
PUE-DIV	SmartGuide	Filipe Joel Soares	01-04-2016	31-03-2019
PUE-DIV	Smares	Carlos Moreira	01-04-2016	30-09-2018
PUE-DIV	INDuGRID	Carlos Moreira	01-09-2016	31-08-2019
PUE-FP	iTESLA	André Madureira	01-01-2012	31-03-2016
PUE-FP	SuSTAINABLE	Luís Seca	01-01-2013	31-03-2016
PUE-FP	evolvDSO	Manuel Matos	01-09-2013	31-12-2016
PUE-FP	Hyperbole	Carlos Moreira	01-09-2013	28-02-2017
PUE-FP	EleCtra	José Nuno Fidalgo	01-12-2013	30-11-2017
PUE-FP	SENSIBLE	Ricardo Bessa	01-02-2015	31-07-2018
PUE-FP	UPGRID	Luís Seca	01-02-2015	31-01-2018
PUE-FP	AnyPLACE	David Rua	01-02-2015	31-01-2018
PUE-FP	SmarterEMC2	David Rua	01-02-2015	31-01-2018
SERV-NAC	EFACEC-DMS	Jorge Correia Pereira	15-04-2001	
SERV-NAC	PROB	José Nuno Fidalgo	01-04-2012	31-12-2016
SERV-INT	SECRETS	Luís Seca	01-12-2013	31-05-2017
SERV-NAC	Madeirarenov_2014	Luís Seca	01-01-2014	30-09-2016
SERV-NAC	CP_T_Dinamicas	João Tomé Saraiva	01-02-2015	30-06-2017
SERV-NAC	ReservaProb	Ricardo Bessa	01-10-2015	30-11-2016
SERV-NAC	Automacao_Faial	Clara Gouveia Moura	01-01-2016	30-06-2017
SERV-NAC	Tarif_Dinam_Acores	João Saraiva	01-12-2015	31-01-2018
SERV-NAC	Estim_Invest_Dist	José Nuno Fidalgo	01-09-2015	31-03-2017
SERV-NAC	Segur_Abast_Madeira	João Saraiva	01-10-2015	30-06-2016
SERV-NAC	Terceira_Renov	Bernardo Amaral Silva	01-09-2015	30-06-2016
SERV-INT	Meteo_NMP_Forecast	Ricardo Bessa	01-12-2015	31-12-2016
SERV-NAC	BIOGAS	João Peças Lopes	24-11-2015	23-05-2016
SERV-NAC	Cidade_sustentavel	Filipe Joel Soares	01-01-2016	31-12-2017
SERV-NAC	Tarif_Dinam_Madeira	João Tomé Saraiva	01-02-2016	31-12-2017
SERV-NAC	MORA	Leonel Magalhães Carvalho	05-04-2016	04-04-2018
SERV-NAC	ADMS4LV	Luís Seca	01-04-2016	31-03-2018
SERV-NAC	SACC	Filipe Joel Soares	01-01-2016	31-12-2017

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-INT	StatProbWind	Ricardo Bessa	01-05-2016	30-04-2017
SERV-NAC	Hidrica_reversivel	João Peças Lopes	01-03-2016	31-08-2017
SERV-NAC	Automacao_PST	André Madureira	30-04-2016	29-06-2017
SERV-NAC	Wind_curteil_soft	Leonel Magalhães Carvalho	12-05-2016	11-01-2017
SERV-INT	STABLING	Carlos Moreira	01-09-2016	31-03-2017
SERV-NAC	PANACea	José Nuno Fidalgo	08-08-2016	07-03-2017
SERV-NAC	Perfis_Perdas_2017	José Nuno Fidalgo	01-11-2016	28-02-2017
SERV-NAC	Graciosa	João Peças Lopes	25-11-2016	24-05-2017
SERV-NAC	Consultoria	Manuel Matos	01-01-2008	
OP	CoordEES-UETP	João Peças Lopes	01-04-2007	
OP	EEM_2016	João Tomé Saraiva	01-04-2016	31-12-2016

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.5.9 List of Publications

International Journals with Scientific Referees

1. Augusto, AA, Do Coutto Filho, MB, Stacchini de Souza, JCS, Miranda, V, "Probabilistic assessment of state estimation capabilities for grid observation", IET Generation Transmission & Distribution, vol.10, no.12, pp.2933-2941, 2016
2. Barreras, JV, Pinto, C, de Castro, R, Schaltz, E, Andreasen, SJ, Rasmussen, PO, Araujo, RE, "Evaluation of a Novel BEV Concept Based on Fixed and Swappable Li-Ion Battery Packs", IEEE Transactions on Industry Applications, vol.52, no.6, pp.5073-5085, 2016
3. Bizuayehu, AW, Sanchez de la Nieta, AAS, Contreras, J, Catalao, JPS, "Impacts of Stochastic Wind Power and Storage Participation on Economic Dispatch in Distribution Systems", IEEE Transactions on Sustainable Energy, vol.7, no.3, pp.1336-1345, JUL, 2016
4. Brito, M, Cavalcante, L, Moreira Freitas, ACM, "Bias-corrected geometric-type estimators of the tail index", Journal of Physics A-Mathematical and Theoretical, vol.49, no.21, pp.214003, 2016
5. Cerveira, A, de Sousa, A, Solteiro Pires, EJS, Baptista, J, "Optimal Cable Design of Wind Farms: The Infrastructure and Losses Cost Minimization Case", IEEE Transactions on Power Systems, vol.31, no.6, pp.4319-4329, NOV, 2016
6. Da Silva Filho, JI, Camargo, JDM, Dos Santos, MR, Onuki, AS, Mario, MC, Ferrara, LFP, Garcia, DV, Pereira, JMC, Rocco, A, "Support at Decision in Electrical Systems of subtransmission through selection of Topologies by a Paraconsistent Simulator", IEEE Latin America Transactions, vol.14, no.4, pp.1993-1999, 2016

7. de Castro, R, Tanelli, M, Araujo, RE, Savaresi, SM, "Minimum-Time Path-Following for Highly Redundant Electric Vehicles", IEEE Transactions on Control Systems Technology, vol.24, no.2, pp.487-501, Mar, 2016
8. Fidalgo, JN, Couto, M, Fournie, L, "The worth of network upgrade deferral in distribution systems - Truism or myth?", Electric Power Systems Research, vol.137, pp.96-103, Aug, 2016
9. Gallego Castillo, C, Bessa, R, Cavalcante, L, Lopez Garcia, O, "On-line quantile regression in the RKHS (Reproducing Kernel Hilbert Space) for operational probabilistic forecasting of wind power", ENERGY, vol.113, pp.355-365, 2016
10. Godina, R, Rodrigues, EMG, Matias, JCO, Catalao, JPS, "Smart electric vehicle charging scheduler for overloading prevention of an industry client power distribution transformer", Applied Energy, vol.178, pp.29-42, 2016
11. Godina, R, Rodrigues, EMG, Paterakis, NG, Erdinc, O, Catalao, JPS, "Innovative impact assessment of electric vehicles charging loads on distribution transformers using real data", Energy Conversion and Management, vol.120, pp.206-216, 2016
12. Gouveia, C, Rua, D, Ribeiro, F, Miranda, L, Rodrigues, JM, Moreira, CL, Pecas Lopes, JAP, "Experimental validation of smart distribution grids: Development of a microgrid and electric mobility laboratory", International Journal of Electrical Power & Energy Systems, vol.78, pp.765-775, JUN, 2016
13. Guerrero Mestre, V, de la Nieta, AAS, Contreras, J, Catalao, JPS, "Optimal Bidding of a Group of Wind Farms in Day-Ahead Markets Through an External Agent", IEEE Transactions on Power Systems, vol.31, no.4, pp.2688-2700, JUL, 2016
14. Heleno, M, Matos, MA, Pecas Lopes, JAP, "A bottom-up approach to leverage the participation of residential aggregators in reserve services markets", Electric Power Systems Research, vol.136, pp.425-433, JUL, 2016
15. Lujano Rojas, JM, Dufo Lopez, R, Atencio Guerra, JL, Rodrigues, EMG, Bernal Agustin, JL, Catalao, JPS, "Operating conditions of lead-acid batteries in the optimization of hybrid energy systems and microgrids", APPLIED ENERGY, vol.179, pp.590-600, 2016
16. Mehrasa, M, Pouresmaeil, E, Zabihi, S, Caballero, JCT, Catalao, JPS, "A Novel Modulation Function-Based Control of Modular Multilevel Converters for High Voltage Direct Current Transmission Systems", ENERGIES, vol.9, no.11, NOV, 2016
17. Mehrasa, M, Pouresmaeil, E, Zabihi, S, Catalão, JPS, "Dynamic model, control and stability analysis of MMC in HVDC transmission systems", IEEE Transactions on Power Delivery, vol.PP, no.99, pp.1-1, 2016
18. Miranda, I, Leite, H, Silva, N, "Coordination of multifunctional distributed energy storage systems in distribution networks", IET Generation Transmission & Distribution, vol.10, no.3, pp.726-735, 2016
19. Miranda, I, Silva, N, Leite, H, "A Holistic Approach to the Integration of Battery Energy Storage Systems in Island Electric Grids With High Wind Penetration", IEEE Transactions on Sustainable Energy, vol.7, no.2, pp.775-785, APR, 2016
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21. Moutinho, JN, Araujo, RE, Freitas, D, "Indoor localization with audible sound - Towards practical implementation", Pervasive and Mobile Computing, vol.29, pp.1-16, JUL, 2016
22. Neyestani, N, Yazdani Damavandi, M, Shafie Khah, M, Bakirtzis, AG, Catãlao, JPS, "Plug-in Electric Vehicles Parking Lot Equilibria with Energy and Reserve Markets", IEEE Transactions on Power Systems, vol.PP, no.99, pp.2001-2016, 2016
23. Ortiz, M, Ukar, O, Azevedo, F, Mugica, A, "Price forecasting and validation in the Spanish electricity market using forecasts as input data", International Journal of Electrical Power & Energy Systems, vol.77, pp.123-127, MAY, 2016
24. Osorio, GJ, Goncalves, JNDL, Lujano Rojas, JM, Catalao, JPS, "Enhanced Forecasting Approach for Electricity Market Prices and Wind Power Data Series in the Short-Term", ENERGIES, vol.9, no.9, pp.693

25. Paterakis, NG, Erdinc, O, Pappi, IN, Bakirtzis, AG, Catalao, JPS, "Coordinated Operation of a Neighborhood of Smart Households Comprising Electric Vehicles, Energy Storage and Distributed Generation", IEEE Transactions on Smart Grid, vol.7, no.6, pp.2736-2747, Nov, 2016

26. Paterakis, NG, Pappi, IN, Erdinc, O, Godina, R, Rodrigues, EMG, Catalao, JPS, "Consideration of the Impacts of a Smart Neighborhood Load on Transformer Aging", IEEE Transactions on Smart Grid, vol.7, no.6, pp.2793-2802, NOV, 2016

27. Paterakis, NG, Tascikaraoglu, A, Erdinc, O, Bakirtzis, AG, Catalao, JPS, "Assessment of Demand-Response-Driven Load Pattern Elasticity Using a Combined Approach for Smart Households", IEEE Transactions on Industrial Informatics, vol.12, no.4, pp.1529-1539, Aug, 2016

28. Pinto, C, Barreras, JV, Schaltz, E, Araujo, RE, "Evaluation of Advanced Control for Li-ion Battery Balancing Systems Using Convex Optimization", IEEE Transactions on Sustainable Energy, vol.7, no.4, pp.1703-1717, Oct, 2016

29. Pinto, MSS, Miranda, V, Saavedra, OR, "Risk and unit commitment decisions in scenarios of wind power uncertainty", RENEWABLE ENERGY, vol.97, pp.550-558, Nov, 2016

30. Sanchez de la Nieta, AAS, Contreras, J, Catalao, JPS, "Optimal Single Wind Hydro-Pump Storage Bidding in Day-Ahead Markets Including Bilateral Contracts", IEEE Transactions On Sustainable Energy, vol.7, no.3, pp.1284-1294, Jul, 2016

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33. Souza, SSF, Romero, R, Pereira, J, Saraiva, JT, "Artificial immune algorithm applied to distribution system reconfiguration with variable demand", International Journal of Electrical Power & Energy Systems, vol.82, pp.561-568, Nov, 2016

34. Souza, SSF, Romero, R, Pereira, J, Saraiva, JT, "Reconfiguration of Radial Distribution Systems with Variable Demands Using the Clonal Selection Algorithm and the Specialized Genetic Algorithm of Chu-Beasley", Journal of Control Automation and Electrical Systems, vol.27, no.6, pp.689-701, Dec, 2016

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2. Barbeiro, P, Pereira, J, Teixeira, H, Seca, L, Silva, P, Silva, N, Melo, F, "LV SCADA Project: in-Field Validation of a Distribution State Estimation Tool for LV Networks", CIRED Workshop 2016 , 2016

3. Barbosa, D, Lopes, A, Araújo, RE, "Sensor fusion algorithm based on Extended Kalman Filter for estimation of ground vehicle dynamics", IECON Proceedings (Industrial Electronics Conference), pp.1049-1054

4. Bessa, RJ, "On the Quality of the Gaussian Copula for Multi-temporal Decision-making Problems" Power Systems Computation Conference (PSCC)

5. Bremermann, L, Rosa, M, Galvis, P, Nakasone, C, Carvalho, L, Santos, F, "Using VaR and CVaR Techniques to calculate the Long-term Operational Reserve", 2016 International Conference on Probabilistic Methods Applied to Power Systems (PMAPS)

6. Calabria, FA, Saraiva, JT, Rocha, AP, "A design and simulation of a Brazilian Bid Based Short-Term Electricity Market", 2016 13TH International Conference on the European Energy Market (EEM), vol.2016-Jul

7. Carvalho, LM, Teixeira, J, Matos, M, "Modeling Wind Power Uncertainty in the Long-Term Operational Reserve Adequacy Assessment: a Comparative Analysis between the Naive and the ARIMA Forecasting Models", 2016 International Conference on Probabilistic Methods Applied to Power Systems (PMAPS)

8. Castro, MS, Saraiva, JT, Sousa, JC, "Application of the Matlab (R) Linprog Function to Plan the Short Term Operation of Hydro Stations Considered as Price Makers", 2016 13th International Conference on the European Energy Market (EEM), vol.2016-Jul

9. Coelho, A, Matos, M, "Impact of self-production in the operation and regulation of distribution networks", IET Conference Publications, vol.2016, no.CP711

10. Costa, H, Miranda, M, Ramos, J, Seca, L, Madureira, A, Lemos, D, Santana, R, Louro, M, Matos, PG, Rosa, L, Silva, N, "Voltage control demonstration for LV networks with controllable der - The SuSTAINABLE project approach", IET Conference Publications, vol.2016, no.CP686

11. Cruz, DF, Rodrigues, EMG, Godina, R, Cabrita, CMP, Matias, JCO, Catalao, JPS, "Innovative Experimental Low Cost Electronics Operated Instrumentation for Wearable Health Systems with High Resolution Physiological Measurements", 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC)

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14. De Oliveira, LB, Marcelino, CG, Milanes, L, Almeida, PEM, Carvalho, LM, "A Successful Parallel Implementation of NSGA-II on GPU for the Energy Dispatch Problem on Hydroelectric Power Plants", 2016 IEEE Congress on Evolutionary Computation (CEC), pp.4305-4312

15. Ferreira, R, Matos, M, Lopes, JP, "Regulatory Issues in the Deployment of Distributed Storage Devices in Distribution Networks", 2016 13TH International Conference On The European Energy Market (EEM), vol.2016-Jul

16. Filipe, JM, Moreira, CL, Bessa, RJ, Silva, BA, "Optimization of the Variable Speed Pump Storage Participation in Frequency Restoration Reserve Market", 2016 13th International Conference on the European Energy Market (EEM), vol.2016-Jul

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18. Fonte, PM, Monteiro, C, Barbosa, FM, "Net load forecasting in presence of renewable power curtailment", 2016 13th International Conference on the European Energy Market (EEM), vol.2016-Jul

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21. Godina, R, Rodrigues, EMG, Pouresmaeil, E, Matias, JCO, Catalao, JPS, "Model Predictive Control Technique for Energy Optimization in Residential Sector", 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC)

22. Godina, R, Rodrigues, EMG, Shafie khah, M, Matias, JCO, Catalao, JPS, "Overloading Analysis of an Industrial Client Distribution Transformer in a Portuguese Island", 2016 IEEE International Energy Conference (Energycon)

23. Gomes, PV, Saraiva, JT, "Evaluation of the Performance of Space Reduction Technique Using AC and DC Models in Transmission Expansion Problems", 2016 13th International Conference on the European Energy Market (EEM), vol.2016-Jul

24. Gomes, PV, Saraiva, JT, "Hybrid Discrete Evolutionary PSO for AC Dynamic Transmission Expansion Planning", 2016 IEEE International Energy Conference (ENERGYCON)

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30. Khenar, M, Pouresmaeil, E, Catalao, JPS, "Control of Voltage Source Converters in Wind Farm Based Multi-Terminal HVDC Transmission Systems", 2016 IEEE/PES Transmission and Distribution Conference and Exposition (T&D)

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36. Maggioli, E, Leite, H, Morais, C, "A Survey of the Portuguese MV Underground Cable Failure", 2016, 13th International Conference on the European Energy Market (EEM)

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38. Marcelino, CG, Almeida, PEM, Wanner, EF, Carvalho, LM, Miranda, V, "Fundamentals of the C-DEEPSO Algorithm and its Application to the Reactive Power Optimization of Wind Farms", 2016 IEEE Congress On Evolutionary Computation (CEC), pp.1547-1554

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42. Mendes, G, Gouveia, C, Guerra, F, Ferreira, A, Murphy O'connor, C, Rocha, L, Bessa, R, Albuquerque, S, "SENSIBLE project: Évora demonstrator enabling energy storage and energy management creating value for grid and customers", IET Conference Publications, vol.2016, no.CP686

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5.6 CESE – CENTRE FOR ENTERPRISE SYSTEMS ENGINEERING

Coordinators: Américo Lopes Azevedo and António Lucas Soares

5.6.1 Presentation of the Centre

CESE accomplishes its mission, within the Cluster I+I - Industry and Innovation, by undertaking multi-disciplinary, system-oriented research and technology development for the strategic and operational management of industrial enterprises and networks. It uses the knowledge generated in research to provide high value-added niche services to the industrial enterprises in areas such as Manufacturing Systems Design, Manufacturing Systems Planning and Management, Collaborative Platforms, Supply Chain Strategy, Manufacturing Intelligence or Construction Information Management.

CESE mission is to advance the scientific knowledge in enterprise systems engineering, fostering high impact management and ICT systems and generating innovative services for industrial organisations. CESE wants to be recognised as a leading research Centre in enterprise systems engineering and as a first choice in helping industrial organisations to achieve sustainable, high-performance levels.

CESE uses the following research approaches to fulfil its mission: Systems Design, Operational Research (Modelling and Optimization and Simulation), Information Management and Analytics, Design Science and Explanatory Research, and Creative Thinking and Problem Structuring. These approaches support CESE RTD activities which are organized in the following research domains: Manufacturing and Services Operations Management, Enterprise and Industrial ICT, Collaborative Networks and Supply Chains, Business Analytics and Decision Support Systems and Transports, Logistics and Mobility.

5.6.2 Research and Technology Development

Manufacturing and Services Operations Management

CESE research activities in the Manufacturing and Services Operations Management research domain address applied research in operations management encompassing Factories Design and Operation, Production Planning, Scheduling and Control and Business Processes Management.

Factories Design and Operation: Industries of the future must be driven by adaptability of the factory design and of its processes. This requires innovative and multidisciplinary approaches to address the increasing complexity and scale of decision-making. CESE research in this line is centered on intelligent manufacturing technologies and methodologies, developed on top of analytical modelling approaches such as simulation and optimization. The research efforts are aimed at (i) the conceptual factory design and layout planning; (ii) integrated design and operation of smart manufacturing systems; (iii) virtual commissioning and operators training; and (iv) real-time performance monitoring and optimization.

Production Planning, Scheduling and Control: This line is a major research area of CESE over the past 15 years. It involves the development of planning and scheduling methods and IT tools for complex production processes. Application areas include footwear, metalwork, and forestry.

Two specific topics are currently researched:

- to advance existing optimization models and heuristics to dealt with tailored production processes, for small series, high-customization; this is particularly important in the case of new installed footwear assembly lines demand a sophisticated planning of resources, namely in what concerns the balancing of mixed model lines and the real-time sequencing of operations. Resources and materials saving in cutting and packing problems will also be studied;
- to evolve planning & scheduling tools to work with other data collection tools within an Internet of Things environment. In fact, the myriad of sensors are other data collection technologies existing today enable remote monitoring of production processes and should be the basis for real-time planning.

Business Processes Management: Business processes in industrial organizations and networks need are characterised by being partly documented and executed with the partial support of a wide range of

information systems. Furthermore, organizations increasingly need to deal with unstructured processes that ordinary Business Process Management (BPM) solutions were not designed to cope with. Research in this line aims at coping with the challenge of managing unstructured or semi-structured processes that are collaborative, knowledge and content-intensive, and subject to constant change.

Research activities are focused in:

- improvement of business processes management by exploiting the linking between operations management, operations research and six sigma methodologies; and
- cost and risk management methodologies for business process environments.

Enterprise and Industrial ICT

The Enterprise and Industrial ICT research domain addresses the design and use of ICT in industrial organisations and networks along the instrumental, architectural and impact dimensions.

In the instrumental dimension, research is focused on the creation of design knowledge for industrial information systems; this is materialised in innovative design concepts and prototypes that cover the upper decision-making levels - performance management, information management, supply-chain management, business process management - as well as the lower levels - manufacturing operations management (including, among-others, production planning systems and manufacturing execution systems);

The architectural dimension addresses research along two lines:

- novel architectures for Cyber-Physical Systems and (Industrial) Internet-of-Things; the focus is on devising new ways of integrating computing and communication with physical and virtual processes across all levels of production, from processes through machines up to production and logistics networks;
- architectures for efficient large amounts of streaming data collected from machines and processes; combination of off-the-shelf big data technology and in-house developments to support different types of data sources, including IoT, as well as other decision support technologies, including analytics, optimization and simulation, delivered as part of enterprise and industrial systems.

The impact dimension addresses the ex-ante and ex-post assessment of instrumental systems and architectures in industrial organisations and networks. The activities within this dimension also run along two lines:

- technological evaluation: characterisation of the available architectures, technologies and solutions covering the MOM domain (including MES); evaluation of the different possibilities around integration technologies for Industrial Information Systems; and the development of frameworks for the selection and implementation of information systems in enterprises and supply chains.
- socio-technical studies of industrial ICT: empirical studies on the adoption and impact of information systems in industrial organisations and networks.

Collaborative Networks and Supply Chains

Collaborative Networks and Supply-Chains is a multi-disciplinary research domain covering the design of collaborative and supply networks, network business models and processes and the study and design of information and knowledge management in collaborative networks.

Design of Collaborative and Supply Networks: The design of collaborative networks involves determining which structural governance forms would be most appropriate for network success, implementing and managing the structure and recognizing when structure should change based on network and participant needs. Digital platforms have a strong role in shaping the behaviour and sustainability of collaboration in the network. One research line along these needs is to create design knowledge on how digital platforms can be used instrumentally to transform networks in sustainable collaborative networks. Another research line is focused

on global supply networks. Current research includes information management for risk management in supply-chains and the design supply networks towards increasing the technological capabilities of regions.

Knowledge and Collaboration Management in collaborative networks: Successful management of enterprise networks strongly depends on the ability of the network members to collaborate towards solving increasingly complex problems. If it is consensual that collaboration is a means to an end, it is not the case in what concerns to how collaboration should be governed within a network. Collaboration nowadays is intertwined with powerful information and communication (digital) platforms whose diversity poses demanding problems of socio-technical optimisation. The research topics addressed in this line are (i) new concepts for the design of collaborative spaces for decision making involving complex information and sense making; (ii) new concepts, models, methods and tools for information and knowledge management in collaborative networks and (iii) to explain information behaviour and knowledge representation processes in collaborative networks.

Business Models and Processes Design: The sharing economy enabled the creation of new business models that leveraged scattered knowledge and spare capacities linked through websites. The objective of this research line is to extend this concept to industry, by studying novel business models for product-services systems that tap into the under-utilized prototyping and manufacturing capacity. The implementation of these business models requires enhanced collaboration and information exchange among the members of the extended value chain to map the existing technology infrastructure, spare capacity, and scattered knowledge.

Business Analytics and Decision Support Systems

Business Analytics and Decision Support Systems research domain involves three research lines: Manufacturing Intelligence and Analytics Systems, Performance Management Systems and Decision Support Systems.

Manufacturing Intelligence and Analytics Systems: As IoT becomes more predominant the need for process improvement based on data arises naturally. Research in this line deals with the application and adaptation of traditional machine learning and data mining methods to the opportunities and challenges raised in this context, including new application areas (e.g. predictive performance management systems and predictive maintenance), new algorithms (e.g. anomaly detection methods) and integration with other approaches (e.g. with simulation and optimization, to design flexible maintenance planning solutions). Recommender systems are another important topic that includes the use spatial context data (from general space coordinates to business-specific information such as the closest shelf to the customer) and product characteristics (e.g. colour of fashion product).

Performance Management Systems: There is an increasingly important challenge for manufacturing organizations to find the strategic decisions that best fit the underlying organization complexity, and the need to evaluate the impact that the strategic decisions will have in the future performance. Research in this line addresses the development of hybrid methods for improved performance management, focusing on exploring the use of hybrid simulation approaches to predict the operational performance, namely for quantifying the impact of operational decisions in the future system's performance. Hybrid approaches, with combined qualitative and quantitative methods, allow for a better understanding of the past operational choices made by the manufacturing organization and of the decisions the organization intends to make in the future. These approaches also help to predict how future operational choices will impact the system's performance.

Decision Support Systems: The ever-growing utilization of more advanced business analytics approaches, along with sophisticated optimization and simulation tools, naturally creates the need for integrated and innovative forms of Decision Support Systems (DSS), that will hopefully complement quantitative methods and algorithms with an active "participation" of human decision-makers. Interfaces design and other ways to address the "human dimension" in DSS development is still an important research topic world-wide. Related with the latter, another important research topic is the use of DSS in a multiple decision-maker environment, including collaborative planning and decision-making processes. It is key to make use of novel collaborative planning methods, that provide a fair distribution of the benefits generated by the collaboration.

Transport, Logistics and Mobility

Transport, Logistics and Mobility is a new domain research at CESE, arising from the challenges that globally distributed industrial organisations and networks pose. It encompasses three research lines, from the natural extension of logistics to the application of CESE's expertise in simulation, optimizations and information and knowledge management.

Transportation Systems and Logistics: Modern manufacturing and supply networks are becoming more and more complex, geographically distributed and fragmented. This is the natural result of the increasing complexity of products and the benefits of specialization associated with new, more efficient forms of collaboration. Sophisticated, complex products involve quite disperse manufacturing and logistic actors, with a huge component of moving raw materials, parts and components, and therefore with a higher role of transportation systems and logistics. Due to this complexity, research in this area is obviously of a multi-disciplinary nature, and with quite dynamic demand patterns, uncertainty (at different levels and with different sources) becomes an important factor to consider in the design or operation of logistic services.

Urban Logistics and Mobility: Mobility of people in urban and metropolitan areas has an enormous importance in the organization of cities and in the quality of life. Huge costs are involved in daily commuting, with a large weight for private cars. Environmental impacts of transport in cities are also at an unacceptable level. Better designing and operating transport services is therefore critical, especially in a time when demand patterns are more and more diverse, and when inter-modality is the basis of urban mobility. Still in the city context, in urban logistics multiple interesting research topics have emerged, to design more efficient services and to better manage operations.

Intelligent Transportation Systems: Embedded "intelligence" in vehicles and in transportation systems has since a long time been an important topic of research, from different perspectives and in various scientific disciplines. However, recent, extraordinary technological advances have created a still more promising landscape for multi-disciplinary research, particularly concerning urban mobility systems. Sensors networks, the co-creation of knowledge, information sharing, big data, or the Internet-of-Things paradigm, are creating the ground for new, promising research projects, strongly aligned with the interests and competences of CESE.

5.6.3 Technology transfer

An important part of the Centre's mission is dedicated to provide innovative, high value-added technology based services to industrial companies and networks. These services are sustained by the RTD activities described above.

A major priority of CESE is to transfer to IT companies - technology up takers - the knowledge and technology resulting from the RTD activities undertaken in the scope of the research domains. For this purpose, the collaborative projects commonly include at least one technology up taker company with interest in the commercial exploitation of the research results generated in the project. However, additional actions are needed for successful transfer of the technology related with manufacturing systems planning, including

- new collaborative research projects to produce market-ready products based on CESE research results;
- new commercial agreements with technology up takers, foreseeing the royalties schema related with the CESE property rights over the exploitable results;
- support to the commercialization efforts of our partners technology up takers, including the parameterization of the CESE developed modules to new clients/end-users as pre-selling initiatives; or adapting the CESE modules to evolving needs of existing end-users. An example is the long-lasting relationship with developers of ERP systems, that incorporate our research results and gives us access to large final clients; partnerships with MES/MOM providers are also being done; and
- initiatives to disseminate research results and seek for new partnerships with technology up takers and end-users, including the participation in sectorial associations, such as Produtech and AIFF and the participation in national and international fairs and seminars.

The more active areas of knowledge and technology transfer and services providing are the following:

Manufacturing Systems Management: Consultancy services in Manufacturing Systems Design including conceptual and functional design of resource-efficient factories, modelling and simulation of manufacturing systems and resource-constrained production processes, development of ICT solutions for designing and managing high-performance manufacturing systems. Business Processes Management as well as Information Systems specification and implementation management are also an important share of the services provided in this area. The Centre is also beginning to provide services at a more strategic level regarding operations and

technology management. An example is a strategic roadmap for Industry 4.0 developed for a sectorial association.

Logistics Systems: The Centre develops intra and inter-organisational logistics systems. Furthermore, it provides services to enable companies to integrate IoT components and orchestrate manufacturing modules, such as planning, scheduling, balancing with internal logistics to increase the flexibility of the manufacturing systems. In the inter-organisational area, novel methods for transportation/distribution planning, combined with other upstream and downstream supply chain processes. Examples are applications in biomass and wood-based products distribution across forest-based supply chains. CESE also develops multi-disciplinary approaches (based on advanced decision support tools) to design transport networks or inter-modal logistic solutions, integrated in broader distributed manufacturing systems. This includes problems such as: fleet sizing and management; vehicle routing planning (for product distribution or collection); or the design of logistic networks.

Digital platforms for networks and supply chains: Levered in the research domain of Collaborative Networks and Supply-Chains, the Centre is providing consultancy and development services on digital platforms for managing several types of collaborative networks. Contracts are being made with enterprise associations and sectorial clusters to develop collaborative platforms for managing information, communication and collaboration together with networks and collaboration governance models. The distinctive aspect of the Centre's offer is the integrated approach to network governance and digital platform development.

Business Intelligence: The research line Manufacturing Intelligence and Analytics Systems together with the research in Enterprise and Industrial ICT domain is producing results that are being used to setup services in Business Intelligence for several types of organizations. Furthermore, recommender systems are now raising interest on several industrial companies, mainly in the areas of predictive maintenance and performance and customer oriented services.

Urban Mobility: CESE provides consultancy services and develop customized decision support systems to help municipalities, authorities, public agencies, transport operators, and logistic providers, in designing and managing transport and logistics services. Specific services and decision support tools can be designed for urban mobility, based on the principles and techniques of data science, knowledge management, optimization and simulation, or multi-criteria analysis. Particularly interesting applications can be developed in areas such as: demand responsive transport (DRT) services; vehicle and crew scheduling systems; demand data management; urban logistics services.

Construction Information and Knowledge Management: The lifecycle management of large civil construction buildings and facilities requires complex computer information systems the deal simultaneously with teamwork over the internet, relational and non-relational data, large datasets, synchronous and asynchronous document generation, certification, tight security, among others. Having developed and worked more than a decade with conventional multi-tier applications, we became aware of some of its limitations and we're now developing a novel architecture and framework that will allow fast development of new apps and streamline the access and treatment of information. Consultancy services in this area are being provided to the Portuguese central administration.

5.6.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CESE – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Areas of Technology Transfer --> relationships (3)						
		Status (2)	Manufacturing Systems Management	Logistics Systems	Digital Platforms for Networks and Supply Chains	Business Intelligence	Urban Mobility	Construction Information and Knowledge Management
Manufacturing and Services Operations Management		I	H	M	L	L	M	L
Enterprise and Industrial ICT		I	H	M	M	H	L	H
Collaborative Networks and Supply Chain		I	M	L	H	L	M	M
Business Analytics and Decision Support Systems		I	H	M	L	H	M	L
Transport, Logistics and Mobility		I	M	H	L		H	
Other areas (1)	CEGI	O	M	H	M	H	H	L
	CRIIS	O	M	H	L	L	L	L
	CITE	O	M	L	H	M	L	M
	LIAAD	O	L	L	M	H	L	M
	CSIG	O	L	L	H	H	L	H

1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer

(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership

(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.6.5 Main Achievements in 2016

In the research and technology development area, two achievements must be highlighted:

One of the achievements was the completion of the first research programme — SmartSL — with KYAIA, a company in the footwear sector. Under this programme, research results such as new sequencing and production balancing techniques were achieved and used to develop an innovative system for the management of stitching departments. This solution takes the production of footwear to a next step, managing efficiently resources, increasing the production, reducing the lot and producing faster. INESC TEC with KYAIA own the property rights and in 2016 already sold 3 licenses.

The second achievement in the research area was the organization of the 17th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2016, Porto, Portugal, October 3-5. This is the main international conference in the area of collaborative networks. This scientific event gathered approximately 70 international specialists from several disciplines.

In the technology transfer area the main achievement has been the consolidation of simulation-centered advanced consulting services. Levered on the IKEA service contracts, CESE was able to build a highly qualified team and develop a specific methodology for factory layout design. With this team and approach, CESE became the main partner of IKEA for layout design and planning.

5.6.6 Centre Organizational Structure and Research Team

The Centre for Enterprise Systems Engineering is coordinated by Américo Azevedo and António Lucas Soares and is organized in the following Areas:

- Manufacturing and Services Operations Management – Responsible: Américo Azevedo and Alexandra Marques
- Enterprise and Industrial ICT – Responsible: César Toscano
- Collaborative Networks and Supply Chains – Responsible: António Lucas Soares and Ana Barros
- Business Analytics and Decision Support Systems – Responsible: Carlos Soares
- Transport, Logistics and Mobility – Responsible: Jorge Pinho de Sousa

The Centre has a coordination board and a scientific board that assist the coordinators.

Table 5.2 - CESE – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	12	12	12	
		Academic Staff	11	11	11	
		Grant Holders and Trainees	32	33	33	
		Total Core Researchers	**55**	**56**	**56**	
	Affiliated Researchers		3	4	4	
	Admin. & Tech	Employees	2	2	2	
		Grant Holders and Trainees				
	Total Integrated HR		**60**	**62**	**62**	
	Total Integrated PhD		**18**	**22**	**19**	**-3**
Curricular Trainees			4	9	7	-2
External Research Collaborators			8	5	8	3
External Administrative and Technical Staff						
External Students					1	1
Total			**72**	**76**	**78**	**2**

5.6.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CESE – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	37	63	76	13
PN-PICT	National R&D Programmes - S&T Integrated Projects	135	126	101	-26
PN-COOP	National Cooperation Programmes with Industry	292	129	118	-11
PUE-FP	EU Framework Programmes	359	449	391	-58
PUE-DIV	EU Cooperation Programmes - Other	28	77	108	31
SERV-NAC	R&D Services and Consulting - National	449	435	259	-176
SERV-INT	R&D Services and Consulting - International	93	44	58	15
OP	Other Funding Programmes			37	37
Closed Projects		13	48	41	-7
	Total Funding	**1.405**	**1.370**	**1.187**	**-183**

Table 5.4 - CESE – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	11	12	18
International conference proceedings indexed by ISI, Scopus or DBLP	19	21	38
Books (author)			
Chapter/paper in books	4	4	3
PhD theses concluded by members of the Centre	4	2	4
Concluded PhD theses supervised by members of the Centre		3	5

Table 5.5 - CESE – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	1
Software copyright registrations	1
Patent applications	

Table 5.6 - CESE – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	12
Participation in events such as fairs, exhibitions or similar	7
Advanced training courses	

5.6.8 List of Projects

Table 5.7 - CESE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	E2Web	Ana Barros	01-06-2014	31-05-2018
PN-FCT	VR2Market-1	Ana Barros	15-07-2014	14-07-2018
PN-FCT	EasyFlow	Alexandra Sofia Marques	01-06-2016	31-05-2019
PN-FCT	DM4Manufacturing-1	César Toscano	01-11-2016	31-10-2019
PUE-DIV	MANTIS	Hugo Ferreira	01-05-2015	30-04-2018
PN-COOP	FASCOM	Rui Diogo Rebelo	01-10-2015	30-09-2017
PN-PICT	iMAN	Américo Azevedo	01-07-2015	30-06-2018
PN-COOP	PrecisionCork	Américo Azevedo	15-05-2016	14-10-2018
PN-COOP	3GEnergy	António Lucas Soares	01-09-2016	31-08-2018
PN-COOP	ADIRA_I4.0	António Correia Alves	01-09-2016	31-08-2019
PN-COOP	AdaptPack	Américo Azevedo	01-09-2016	31-08-2019
PN-COOP	ATM	António Correia Alves	01-09-2016	28-02-2018
PN-COOP	MAPPLE	António Correia Alves	01-09-2016	28-02-2018
PUE-FP	FOCUS	Alexandra Sofia Marques	01-01-2014	30-06-2016
PUE-FP	STAMINA-1	César Toscano	01-10-2013	31-03-2017
PUE-FP	EU-GREAT	Luís Carneiro	01-01-2015	31-12-2016
PUE-FP	WMF2015	Luís Carneiro	01-02-2015	31-07-2016
PUE-FP	BEinCPPS	César Toscano	01-10-2015	30-09-2018
PUE-FP	Futuring	Luís Carneiro	01-09-2016	28-02-2018
SERV-INT	IzaroGrey	António Correia Alves	01-01-2007	

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	ParqueEscolar	Luís Guardão	01-11-2009	31-12-2017
SERV-NAC	ProdExport	António Correia Alves	01-07-2013	31-03-2016
SERV-NAC	Cap@CIDADE	António Lucas Soares	04-08-2014	30-09-2016
SERV-NAC	SmartSL	Rui Diogo Rebelo	01-07-2015	31-08-2016
SERV-NAC	ProGrow	Pedro Ribeiro	14-08-2015	30-06-2016
SERV-NAC	TimeWriting	Luís Carneiro	16-05-2016	30-09-2016
SERV-NAC	PlantSetup	Samuel Moniz	01-05-2016	30-04-2017
SERV-NAC	FlexLayout	Rui Diogo Rebelo	06-04-2016	31-10-2016
SERV-NAC	CMLDM	Carlos Soares	16-05-2016	15-05-2017
SERV-NAC	BI4UP2	António Lucas Soares	01-08-2016	31-03-2017
SERV-NAC	MESAI	Rui Diogo Rebelo	12-11-2016	31-01-2017
SERV-NAC	SmartRetail	Rui Diogo Rebelo	13-12-2016	12-12-2017
SERV-INT	EasyManufacturing	Samuel Moniz	05-07-2016	30-09-2016
SERV-INT	ROGER	Samuel Moniz	05-12-2016	04-02-2017
SERV-NAC	Consultoria	Luís Carneiro	01-01-2009	
OP	PRO-VE'16	António Lucas Soares	01-02-2016	31-12-2016

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.6.9 List of Publications

International Journals with Scientific Referees

1. Almeida, A, Bastos, J, Francisco, RDP, Azevedo, A, Ávila, P, "Sustainability assessment framework for proactive supply chain management", International Journal of Industrial and Systems Engineering, vol.24, no.2, pp.198-222, 2016
2. Bandeira, JM, Carvalho, DO, Khattak, AJ, Rouphail, NM, Fontes, T, Fernandes, P, Pereira, SR, Coelho, MC, "Empirical assessment of route choice impact on emissions over different road types, traffic demands, and driving scenarios", International Journal of Sustainable Transportation, vol.10, no.3, pp.271-283, 2016
3. Borrego, C, Amorim, JH, Tchepel, O, Dias, D, Rafael, S, Sa, E, Pimentel, C, Fontes, T, Fernandes, P, Pereira, SR, Bandeira, JM, Coelho, MC, "Urban scale air quality modelling using detailed traffic emissions estimates", Atmospheric Environment, vol.131, pp.341-351, Apr, 2016

4. Costa, E, Soares, AL, de Sousa, JP, "Information, knowledge and collaboration management in the internationalisation of SMEs: A systematic literature review", International Journal of Information Management, vol.36, no.4, pp.557-569, Aug, 2016

5. de Sa, CR, Soares, C, Knobbe, A, "Entropy-based discretization methods for ranking data", Information Sciences, vol.329, pp.921-936

6. Fernandes, P, Bandeira, JM, Fontes, T, Pereira, SR, Schroeder, BJ, Rouphail, NM, Coelho, MC, "Traffic restriction policies in an urban avenue: A methodological overview for a trade-off analysis of traffic and emission impacts using microsimulation", International Journal of Sustainable Transportation, vol.10, no.3, pp.201-215

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10. Krueger, V, Chazoule, A, Crosby, M, Lasnier, A, Pedersen, MR, Rovida, F, Nalpantidis, L, Petrick, R, Toscano, C, Veiga, G, "A Vertical and Cyber-Physical Integration of Cognitive Robots in Manufacturing", Proceedings of the IEEE - Proc. IEEE, pp.1-14, 2016

11. Lopes, MA, Soares, C, Almeida, A, Almada Lobo, B, "Comparing comparables: an approach to accurate cross-country comparisons of health systems for effective healthcare planning and policy guidance", Health Systems, vol.5, no.3, pp.192-212, Oct

12. Putnik, G, Costa, E, Alves, C, Castro, H, Varela, L, Shah, V, "Analysing the correlation between social network analysis measures and performance of students in social network-based engineering education", International Journal of Technology and Design Education, vol.26, no.3, pp.413-437, Aug

13. Ramos, P, Oliveira, JM, "A Procedure for Identification of Appropriate State Space and ARIMA Models Based on Time-Series Cross-Validation", ALGORITHMS, vol.9, no.4, pp.76, Dec

14. Shamsuzzoha, A, Toscano, C, Carneiro, LM, Kumar, V, Helo, P, "ICT-based solution approach for collaborative delivery of customised products", Production Planning & Control, vol.27, no.4, pp.280-298

15. Sousa, AFM, Prudêncio, RBC, Ludermir, TB, Soares, C, "Active learning and data manipulation techniques for generating training examples in meta-learning", Neurocomputing, vol.194, pp.45-55

16. Sousa, CD, Soares, AL, Pereira, CS, "Collaborative conceptualisation processes in the development of lightweight ontologies", VINE Journal of Information and Knowledge Management Systems, vol.46, no.2, pp.175-193

17. Torrao, G, Fontes, T, Coelho, M, Rouphail, N, "Integrated indicator to evaluate vehicle performance across: Safety, fuel efficiency and green domains", Accident Analysis and Prevention, vol.92, pp.153-167

18. Vieira, Miguel, Varela, TaniaPinto, Moniz, Samuel, Póvoa, AnaPaulaF.D.Barbosa, Papageorgiou, LazarosG., "Optimal planning and campaign scheduling of biopharmaceutical processes using a continuous-time formulation", Computers & Chemical Engineering, vol.91, pp.422-444, 2016

International Conference Proceedings with Scientific Referees

1. Arrais, R, Oliveira, M, Toscano, C, Veiga, G, "A Hybrid Top-Down Bottom-Up Approach for the Detection of Cuboid Shaped Objects", Image Analysis and Recognition (ICIAR 2016), vol.9730, pp.512-520

2. Azevedo, MM, Crispim, JA, de Sousa, JP, "Layout Design and Reconfiguration in a Collaborative Manufacturing Network", Collaboration in a Hyperconnected World, vol.480, pp.545-556

3. Barbosa, C, Azevedo, A, "Evaluation of improvement actions impact on manufacturing operational performance", IEEE International Conference on Industrial Engineering and Engineering Management, vol.2016-January, pp.952-956

4. Bastos, J, Azevedo, A, Avila, P, "A Lean Set-Based Design Approach for Development of Customizable Products in Collaborative Networks", Collaboration in a Hyperconnected World, vol.480, pp.420-432

5. Borges, MA, Soares, AL, Dandolini, GA, "Collaborative Networks as Ways to Improve Cross-sector Collaboration in Social Innovation: an Exploratory Study", Collaboration in a Hyperconnected World, vol.480, pp.137-147

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7. Costa, A, Cunha, T, Soares, C, "AToMRS: A Tool to Monitor Recommender Systems", KDIR: Proceedings of The 8th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management - Vol. 1, pp.133-140

8. Costa, E, Soares, AL, de Sousa, JP, "Situating Case Studies Within the Design Science Research Paradigm: an Instantiation for Collaborative Networks", Collaboration in a Hyperconnected World, vol.480, pp.531-544

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11. de Sa, CR, Duivesteijn, W, Soares, C, Knobbe, A, "Exceptional Preferences Mining", Discovery Science, (DS 2016), vol.9956, pp.3-18

12. Felix, C, Soares, C, Jorge, A, "Can Metalearning Be Applied to Transfer on Heterogeneous Datasets?", Hybrid Artificial Intelligent Systems, vol.9648, pp.332-343

13. Fernandes, JD, Crispim, J, "The construction process of the synthetic risk model for military shipbuilding projects in Brazil", International Conference on Enterprise Information Systems/International Conference on Project Management/International Conference on Health and Social Care Information Systems and Technologies, CENTERIS/PROJMAN / HCIST 2016, vol.100, pp.796-803

14. Ferreira, F, Faria, J, Azevedo, A, Marques, AL, "Industry 4.0 as Enabler for Effective Manufacturing Virtual Enterprises", Collaboration In A Hyperconnected World, vol.480, pp.274-285

15. Ferreira, F, Faria, J, Azevedo, A, Marques, AL, "Product Lifecycle Management Enabled by Industry 4.0 Technology", Advances In Manufacturing Technology XXX, vol.3, pp.349-354

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17. Ferreira, F, Marques, AL, Faria, J, Azevedo, A, "Large project management in the automotive industry: A flexible and knowledge based approach", Advances in Intelligent Systems and Computing, vol.444, pp.455-464

18. Inomata, DO, Costa, E, Mazzaroto, S, Santos, C, Barros, AC, Soares, AL, Varvakis, G, "Knowledge Sharing in Industrial Associations and Science and Technology Parks", Collaboration in a Hyperconnected World, vol.480, pp.60-72

19. Lopes, T, Fernandes, P, Barbosa, A, Pereira, C, "Personnel scheduling The starting point for solving real cases", 2016 11th Iberian Conference on Information Systems and Technologies (CISTI)

20. Maia, A, Cunha, T, Soares, C, Abreu, PH, "TweeProfiles3: Visualization of Spatio-Temporal Patterns on Twitter", New Advances in Information Systems and Technologies - Volume 1 [WorldCIST'16, Recife, Pernambuco, Brazil, March 22-24, 2016]., vol.444, pp.869-878, 2016

21. Messina, D, Barros, AC, Soares, AL, "An Information Management Perspective of Supplier Selection Process in Manufacturing Networks", Collaboration in a Hyperconnected World, vol.480, pp.178-188

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29. Romero, F, Costa, E, "Social Network Analysis and the Study of University Industry Relations", Proceedings of the 11th European Conference on Innovation and Entrepreneurship, pp.654-661

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31. Saleiro, P, Gomes, L, Soares, C, "Sentiment Aggregate Functions for Political Opinion Polling using Microblog Streams", Proceedings of the 9th International C* Conference on Computer Science & Software Engineering, C3S2E '16, Porto, Portugal, July 20-22, 2016, vol.20-22-July-2016, pp.44-50

32. Saleiro, P, Soares, C, "Learning from the News: Predicting Entity Popularity on Twitter", Advances In Intelligent Data Analysis XV, vol.9897, pp.171-182

33. Saleiro, P, Teixeira, J, Soares, C, Oliveira, EC, "TimeMachine: Entity-Centric Search and Visualization of News Archives", Advances in Information Retrieval - 38th European Conference on IR Research, ECIR 2016, Padua, Italy, March 20-23, 2016. Proceedings, vol.9626, pp.845-848

34. Santos, C, Araújo, M, Correia, N, "Group support systems features and their contribution to technology strategy decision-making: A review and analysis", Advances in Intelligent Systems and Computing, vol.490, pp.595-605

35. Santos, C, Barros, AC, Dawes, T, Soares, AL, "Using an Information Management Model as a Roadmap for Information Systems Implementation in Supply Networks", Collaboration in a Hyperconnected World, vol.480, pp.73-83

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37. Sobral, T, Costa, V, Borges, J, Fontes, T, Galvao, T, "OBAVUM: An Ontology-based Approach to Visualizing Urban Mobility Data", Proceedings of 2016 IEEE International Conference on Big Data Analysis (ICBDA), pp.206-211

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Books

Blank

Chapter/Paper in Books

1. Costa, E, De Sousa, JP, Soares, AL, Jamil, GL, "Information management for network transformation in industrial enterprises associations: The case of the internationalization process", Handbook of Research on Information Management for Effective Logistics and Supply Chains, pp.415-436
2. Marques, CM, Moniz, S, de Sousa, JP, Barbosa Póvoa, AP, "Optimization and Monte Carlo Simulation for Product Launch Planning under Uncertainty", Computer Aided Chemical Engineering, vol.38, pp.421-426
3. Messina, D, Soares, AL, Santos, C, Barros, AC, "Risk and visibility in supply chains: An information management perspective", Handbook of Research on Information Management for Effective Logistics and Supply Chains, pp.34-57

Publications (Editor)

1. Afsarmanesh, H, Camarinha-Matos, LM, Lucas Soares, A, "Collaboration in a Hyperconnected World", IFIP Advances in Information and Communication Technology
2. Boström, H, Knobbe, AJ, Soares, C, Papapetrou, P, "Advances in Intelligent Data Analysis XV – 15th International Symposium, IDA 2016, Stockholm, Sweden, October 13-15, 2016, Proceedings", IDA, vol.9897
3. Jamil, GL, Soares, AL, Pessoa, CRM, "Handbook of research on information management for effective logistics and supply chains", Handbook of Research on Information Management for Effective Logistics and Supply Chains, pp.1-554

Dissertations (PhD)

1. Greenfield, R., "On the development of network commitment in top-down innovation networks: Towards a practical framework for network creation and sustained development";
2. Nozari, M., "Architectural Aspects of Sensing Applications for Vehicular Networks: from Data Collection to Data Model Management";
3. Sá, C., "Pattern Mining for Label Ranking";
4. Simões, A., "Contributions to the development of a performance measurement framework for Hospital Centres".

5.7 CRIIS - CENTRE FOR ROBOTICS IN INDUSTRY AND INTELLIGENT SYSTEMS

Coordinator: António Paulo Moreira

5.7.1 Presentation of the Centre

CRIIS accomplishes its mission, within the Cluster I+I - Industry and Innovation, by designing and implementing innovative solutions within the areas of industrial robotics and intelligent systems.

The Centre works in close cooperation with Companies, other INESC TEC Centres and other Institutes and Universities, following the lemma from Research and Development to Innovation, passing through Design, Prototyping and Implementation.

5.7.2 Research and Technology Development

Navigation and Localization of Mobile Robots
Industrial and indoor robotics, industrial robotic manipulators, Automated Guided Vehicles (AGVs), navigation solutions for indoor and outdoor environments.

The Centre for Robotics in Industry and Intelligent Systems (CRIIS) develops mobile robotic systems that can be applied in industry, indoor and outdoor environments.

Intelligent Sensors and Control of Dynamical Systems
Research in Dynamics and Control can be applied in several systems from robots to industrial process and is crucial to the efficient control and design of complex and optimized systems. Using the mathematics and physics laws, we build a model based approach, namely model based predictive controllers, and apply it to a wide range of systems from process control to robotics and industrial production lines. To have a correct and cost-effective monitoring and control the use of sophisticated sensors is mandatory. The development of smart-sensors, software-sensors and networked sensors is also a main research topic for CRIIS.

2D/3D Industrial Vision and Advanced Sensing
Sensing is a key component on modern industrial robotics systems. The advent of 3D point-cloud based perception systems opens a wide variety of opportunities to deal not only with dynamic environments, where parts are placed in unknown places, but also to deal with robot accuracy limitations and part dimensional deviations. Furthermore the widespread use of different sensing technologies, including force-sensing, laser range finders or sonar, for example, are key element in the development of upcoming robotics systems. The research line followed by the Centre is focused on the development of algorithms tailored for industrial use, robotics in particular, with special emphasis on multimodal sensor fusion, integrated machine learning, active perception among others.

Mobile Manipulators
During the last years, the Centre had a strong focus on the development of Mobile Manipulators. These robotics systems present high flexibility and are particularly adapted to the needs existing production systems, where layout reconfiguration are difficult. The application of such systems goes from internal logistics to novel applications such as on-site construction. This research line had been developed in with extensive international collaborations in the context of 3 European projects (FP7 - CARLoS, FP7- STAMINA and H2020 ColRobot) with reference end-users such as PSA - Peugeot Citroen, Renault or Thales-Alenia Aerospace. For the upcoming years, the goal is to push the mobile manipulators systems closer full production systems, either through the development of basic technologies, but also the development of higher TRL projects namely through the application of the previous developments industrial settings.

Special Structures and Architectures for Robots
Many robotics applications still require novel robotic structures to fulfil its requirements. The unit has experience in the development of completely new robotics structures, such as cable robots p.e., and will continue to explore such systems with novel robotic systems in mind.

Human Robot Interfacing and Augmented Reality
Together with machine vision, human robot interfacing is a key element on the development of flexible robotics systems. Although a topic of extensive research in the past, also by the Centre, the potential of applications unleashed by the human intervention in robotic systems is still very significant. The approach will explore previous developments on Programming-by-demonstration, CAD based programming but will put a strong emphasis on techniques for uncertainty handling on robotic systems, namely through the combination of augmented reality (projection mapping) in which the Centre have proven expertise.

Future Industrial Robotics and Collaborative Robots
Future industrial robotics will move from a robot centred perspective of a robotics work cell, to an integrated approach that involves perception, multiple sources of information (either sensors of IT support systems), close collaboration with humans and continuous process learning. This requires a multidisciplinary work that includes the above-mentioned development of Human Robot interfaces and advanced 2D 3D sensing but also the in depth evaluation of the strengths and weaknesses of the use of use of safe collaborative robots.

Collaborative robotics are commonly evaluated as a game-changing technology in the future of industrial robotised operations. However, for these robots to be used spread out in industry, there is still the need for applied research applications that would show the success of the concept. The research approach will be the development of accessing tools that include the safety analysis of the according to the ISO technical standard 15066 and the related norms ISO 10218-1, and also on the economic analysis of the use of such systems.

Vertical Integration, IoT, Industry 4.0
The success of industrial and mobile robotics application is heavily dependent on the integration with the connected factory of the future. In this regard the unit will further develop the use development of integration tools with a network of partners, namely within INESC TEC with the CESE and CEGI Centres. The role of robotics in the Industry 4.0 is an open challenge that requires a change of approach from a work-cell integration to a factory or even inter-factory level integration. In a connected factory scenario, advanced mobile robots play a differentiated role from other Industry 4.0 actors, namely due to the advanced sensing capabilities, CPU/GPU processing power inherent to the robot. Therefore, in the mobile robotics sector, the approach will explore the concept of a robot as a mobile sensor that can dynamically populate the digital shadow of the manufacturing plant. Concerning collaborative robots, the approach will explore the impact of such systems in the upper layers of the connected factory, namely through the development of decision-making strategies that consider the new capabilities/limitations of collaborative robots and their balance with the human operators. The Centre previous experience in vertically integrated projects, namely the STAMINA project, is the foundation for Centre offer of consultancy services.

5.7.3 Technology transfer

Internal Logistics
The Centre has a strong activity in internal logistic system that goes from the development of simple AGV systems in partnership with Portuguese companies, to the development of advanced mobile manipulators in Flagship European projects such as STAMINA and ColRobot. The Centre offers consultancy services for the installation of existing and mature robotics systems, such as the LeanAGV, but is also capable of developing novel robotics systems, namely mobile manipulators for high flexible logistics operations. The Centre developed a well-proven network of competences, both internally at INESC TEC as well as with external companies, that provides the Centre with the capabilities to provide complete logistics systems that vertically integrates the robotic system in the production environment.

Robotics for Agriculture and Forestry
The Agriculture and Forestry R&D line has a 10-year road-map, considering the Portuguese reality (needs and desires) and the European Robotics agenda. It is focused in three application topics: Vineyards (Steep Slope), Forest biomass harvesting, and Greenhouses (urban and traditional). Our main efforts are concentrated to develop cost effective visual-based sensors, manipulators and small machinery with advanced localization, mapping, control and perception algorithms (where we believe that can occurs technology transference). This R&D line has started in 2015, and in 2017 we will have 2 active national projects in co-promotion with national companies/associations (Tekever, ADVID, Prodfarmer, Herdade do Esporão, Herdade Maria da Guarda) and 2 international projects in co-promotion with international companies/associations (Wageningen University &

Research, Aveleda, isardSAT, AIB University, IMAMOTER). In addition to these ongoing projects, other ones with reference institutions/companies (INIAV, Forestis, CTAG, ENERMETER, FERTIPRADO, WHITUS, HIDROSOPH, CERSUL, INCREASE and ELAIA 2) are being evaluated under P2020, POCTEP, and PDR2020 programs. We are working together with Pulverizadores Rocha, Herculano Alfaias Agrícolas, Aveleda and WiseCrop in order to set new goals and common projects. The technology transference by intellectual property, start-up/spin-off creation is targeted to the midterm of 2018.

Flexible Production using Robotics
The Centre presents a proven track record of successful robotics based Flexible production systems that were installed and transfer to the market. The use of Industrial robotic systems on SME's is a strong demand on the Portuguese and European markets, and requires novel approaches that combine Advanced sensing, human machine interfacing, high level programming, augmented reality among others. The Centre accumulated expertise in the different scientific/technological areas and a well-established network of partnerships, gives the Centre a large set of tools to answer to the most demanding challenges.

Inspection, Control and Embebed Systems
Machine vision is widely applied in quality control (non-conformity detection, dimensional control,...) using or not industrial robotics systems. Some success projects have already been developed and applied in the industry (CONTINENTAL) and other are in progress (GISLOTICA, Rail-Inspect).

The application of the control theory for Dynamics Systems is now used in a wide range of different systems, from classic process control systems to production lines and logistic systems all using similar dynamical models. With these models we use model based predictive controllers (project FOCUS).

To the efficient control, modelling and monitoring of complex and optimized systems it is mandatory the acquisition of large amounts of information (sensors data and inputs from operators) and so the development of the appropriate devices that facilitates the integration with the connected factory of the future is under progress, following the paradigms of the Industry 4.0.

New challenges in Robotics
The Centre has a strong track record on the development of novel robotics systems for new application sectors, such as Surveillance (RobVigil), Architecture and construction (RobArc) or the health sector (TriHo). The Centre broad range of expertise allows multidisciplinary approaches for the development of software and hardware customized for specific applications.

5.7.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CRIIS – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Status (2)	Areas of Technology Transfer --> relationships (3)				
		Internal Logistics	Robotics for Agriculture and Forestry	Flexible Production using Robotics	Inspection, Control and Emb. Systems	New challenges in Robotics
Navigation and Localization of Mobile Robots	I	H	H	H	L	M
Intelligent Sensors and Control of Dynamical Systems	I	L	H	M	H	M
2D/3D Industrial Vision and Advanced Sensing	I	L	H	H	H	H
Mobile Manipulators	I	H	H	H	L	H
Special Structures and Architectures for Robots	I	L	M	H	M	H
Human Robot interfacing and Augmented Reality	I	L	M	H	M	H

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)				
			Internal Logistics	Robotics for Agriculture and Forestry	Flexible Production using Robotics	Inspection, Control and Emb. Systems	New challenges in Robotics
Future Industrial Robotics and Collaborative Robots		I	M	L	H	M	H
Other areas (1)	Vertical Integration, IoT, Industry 4.0 (CESE, CEGI)	O	H	M	H	H	H

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.7.5 Main Achievements in 2016

In terms of industrial visibility and dissemination, the Centre had in 2016 two important moments, the AUTOMATICA trade fair and the EMAF. The AUTOMATICA trade fair is held each two years in Munich, and is the main event in the world in terms of Industrial and Service Robotics. In 2016, INESC TEC had a strong presence at AUTOMATICA, with robots present in 3 booths, showing results from 3 European Projects: the developed in the FP7 CARLoS, FP7 STAMINA and FP7 SMERobotics. In November 2016 the biggest national industrial trade fair took place at Exponor, EMAF, and the CRIIS robots have been shown in 3 different booths: (1) The STAMINA robot at the INESC TEC booth, the LeanAGV at the PRODUTECH booth in partnership with ANTIPODA and finally the CoopWeld Robot was shown at SARKKIS Robotics. Two of these robots were awarded the 1st and 2nd prize in the EMAF/Robotica innovation award.

In the Robotics for Agriculture and Forestry application field, the Centre has proposed eleven projects and got four projects approved (two national SmartFarming, ROMOVI and two international Agrisensus and Water4Ever). This will allow to reach the first goal of our Agriculture and Forestry robotics roadmap, propose advanced solutions for agricultural monitoring systems. The Centre/INESC TEC received a special invitation for the participation on the agricultural fair AgroGlobal 2016 (The biggest technology fair in Portugal) and got more than a dozen of articles on the main national media (referring the Agrob V14 and Agrob V16 platforms). This type of news will make INESC TEC a national reference on robotics R&D for Agriculture and Forestry application.

5.7.6 Centre Organizational Structure and Research Team

The Centre for Robotics in Industry and Intelligent Systems is coordinated by António Paulo Moreira and is organized in the following Areas:

- Navigation and Localization of Mobile Robots - Responsible: Paulo Costa / Héber Sobreira
- Collaborative Robots - Responsible: J. Lima / Luis Rocha
- Intelligent Sensors and Control of Dynamical Systems - Responsible: J. Boaventura / Filipe Santos
- 2D/3D Industrial Vision - Responsible: Hélio Mendonça / Luís Rocha
- Mobile Manipulators – Responsible: Germano Veiga / Héber Sobreira
- Special Structures and Architectures for Robots – Responsible: Manuel Silva / Filipe Santos
- Human Robot Interfacing - Responsible: Germano Veiga / Rafael Arrais
- Future Industrial Robotics - Responsible: Pedro Costa / Germano Veiga
- Vertical Integration, IoT, Industry 4.0 – Responsible: Hélio Mendonça / Rafael Arrais

The Centre research team present composition and evolution is presented in Table 5.2. The Centre was established in 2016 as a split from the previous Centre CROB (Centre for Robotics and Intelligent Systems) – figures for 2015 apply for the group within CROB that emerged as CRIIS.

Table 5.2 - CRIIS – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees		3	3	
		Academic Staff		20	21	1
		Grant Holders and Trainees		10	15	5
		Total Core Researchers		**33**	**39**	**6**
	Affiliated Researchers					
	Admin. & Tech	Employees		2	2	
		Grant Holders and Trainees		1	1	
	Total Integrated HR			**36**	**42**	**6**
	Total Integrated PhD			**24**	**26**	**2**
Curricular Trainees					1	1
External Research Collaborators				3	5	2
External Administrative and Technical Staff					1	1
External Students				4	4	
Total				**43**	**53**	**10**

5.7.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CRIIS – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT			4	4
PN-PICT	National R&D Programmes - S&T Integrated Projects			63	63
PN-COOP	National Cooperation Programmes with Industry			54	54
PUE-FP	EU Framework Programmes			313	313
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National			169	169
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes				
Closed Projects				54	54
Total Funding				**657**	**657**

Table 5.4 - CRIIS – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP		22	27
International conference proceedings indexed by ISI, Scopus or DBLP		79	62
Books (author)		1	1
Chapter/paper in books		3	6
PhD theses concluded by members of the Centre			
Concluded PhD theses supervised by members of the Centre		4	5

Table 5.5 - CRIIS – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	1
Software copyright registrations	1
Patent applications	

Table 5.6 - CRIIS – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	18
Participation in events such as fairs, exhibitions or similar	6
Advanced training courses	

5.7.8 List of Projects

Table 5.7 - CRIIS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	DM4Manufacturing	Germano Veiga	01-11-2016	31-10-2019
PN-COOP	CoopWeld	Germano Veiga	28-12-2015	27-06-2017
PN-PICT	iMAN-3	António Paulo Moreira	01-07-2015	30-06-2018
PN-COOP	PrecisionCork-1	Hélio Mendonça	15-05-2016	14-10-2018

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-COOP	AdaptPack-1	Manuel Santos Silva	01-09-2016	31-08-2019
PUE-FP	STAMINA	Germano Veiga	01-10-2013	31-03-2017
PUE-FP	FOCUS-1	José Boaventura	01-01-2014	30-06-2016
PUE-FP	CLARISSA	Germano Veiga	01-01-2014	30-06-2016
PUE-FP	ColRobot	Germano Veiga	01-02-2016	31-01-2019
SERV-NAC	AutoClassII	António Paulo Moreira	01-01-2015	31-10-2017
SERV-NAC	RAIL_INSPECT	António Paulo Moreira	01-01-2016	30-04-2017
SERV-NAC	TEXTILPRINT	Hélio Mendonça	04-01-2016	29-11-2017
SERV-NAC	TRiHo	Germano Veiga	01-07-2016	31-03-2018
SERV-NAC	Consultoria	António Paulo Moreira	01-01-2014	

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.7.9 List of Publications

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Books

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Chapter/Paper in Books

1. Oliveira, PBdM, Pires, EJS, "Conflict Resolution Problem Solving with Bio-Inspired Metaheuristics:", Interdisciplinary Perspectives on Contemporary Conflict Resolution, pp.168-182, 2016
2. Pinho, TM, Campos, D, Boaventura-Cunha, J, Azevedo, A, Paulo Moreira, A, "Reduction of Drying Process Time of Natural Cork Stoppers Process in Lean Improvement Efforts", Lecture Notes in Management and Industrial Engineering - Engineering Systems and Networks, pp.267-275

3. Santos, F, Almeida, A, Martins, C, Oliveira, P, Gonçalves, R, "Tourism Recommendation System based in User Functionality and Points-of-Interest Accessibility levels", Advances in Intelligent Systems and Computing - Trends and Applications in Software Engineering, pp.275-284
4. Sousa, JP, Palop, CG, Moreira, E, Pinto, AM, Lima, J, Costa, P, Costa, P, Veiga, G, Paulo Moreira, A, "Erratum to: The SPIDERobot: A Cable-Robot System for on-site Construction in Architecture", Robotic Fabrication in Architecture, Art and Design 2016, pp.E1-E2
5. Sousa, JP, Palop, CG, Moreira, E, Pinto, AM, Lima, J, Costa, P, Costa, P, Veiga, G, Paulo Moreira, A, "The SPIDERobot: A Cable-Robot System for on-site Construction in Architecture", Robotic Fabrication in Architecture, Art and Design 2016, pp.230-239
6. Valente, A, "MEMS Devices in Agriculture", Advanced Mechatronics and MEMS Devices II - Microsystems and Nanosystems, pp.367-385

Publications (Editor)

1. Reis, Luis Paulo, Moreira, AntonioPaulo, Lima, PedroU., Montano, Luis, Martínez, VictorF.Munoz, "Robot 2015: Second Iberian Robotics Conference - Advances in Robotics, Lisbon, Portugal, 19-21 November 2015, Volume 2", ROBOT (2), vol.418

Dissertations (PhD)

Blank

5.8 CEGI – CENTRE FOR INDUSTRIAL ENGINEERING AND MANAGEMENT

Coordinator: Ana Viana and Pedro Amorim

5.8.1 Presentation of the Centre

CEGI accomplishes its mission, within the Cluster I+I - Industry and Innovation, by following an organizational structure based on six knowledge fields (Service Design, Decision Support, Performance Assessment, Asset Management, Business Intelligence, and Prescriptive Analytics) and on five areas of application (Mobility and Transports, Energy, Retail, Industry, and Health). Each of the knowledge fields is headed by one/two senior researchers that are responsible to foster collaboration, among CEGI researchers, in the respective topic, and to look for funding opportunities and external collaboration. A similar coordination structure is used in each of the application areas. Activity in each of the identified fields ranges from fundamental research to consultancy and service providing.

CEGI aims to pursue research areas that are just at the interface of these fields. Namely, CEGI wants to investigate the methodologies that should be used to hybridize optimization and data-mining techniques. Moreover, the relevance of using service design and engineering approaches to better frame decision problems is another goal to be attained.

Currently, CEGI has 30 integrated PhD members. This number is expected to rise in the years to come as several structural projects were recently approved.

5.8.2 Research and Technology Development

SERVICE DESIGN

In the service design knowledge field there are three intertwined goals to be addressed:

- Design and engineering of complex service systems and value networks, creating new services in the context of distributed and interconnected value co-creating actors, such as health care.
- Design for the customer experience, pursuing a holistic understanding of the customer experience and a human-centered design approach that continuously feeds the service design process with customer experience input.
- Design and engineering of technology enabled services, integrating multiple disciplines such as ICT (Information and Communication Technologies), Human Computer Interaction, Service Design and Service Management, to support the transition from technology development to creation of innovative services that create value for customers and organizations, particularly in the areas of mobile services, smart services, and social networks.

DECISION SUPPORT

In this knowledge field, researchers design, develop and implement quantitative models, methods and tools to solve operations management problems. These problems involve different decision making procedures, planning horizons, entities and objectives, and are usually classified according to their hierarchical level:

- Strategic (e.g., Capacity Planning).
- Tactical (e.g., Resource Allocation).
- Operational (e.g., Scheduling and Control).

Besides the development of models, this knowledge field is also concerned about improving visualization tools and the interfaces that support human-machine interactions.

PERFORMANCE ASSESSMENT

Regarding the performance assessment stream, there are several goals to be addressed:

- Performance assessment exploring Data Envelopment Analysis, econometric and statistical techniques.
- Development of enhanced efficiency and productivity measurement models that can identify the drivers of good performance in companies.
- Enhancement of organizational performance in different sectors, and promotion of robust benchmarking.
- Exploration of new methodologies to assess and improve quality of life and livability of urban areas, as they are essential to the sustainable development of countries given their role in the attractiveness of human capital.

ASSET MANAGEMENT

CEGI core competences on asset management and reliability can be explored in the following areas:

- Predictive maintenance and asset management.
- Power system planning, in particular in the development of tools for reliability analysis, for security of supply evaluation and reserves adequacy evaluation.

CEGI has been involved in several R&D projects with utilities companies in asset management. Its expertise has already been shared and discussed with several stakeholders and there is a large potential for future collaboration.

BUSINESS INTELLIGENCE

Activity in Business Intelligence includes Data Mining, Data Analysis and Statistical methods (applied to companies' management). The objectives of this knowledge field can be decomposed in two axes:

- Extract knowledge from data that could be leveraged to increase, for example, revenues of a business.
- Develop new analytical techniques to circunvent the challenges posed by large data sets. In particular, analyze the redefinition of the processes of data analysis to find patterns and relationships between data elements in large and noisy data sets.

PRESCRIPTIVE ANALYTICS

The solution approaches used to tackle these problems make a trade-off between effectiveness and efficiency, and include:

- Mathematical modelling and programming.
- Robust and efficient optimization algorithms to produce resilient solutions, adaptable to frequent changes in the operating conditions.
- Matheuristics that exploit the hybridization of mathematical programming techniques in (meta)heuristic frameworks.
- Simulation-based Optimization that integrate optimization techniques into simulation analysis.

5.8.3 Technology transfer

ENERGY

The energy application area is a core area for CEGI, in terms of technology transfer. Both asset management, decision support and prescriptive analytics have been used to significantly improve processes in this industry.

RETAIL

The retail area is also a core area for CEGI. Prescriptive analytics, decision support and business analytics have contributed significantly to the advance of business processes in this area.

INDUSTRY

The industry application area is the area where CEGI has historically been more active, and covers both the industrial and the service sectors. CEGI provides services that build on top of the different research areas.

HEALTHCARE

The healthcare area has evolved due to the close collaboration between CEGI and several entities of the public sector, namely hospitals and central regulatory entities. Both Service Design and Decision Support/Prescriptive Analytics have contributed with best practices to this sector.

MOBILITY AND TRANSPORTS

CEGI has historically led several research projects in the area of Mobility linking research streams as diverse as Operations Research, Human-Machine Interface and Information Technology. Recently, CEGI has also collaborated in several Transports related projects covering mainly optimization problems in this field.

5.8.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CEGI – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)				
			Energy	Mobility and Transports	Retail	Industry	Health
Service Design		I	M	M	L	H	M
Decision Support		I	M	M	H	H	M
Performance Management		I				M	M
Asset Management		I	H			M	
Business Intelligence		I		M		M	
Prescriptive Analytics		I	H	M	H	H	H
Other areas (1)	Energy (CPES)	O	M				
	Operations (CESE)	O				M	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.8.5 Main Achievements in 2016

36 papers related with the main research topics of CEGI have been published in international peer-review leading journals. 25 of these articles in the first quartile.

CEGI members have also contributed with 5 book chapters and 24 articles in international conferences, 16 of each are indexed at ISI.

CEGI colaborators are members of the scientific and programme committee of over 14 international conferences and members of the organizing committee of 2 international conferences.

In terms of editorial roles, CEGI members participate in 4 international outlets:

- Ana Viana – Associate editor of International Transactions in Operations Research
- José Fernando Oliveira – Editor of European Journal of Operations Research / Editor of Advanced Tutorials in Operational Research
- Jorge Freire – Editorial Board of TRPRO

All these numbers show the intense activity of CEGI in terms of moving forward the research in Industrial and Services Engineering.

In terms of projects, in 2016 there were 4 new projects financed by FCT, 1 European project and 6 national consultancy ones.

During the year of 2016, several researchers of CEGI have been distinguished with nominations and prizes, as follows:

- Bernardo Almada Lobo e Pedro Amorim – first in the Iberia Peninsula to obtain the Certified Analytics Professional certificate.
- Mário Lopes nominated deputy of Health Parliament Portugal.
- Pedro Amorim nominated coordinated of the EURO Working Group on Retail Operations.
- José Fernando Oliveira nominated APDIO President
- Gabriela Beirão and José Sarsfield Cabral received a prize for the most influential paper published at Transport Policy.
- José Sarsfield Cabral became the non-executive board member of A3ES, National Agency for Accreditation in High Education.
- Pedro Amorim obtained a FEUP diploma for Pedagogical Merit 2015/2016
- Ana Camanho, Bernardo Almada Lobo, João Falcão e Cunha, José Luis Borges, Teresa Galvão obtained a FEUP diploma for Scientific Merit
- Additionally, for the sixth consecutive year the paper “O.R. in Healthcare: A survey”, co-authored by a researcher of CEGI (Ana Viana), was the most downloaded paper of the International Transactions in Operational Research.

Finally, in 2016 we had two members that concluded their aggregation proofs: Bernardo Almada Lobo and Ana Camanho.

5.8.6 Centre Organizational Structure and Research Team

The Centre for Industrial Engineering and Management is coordinated by Ana Viana and Pedro Amorim and is organized as follows:

- Service Design - Responsible: Lia Patrício and Jorge Teixeira
- Decision Support - Responsible: João Pedro Pedroso and Gonçalo Figueira
- Performance Assessment - Responsible: Ana Camanho
- Business Intelligence - Responsible: José Luís Borges and Vera Miguéis
- Prescriptive Analytics - Responsible: José Fernando Oliveira

Moreover, there is an advisory board to assist the coordination.

The evolution of the Centre research team from 2014 to 2016 is presented in Table 5.2.

Table 5.2 - CEGI – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees				
		Academic Staff	16	19	19	
		Grant Holders and Trainees	32	25	34	9
		Total Core Researchers	**48**	**44**	**53**	**9**
	Affiliated Researchers		1	4	3	-1
	Admin.& Tech	Employees				
		Grant Holders and Trainees				
	Total Integrated HR		**49**	**48**	**56**	**8**
	Total Integrated PhD		**23**	**28**	**32**	**4**
Curricular Trainees			3	12	5	-7
External Research Collaborators			10	10	8	-2
External Administrative and Technical Staff			2	2	2	
External Students			2	1	3	2
Total			**66**	**73**	**74**	**1**

5.8.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CEGI – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	91	18	24	6
PN-PICT	National R&D Programmes - S&T Integrated Projects	41	25	65	40
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes		19	43	24
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	227	330	181	-149
SERV-INT	R&D Services and Consulting - International	28	36		-36
OP	Other Funding Programmes				
Closed Projects				55	55
Total Funding		**386**	**428**	**367**	**-61**

Table 5.4-CEGI – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	40	32	32
International conference proceedings indexed by ISI, Scopus or DBLP	17	16	16
Books (author)			
Chapter/paper in books	11	8	5
PhD theses concluded by members of the Centre	6	6	3
Concluded PhD theses supervised by members of the Centre		9	4

Table 5.5-CEGI – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6-CEGI – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	4
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	2
International events in which INESC TEC members participate in the program committees	14
Participation in events such as fairs, exhibitions or similar	
Advanced training courses	

5.8.8 List of Projects

Table 5.7-CEGI – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	HHRPLAN	Bernardo Almada Lobo	01-04-2016	31-03-2018
PN-FCT	mKEP	Ana Viana	01-04-2016	31-03-2019
PN-FCT	EasyFlow-1	Pedro Amorim	01-06-2016	31-05-2019
PN-PICT	iMAN-2	Luís Guimarães	01-07-2015	30-06-2018
PN-PICT	CORAL-TOOLS-6	João Pedro Pedroso	01-01-2016	31-12-2018
PUE-FP	UPGRID-1	Lia Patrício	01-02-2015	31-01-2018

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	Supply_Chain	Bernardo Almada Lobo	03-11-2014	31-12-2016
SERV-NAC	ShortPath	Pedro Amorim	23-02-2015	31-12-2016
SERV-NAC	BestWare	Pedro Amorim	01-03-2015	28-02-2017
SERV-NAC	RosaEvolution	Bernardo Almada Lobo	06-04-2015	05-01-2017
SERV-NAC	HIDRO	Bernardo Almada Lobo	29-06-2015	31-12-2016
SERV-NAC	UpGas	Bernardo Almada Lobo	30-11-2015	31-12-2016
SERV-NAC	LTP	Gonçalo Reis Figueira	01-01-2016	31-12-2016
SERV-NAC	Consultoria	Bernardo Almada Lobo	01-01-2014	

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.8.9 List of Publications

International Journals with Scientific Referees

1. Alvelos, F, Klimentova, X, Rais, A, Viana, A, "Maximizing expected number of transplants in kidney exchange programs", Electronic Notes in Discrete Mathematics, vol.52, pp.269-276
2. Amorim, P, Curcio, E, Almada Lobo, B, Barbosa Póvoa, APFD, Grossmann, IE, "Supplier selection in the processed food industry under uncertainty", European Journal of Operational Research, vol.252, no.3, pp.801-814
3. Amorim, P, Martins, S, Curcio, E, Almada Lobo, B, "Defining the Best distribution Network for Grocery Retail Stores", ERCIM NEWS, no.105, pp.10-11
4. Arabi, B, Munisamy, S, Emrouznejad, A, Toloo, M, Ghazizadeh, MS, "Eco-efficiency considering the issue of heterogeneity among power plants", Energy, vol.111, pp.722-735
5. Bianchi Aguiar, T, Silva, E, Guimaraes, L, Carravilla, MA, Oliveira, JF, Amaral, JG, Liz, J, Lapela, S, "Using Analytics to Enhance a Food Retailer's Shelf-Space Management", INTERFACES, vol.46, no.5, pp.424-443
6. Brandao, F, Pedroso, JP, "Bin packing and related problems: General arc-flow formulation with graph compression", Computers & Operations Research, vol.69, pp.56-67
7. Caprara, A, Carvalho, M, Lodi, A, Woeginger, GJ, "Bilevel Knapsack with Interdiction Constraints", INFORMS Journal on Computing, vol.28, no.2, pp.319-333
8. Cherri, LH, Mundim, LR, Andretta, M, Toledo, FMB, Oliveira, JF, Carravilla, MA, "Robust mixed-integer linear programming models for the irregular strip packing problem", European Journal of Operational Research, vol.253, no.3, pp.570-583
9. Cherri, LH, Carravilla, MA, Toledo, FMB, Universidade do Porto, Portugal, "A model-based heuristic for the irregular strip packing problem", Pesquisa Operacional, vol.36, no.3, pp.447-468

10. El Mashaleh, MS, Horta, IM, "Evaluating Contractors for Bonding: DEA Decision Making Model for Surety Underwriters", Journal of Management In Engineering, vol.32, no.1

11. Ferreira, NB, Oliveira, MM, "Portfolio efficiency analysis with SFA: the case of PSI-20 companies", APPLIED ECONOMICS, vol.48, no.1, pp.1-6

12. Fisk, RP, Anderson, L, Bowen, DE, Gruber, T, Ostrom, A, Patricio, L, Reynoso, J, Sebastiani, R, "Billions of impoverished people deserve to be better served A call to action for the service research community", Journal Of Service Management, vol.27, no.1, pp.43-55

13. Galrão Ramos, AG, Oliveira, JF, Goncalves, JF, Lopes, MP, "A container loading algorithm with static mechanical equilibrium stability constraints", Transportation Research Part B-Methodological, vol.91, pp.565-581

14. Horta, IM, Camanho, AS, Dias, TG, "Residential building resource consumption: A comparison of Portuguese municipalities' performance", CITIES, vol.50, pp.54-61

15. Horta, IM, Kapelko, M, lansink, AO, Camanho, AS, "The Impact Of Internationalization And Diversification On Construction Industry Performance", International Journal of Strategic Property Management, vol.20, no.2, pp.172-183

16. Klimentova, X, Pedroso, JP, Viana, A, "Maximising expectation of the number of transplants in kidney exchange programmes", Computers & OR, vol.73, pp.1-11

17. Leao, AAS, Toledo, FMB, Oliveira, JF, Carravilla, MA, "A semi-continuous MIP model for the irregular strip packing problem", International Journal of Production Research, vol.54, no.3, pp.712-721

18. Lopes, MA, Soares, C, Almeida, A, Almada Lobo, B, "Comparing comparables: an approach to accurate cross-country comparisons of health systems for effective healthcare planning and policy guidance", Health Systems, vol.5, no.3, pp.192-212

19. Magalhaes, SMC, Leal, VMS, Horta, IM, "Predicting and characterizing indoor temperatures in residential buildings: Results from a monitoring campaign in Northern Portugal", Energy and Buildings, vol.119, pp.293-308

20. Moreira Matias, L, Cats, O, Gama, J, Mendes Moreira, J, de Sousa, JF, "An online learning approach to eliminate Bus Bunching in real-time", Applied Soft Computing, vol.47, pp.460-482

21. Motta Toledo, CFM, Arantes, MD, Bressan Hossomi, MYB, Almada Lobo, B, "Mathematical programming-based approaches for multi-facility glass container production planning", Computers & Operations Research, vol.74, pp.92-107

22. Neves Moreira, F, Amorim, P, Guimaraes, L, Almada Lobo, B, "A long-haul freight transportation problem: Synchronizing resources to deliver requests passing through multiple transshipment locations", European Journal of Operational Research, vol.248, no.2, pp.487-506

23. Nunes, AA, Dias, TG, Falcao e Cunha, JFE, "Passenger Journey Destination Estimation From Automated Fare Collection System Data Using Spatial Validation", IEEE Transactions on Intelligent Transportation Systems, vol.17, no.1, pp.133-142

24. Nunes, AA, Dias, TG, Zegras, C, Falcao e Cunha, JFE, "Temporary user-centred networks for transport systems", Transportation Research Part C-Emerging Technologies, vol.62, pp.55-69

25. Oliveira, JF, Neuenfeldt, A, Silva, E, Carravilla, MA, "A surveyonheuristics for the two-dimensional rectangular strip packing problem", Pesquisa Operacional, vol.36, no.2, pp.197-226

26. Pedroso, JP, Cunha, S, Tavares, JN, "Recursive circle packing problems", International Transactions in Operational Research, vol.23, no.1-2, pp.355-368

27. Pinto, E, Brito, AC, Cruz Correia, RJ, "Identification and Characterization of Inter-Organizational Information Flows in the Portuguese National Health Service", Applied Clinical Informatics, vol.7, no.4, pp.1202-1220

28. Polzin, P, Borges, J, Coelho, A, "A decision support method to identify target geographic markets for health care providers", Papers In Regional Science, vol.95, no.4, pp.843

29. Ramos, AG, Oliveira, JF, Lopes, MP, "A physical packing sequence algorithm for the container loading problem with static mechanical equilibrium conditions", International Transactions in Operational Research, vol.23, no.1-2, pp.215-238

30. Silva Portela, MCAS, Camanho, AS, Almeida, DQ, Lopes, L, Silva, SN, Castro, R, "Benchmarking hospitals through a web based platform", Benchmarking-An International Journal, vol.23, no.3, pp.722-739

31. Silva, Elsa, Oliveira, JoseFernando, Wäscher, Gerhard, "The pallet loading problem: a review of solution methods and computational experiments", ITOR, vol.23, no.1-2, pp.147-172

32. Vieira, B, Viana, A, Matos, M, Pedroso, JP, "A multiple criteria utility-based approach for unit commitment with wind power and pumped storage hydro", Electric Power Systems Research, vol.131, pp.244-254

International Conference Proceedings with Scientific Referees

1. Battaglia, D, Borchardt, M, Patricio, L, "PSS offering in a B2B context: towards the drivers to enable integrated solutions", Product-Service Systems Across Life Cycle, vol.47, pp.400-405

2. Carpanen, P, Patricio, L, Ribeiro, B, "Designing Product Service Systems in the Context of Social Internet of Things", Exploring Services Science (IESS 2016), vol.247, pp.419-431

3. Costa, PM, Fontes, T, Nunes, AA, Ferreira, MC, Costa, V, Dias, TG, Borges, JL, Falcao e Cunha, JFE, "Application of collaborative information exchange in urban public transport: the Seamless Mobility solution", Transport Research Arena Tra2016, vol.14, pp.1201-1210

4. dos Reis, JGM, Amorim, P, Cabral, JAS, "Effects of price and transportation costs in soybean trade", IFIP Advances in Information and Communication Technology, vol.488, pp.563-570

5. Dragoicea, M, Constantinescu, D, Falcao e Cunha, JFE, "Experience from a Modelling and Simulation Perspective in Smart Transport Information Service Design", Exploring Services Science (IESS 2016), vol.247, pp.75-88

6. Hora, J, Dias, TG, Camanho, A, "Improving the Service Level of Bus Transportation Systems: Evaluation and Optimization of Bus Schedules' Robustness", Exploring Services Science (IESS 2016), vol.247, pp.604-618

7. Horta, IM, Camanho, AS, Dias, TG, Niza, S, "The Assessment of Municipal Services: Environmental Efficiency of Buildings Construction", Exploring Services Science (IESS 2016), vol.247, pp.237-250

8. Maciel, F, Dias, TG, "Challenging user interaction in Public Transportation Spider Maps: a Cobweb solution for the city of Porto", 2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC), pp.181-188

9. Maher, S, Miltenberger, M, Pedroso, JP, Rehfeldt, D, Schwarz, R, Serrano, F, "PySCIPOPT: Mathematical Programming in Python with the SCIP Optimization Suite", Mathematical Software, Icms 2016, vol.9725, pp.301-307

10. Mahfudhi, MG, Dias, TG, "Specifying Modernization into Service-Oriented SaaS System in a Case of Public Transport Document Generator", Exploring Services Science (IESS 2016), vol.247, pp.590-603

11. Migueis, VL, Novoa, H, "Using User-Generated Content to Explore Hotel Service Quality Dimensions", Exploring Services Science (IESS 2016), vol.247, pp.155-169

12. Portela, MCAS, Camanho, AS, "The Assessment of Performance of Educational Services: The Case of Portuguese Secondary Schools", Exploring Services Science (IESS 2016), vol.247, pp.717-731

13. Santos, D, Kokkinogenis, Z, de Sousa, JF, Perrotta, D, Rossetti, RJF, "Towards the Integration of Electric Buses in Conventional Bus Fleets", 2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC), pp.88-93

14. Sobral, T, Costa, V, Borges, J, Fontes, T, Galvao, T, "OBAVUM: An Ontology-based Approach to Visualizing Urban Mobility Data", Proceedings Of 2016 IEEE International Conference on Big Data Analysis (ICBDA), pp.206-211

15. Sobral, T, Galvao, T, Borges, J, "VUMO: Towards an Ontology of Urban Mobility Events for Supporting Semi-Automatic Visualization Tools", 2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC), pp.1700-1705

16. Teles, MD, de Sousa, JF, "An Operations Research-Based Morphological Analysis to Support Environmental Management Decision-Making", Decision Support Systems VI - Addressing Sustainability and Societal Challenges, vol.250, pp.16-30

Books

Blank

Chapter/Paper in Books

1. de Queiroz, TA, Oliveira, JF, Carravilla, MA, Miyazawa, FK, "Demand uncertainty for the location-routing problem with two-dimensional loading constraints", Lecture Notes in Economics and Mathematical Systems, vol.682, pp.47-53
2. Heshmati, S, Kokkinogenis, Z, Rossetti, RJF, Carravilla, MA, Oliveira, JF, "An agent-based approach to schedule crane operations in rail-rail transshipment terminals", Lecture Notes in Economics and Mathematical Systems, vol.682, pp.91-97
3. Oliveira, BB, Carravilla, MA, Oliveira, JF, "A GRASP algorithm for the vehicle-reservation assignment problem", Lecture Notes in Economics and Mathematical Systems, vol.682, pp.63-71
4. Oliveira, F, Vaz, CB, "Spare Parts Inventory Management Using Quantitative and Qualitative Classification", Lecture Notes in Management and Industrial Engineering - Engineering Systems and Networks, pp.233-241
5. Ospina, DY, Carravilla, MA, Oliveira, JF, "A MIP model for production planning in the roasting coffee industry", Lecture Notes in Economics and Mathematical Systems, vol.682, pp.157-163

Publications (Editor)

Blank

Dissertations (PhD)

1. Nunes, A., "A user collaboration model for urban passenger transport";
2. Carvalho, M., "Computation of equilibria on integer programming games";
3. Cherri, L., "Nesting Problems".

5.9 CITE – CENTRE FOR INNOVATION, TECHNOLOGY AND ENTREPRENEURSHIP

Coordinator: Alexandra Lobo Xavier

5.9.1 Presentation of the Centre

CITE accomplishes its mission, within the Cluster I+I - Industry and Innovation, by carrying out R&D, advanced consulting and executive education in Technology Management, Innovation Management and Technology Entrepreneurship. The Group seeks to promote the valorisation of the knowledge it creates, by developing conceptual frameworks, methodologies, tools, and executive programs, to be provided to private and public organizations.

CITE also coordinate LET-IN, a pre incubation service that offers mentoring, coaching, technological and business consultancy, supporting the development of technology-based entrepreneurial projects related to the institution's core areas.

The CITE was created in 2007 to consolidate the significant investments and experience of INESC Porto in the development of internal processes and tools to manage R&D results, and organize the resulting knowledge and competences in order to enable a higher level of responsibility and leadership of the process of knowledge valorisation.

5.9.2 Research and Technology Development

Innovation Management

Investigating how innovation is organised, developed and commercialised within the scope of technology-based companies; an emphasis is placed on innovation management practices and tools and innovation metrics, building on a history of contributions to the Portuguese Standard for R&DI Management and for the European Technical Guide for Innovation Management. Participation in ISO-TC279 – WG4 for Innovation Management Assessment.

Develop user centred innovation methodologies and tools to support new business model approaches, new product and services concepts and facilitate the implementation of lean start up approaches to engage potential clients and end users in order to mitigate risks and increase the product-market fit.

Creating multidisciplinary approaches to enabling the Front End of Innovation, combining methods and tools that build on state-of-the-art concepts and trends in enterprise information systems, enterprise integration, information and communication technology and business narrative modelling and analysis.

Technology Management

Looking into the ways companies create, appropriate, and deliver value from technology, to improve the understanding of how it can be used to create and sustain competitive advantage. A particular attention is dedicated to the topics of diffusion, adoption, and implementation of technological innovations, since for an innovation to change the way people live or the way organizations work, it has to be adopted and implemented by them.

This focus on adoption and implementation is complemented by the study of strategies and policies for the use and control of technology for the benefit of communities. Priority is to be given to the design of complex networked infrastructures with flexibility, to enhance their performance in relation to uncertain future conditions of operation, and to improving methods for the design of engineering systems aiming at achieving a better integration of engineering, management and social sciences aspects that are traditionally considered individually.

Technology Entrepreneurship

Improving the knowledge of how new technological businesses form, survive and grow; a focus is placed on understanding the factors that support, delay, or block entrepreneurial intentions and activities of university researchers, in the earliest stages of entrepreneurial ventures, and the ways different organisational solutions, such as pre-incubation and proof-of-concept Centres address the equity gap problem in the early stages of commercialisation:

- Design and implementation of acceleration programs supported by new methodologies and tools to foster the development of technological entrepreneurial projects;
- Create entrepreneurial awareness through the organization of training actions, development of tools, and giving direct support to entrepreneurs in the process of turning ideas and technologies into business;
- Develop open innovation approaches to facilitate the relationship between companies and researchers, in order to facilitate knowledge and technology exploitation.

Complementing the technology management focus on how technology is delivered to customers, there is a second focus on the way operations are organized by academic spin-offs to be able to properly create, appropriate and deliver the value to customers, and how they change along the several stages of evolution of the start-ups as its business model is adapted to achieve the best product-market fit.

5.9.3 Technology transfer

LET IN

LET-In is a service promoted by CITE that offers mentoring, coaching, technological and business consultancy, supporting the development of technology-based entrepreneurial projects related to the institution's core areas.

- Create entrepreneurial awareness through the organization by implementing training actions, seminars and workshops and giving direct support to entrepreneurs in the process of turning ideas and technologies into business;
- Develop and use case studies to disseminate creative entrepreneurship projects that will be examples for emerging new entrepreneurial projects;
- Implement accelerator programmes to facilitate the development of new technological early stage projects.

Executive programmes

CITE's R&D activities related to technology entrepreneurship result in the design of new conceptual frameworks, tools, and executive programs to be provided to private and public organizations.

CITE's R&D activities related to technology management result in the design of new conceptual frameworks, tools, and executive programs to be provided to private and public organizations.

Consulting

CITE's R&D activities related to innovation management result in the design of new conceptual frameworks, tools, to be applying by our consulting team to private and public organizations.

EEN Portugal and EEN Innovation

Participate in European Enterprise Network to facilitate the access of SMEs to international markets and to enhance their innovation capacities.

Innovation Lab - User Centred Innovation

Develop a set of co creation workshops supported by creative tools to generate new business model, product and services concepts.

5.9.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1-CITE – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)					
	Status (2)	LET IN	Executive programmes	EEN Portugal and EEN Innovation	User Centre Innovation	Consulting
Innovation Management	I	M	H	H	M	H
Technology Management	I	M	M	F		F
Technology Entrepreneurship	I/E	H	M	M	M	F

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.9.5 Main Achievements in 2016

Grant approval for three different accelerator programmes that include mentorship and educational components:

- IN&OUT – an early stage start-ups accelerator for everyone who wants to develop a technological based entrepreneurial project;
- BIP – Business Ignition Programme: a programme designed to researchers in order to improve their capacities to be part of the process of the technology exploitation;
- LET IN Catalyst – implement an internal entrepreneurship programme to support INESC TEC researchers in their entrepreneurship initiatives.

Delivered Innovation Management services to at least 40 SMES, under the EEN Innovation Project.

Provided support to 4 companies under the coaching scheme offered to SME Instrument beneficiaries, under the EEN Innovation Project.

Delivered 49 advisory support services to SME´s in International partnerships, European funding, innovation, R&D cooperation, under the EEN Portugal consortium.

Organized 19 local executive training events targeting an audience of around 570 participants in Intellectual Property, European Funding, Project Management, Innovation management.

One of CITE team members was appointed by IPAC as national expert for the **WG4 – "Innovation Assessment" in ISO TC279.**

One of the team members coordinated the JIM **- Journal of Innovation Management** (http://www.open-jim.org/)

Mentoring 3 new start up projects behind Let In services.

Participate in the following projects: Safecloud, Nanostima, iMan, FourEyes, SMILES, CORAL, and Screen-DR, by: study adoption and diffusion behaviors in different industries, Study the challenges during implementation of technology and provide managerial and policy recommendations

5.9.6 Centre Organizational Structure and Research Team

The Centre CITE is coordinated by Alexandra Xavier and is organized in the following Areas:

- Innovation Management - Responsible: Alexandra Xavier & João José Pinto Ferreira
- Technology Management - Responsible: João Claro & José Coelho Rodrigues
- Technology Entrepreneurship - Responsible: Alexandra Xavier & João Claro

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CITE– Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	2	2	2	
		Academic Staff	2	1	1	
		Grant Holders and Trainees	5	5	4	-1
		Total Core Researchers	**9**	**8**	**7**	**-1**
	Affiliated Researchers		1	6	6	
	Admin.& Tech	Employees				
		Grant Holders and Trainees				
	Total Integrated HR		**10**	**14**	**13**	**-1**
	Total Integrated PhD		**3**	**6**	**6**	
Curricular Trainees			1	2	1	-1
External Research Collaborators			6	2	6	4
External Administrative and Technical Staff						
External Students			2	4	6	2
Total			**19**	**22**	**26**	**4**

5.9.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3-CITE – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	30	2		-2
PN-PICT	National R&D Programmes - S&T Integrated Projects			12	12
PN-COOP	National Cooperation Programmes with Industry	13			
PUE-FP	EU Framework Programmes		31	46	15
PUE-DIV	EU Cooperation Programmes - Other	16	53	34	-19
SERV-NAC	R&D Services and Consulting - National	47	63	3	-60
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	-3		17	17
Closed Projects			-5	12	17
Total Funding		**103**	**144**	**123**	**-20**

Table 5.4-CITE – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	16	7	8
International conference proceedings indexed by ISI, Scopus or DBLP	3	1	
Books (author)	1	1	
Chapter/paper in books		3	2
PhD theses concluded by members of the Centre	1		2
Concluded PhD theses supervised by members of the Centre		3	2

Table 5.5-CITE – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6-CITE – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	2
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	1
International events in which INESC TEC members participate in the program committees	2
Participation in events such as fairs, exhibitions or similar	8
Advanced training courses	3

5.9.8 List of Projects

Table 5.7-CITE – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PUE-DIV	EEN	Alexandra Xavier	01-01-2015	31-12-2016
PN-PICT	SMILES-2	João Claro	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL2-1	João Claro	01-07-2015	30-06-2018
PUE-FP	KAM	Alexandra Xavier	01-01-2015	31-12-2016
PUE-FP	SafeCloud-1	João Claro	01-09-2015	31-08-2018
SERV-NAC	Consultoria	Alexandra Xavier	01-01-2008	
OP	BIP	Alexandra Xavier	01-02-2016	31-01-2018
OP	IN&OUT	Alexandra Xavier	01-12-2015	30-11-2017

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.9.9 List of Publications

International Journals with Scientific Referees

1. Barradas, LCS, Rodrigues, EM, Ferreira, JJP, "Deriving an ontology for knowledge management in collaborative innovation networks", International Journal of Innovation and Learning, vol.19, no.3, pp.335-357, 2016
2. Fernandes, PM, Pacheco, AP, Almeida, R, Claro, J, "The role of fire-suppression force in limiting the spread of extremely large forest fires in Portugal", European Journal of Forest Research, vol.135, no.2, pp.253-262, Apr, 2016

3. Nagarajan, NR, Teixeira, AAC, Silva, ST, "The impact of an ageing population on economic growth: An exploratory review of the main mechanisms", Analise Social, vol.51, no.218, pp.4-35
4. Neves, A, Teixeira, AAC, Silva, ST, "Exports-R&D investment complementarity and economic performance of firms located in Portugal", Investigacion Economica, vol.75, no.295, pp.125-156
5. Pato, ML, Teixeira, AA, "Twenty Years of Rural Entrepreneurship: A Bibliometric Survey", Sociologia Ruralis, vol.56, no.1, pp.3-28
6. Teixeira, AAC, "The impact of class absenteeism on undergraduates academic performance: evidence from an elite Economics school in Portugal", Innovations In Education and Teaching International, vol.53, no.2, pp.230-242
7. Teixeira, AAC, Nogueira, J, "Academic Entrepreneurship In Life Sciences: The Case of a Moderate Innovator Country", Journal of Developmental Entrepreneurship, vol.21, no.1, pp.1650004
8. Teixeira, AAC, Queiros, ASS, "Economic growth, human capital and structural change: a dynamic panel data analysis", Research Policy, vol.45, no.8, pp.148-160

International Conference Proceedings with Scientific Referees

Blank

Books

Blank

Chapter/Paper in Books

1. Almeida, F, Monteiro, J, Lousã, M, "Barriers and Critical Success Factors in E-Health Information Technology:", Encyclopedia of E-Health and Telemedicine, pp.13-23
2. Nicola, S, Ferreira, EP, Pinto Ferreira, JJ, "A new and innovative approach to assess and quantify the value for the customer", Lecture Notes in Economics and Mathematical Systems, vol.682, pp.215-223

Publications (Editor)

Blank

Dissertations (PhD)

1. Rodrigues, J., "Aligning technologies and interorganizational networks in implementations: The case of a new health screening program";
2. Schell, K., "Computational Models for Renewable Energy Target Achievement & Policy Analysis".

5.10 CSIG – CENTRE FOR INFORMATION SYSTEMS AND COMPUTER GRAPHICS

Coordinators: António Gaspar and Ângelo Martins

5.10.1 Presentation of the Centre

The Centre for Information Systems and Computer Graphics (CSIG) mission, accomplished within the Computer Science Cluster, is to pursue high quality research, strongly linked to industrial partnerships, consultancy and technology transfer, in five main areas: Computer Graphics and Virtual Environments, Information Management and Information Systems, Software Engineering, Accessibility and Assistive Technologies and Special Purpose Computing Systems.

The Centre is particularly well positioned to address complex and difficult engineering problems faced by industry as it has the expertise to analyse, design, mine and implement large information systems, using best software engineering practices for design, development and testing, and also provide the visual and user interaction components such a solution may require. Furthermore, the Centre is also strongly committed to the training of young researchers and professionals.

Presently its researchers originate from the University of Porto, Polytechnic of Porto, University of Trás-os-Montes e Alto Douro, Universidade Aberta and University of Minho.

5.10.2 Research and Technology Development

Computer Graphics and Virtual Environments

The Computer Graphics and Virtual Environments research area investigates in Image Synthesis and Visual Perception, Geospatial Systems, Virtual Environments and Digital Games.

In the area of Virtual Environments, the main focus of research is Multisensory Virtual Reality, Augmented Reality, Multimodal Interaction, Virtual Environments for Learning and Procedural Modelling of Urban Environments.

In the area of Digital Games, special focus has been given to Serious Games, particularly in training, education and health. This includes Authoring tools, Procedural Content Generation, Pervasive/Location-based Games and Game/Learning Analytics.

Within Geospatial Systems, research topics include geospatial and sensor Web semantics, time-space rationalisation and visualisation, which can be applied in spatial data infrastructures and environment sensor networks, as well as Ambient Assisted Living.

There are also two transversal areas of research regarding Usability and User Experience, as well as Parallel Processing and GPU programming.

Information Management and Information Systems

The Information Systems and Information Management research area investigates in the areas of Information Management, Information Retrieval, Information Processing, Digital Preservation and Research Data Management. This area includes work in frameworks for information management, retrieval and processing in contexts such as Web Mining, Recommender Systems, Social Web, Semantic Web, Information Retrieval and Text Mining. Work in digital preservation includes models, methods and tools for digital preservation, particularly in the area of Database Preservation, Research Data Repository Management and e-Science.

Software Engineering

The Software Engineering research area investigates in the areas of Software Test Automation, Software Process Engineering and Knowledge Management, Software Architecture and Design, and Gamification in software engineering. This area includes work on pattern-based GUI testing, automated pattern-based testing of mobile applications, model-based testing and certification in digital ecosystems, automated scenario-based testing of distributed and heterogeneous systems, modular testing for aspect-oriented programs, automated software process performance analysis and improvement recommendation, recommender systems for requirements maintenance, platforms for collaborative framework understanding, software documentation with adaptive software artifacts, and serious games for software engineering education.

Accessibility and Assistive Technologies

The Accessibility and Assistive Technologies research area investigates in the domain of Human Computer Interaction in particular the areas of Accessibility, Usability, Assistive and Collaborative Technologies, Sports, health and wellbeing. This research area includes the design and development of technologies to help people with special needs, with particular focus on people with disabilities and the elderly, enhancing their life and autonomy, health and wellbeing.

Special Purpose Computing Systems

The Special Purpose Computing Systems area focuses its activities on research and development of Domain-Specific Languages, tools, and methods, to develop and map applications to heterogeneous computer architectures consisting of multi-/many-cores and hardware accelerators. The area mainly addresses compiler transformations and the efficient mapping (in terms of performance, power and energy consumptions) of computations to hardware accelerators using GPGPUs and FPGAs.

5.10.3 Technology transfer

Advanced ICT Consulting

Advanced ICT consulting activities are performed typically for enterprises and institutions that require technical support in their decision processes or for coordinating complex projects. Whenever needed, additional competences from other INESC TEC Centres are incorporated.

Innovative Systems Development

These activities take place whenever a partner has specific systems development needs not addressed by the market and requiring an innovative approach. It has been mostly based on competences in information systems and software engineering, but a larger involvement is expected in the use of multisensorial immersive virtual reality systems.

The main areas of technology transfer have been public administration, namely local authorities and transport, particularly ports.

5.10.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CSIG – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)	
			Advanced ICT Consulting	Innovative Systems Development
Computer Graphics and Virtual Environments		I	M	H
Software Engineering		I	H	H
Information Management and Systems		I	H	H
Accessibility		I	M	M
Special Purpose Computing Systems		I	L	L
Other areas (1)	Communication Networks (CTM)	O	M	

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.10.5 Main Achievements in 2016

The number of articles published in indexed journals has increased 26% since 2015, whilst the number of articles published in indexed conferences increased 20%. The number of PhD theses supervised and concluded has also increased significantly.

FCT funded research was strongly reinforced in 2016, with three new projects: TAIL, CONTEXTWA and iCare4Depression.

Additionally, new funding lines were opened in 2016:

- BEACONING, CSIG's first H2020 project started in January;
- HDR4RTT, HDR for Real Time Tracking, was the first CSIG and INESC TEC's project funded by US Navy (ONRG);
- AV360, was the first CSIG and INESC TEC's project funded by Google DNI.

The MASSIVE Laboratory was also concluded. This 500K€ laboratory, funded by FCT, COMPETE and Norte 2020 is dedicated to research in multisensorial and immersive virtual reality.

In 2016 several distinctions and awards were received:

- Carla Teixeira Lopes, Honorable Mention Award ,CLEF'16;
- Ana Paiva e Nuno Flores, Best Paper Award, HEAD'16;
- Diana Carvalho e Maximino Bessa. Jesús Lorés Best Paper Award, INTERACCIÓN 2016;
- Cristina Ribeiro, invited to the Open Science National Policy Working Group, created by the Ministry of Science, Technology and Higher Education;
- Two different projects led by João Barroso and Tânia Rocha received the two "Inclusion and Digital Literacy Prizes" awarded in 2016 by FCT.

The TISHW Conference (International Conference on Technology and Innovation in Sports, Health and Wellbeing) was launched, with the support of IEEE. ACM SIGACCESS joined us, in the organization and consolidation of DSAI Conference (International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion).

Major results were also obtained in the following projects:

- CE4BLIND presented its prototype of a blind support navigation system, composed by an electronic cane, a mobile application and a computer vision module;
- SEABIODATA designed and implemented a research information management system for IPMA, to support the management and preservation of marine biodiversity data;
- TAIL improved the Dendro platform, connecting it with data repositories for long-term preservation;
- Windscanner implemented an e-infrastructure supporting field experiments for the European Wind Atlas project;
- E-COMPARED prototype supported Randomized Controlled Trials (RCT) in the scope of an European wide study comparing the cost-effectiveness of blended treatment (Internet-based and face-to-face) for depression versus treatment as usual;
- STOPDEPRESSION prototype supported RCT to evaluate the feasibility of a stepped care model for the treatment of depression in the scope of primary care healthcare services in Porto (ACeS Porto Ocidental);
- vCardID, where software validation and verification and project management activities for the future citizen card were developed under contract with INCM, the Portuguese mint and print office;
- SIGAMP created a Regional Spatial Data Infrastructure for Porto Metropolitan Area, using Open Source and OGC standards, under contract with AMP;

- DIW2020 performed a technical study of River Information Services and related IT infrastructure to support and improve Douro river navigation (passengers and cargo). It was funded by EU TEN-T programme under subcontract with APDL;
- WIDERMOS developed a prototype of a marketplace for interoperable business platforms, to sell door-to-door multimodal logistic services, implementing a Logistics Single Window, with a focus on the maritime logistic component. It was funded by EU TEN-T programme under subcontract with APDL.

Additionally, as a result of the WIDERMOS project, a spin-off company, MITMYNID, was created by six CSIG members to exploit its results.

5.10.6 Centre Organizational Structure and Research Team

The Centre for Information Systems and Computer Graphics is coordinated by António Gaspar and Ângelo Martins and is organized in the following scientific areas:

- Computer Graphics and Virtual Environments - Responsible: António Coelho
- Information Management and Information Systems - Responsible: Cristina Ribeiro
- Software Engineering - Responsible: João Pascoal Faria
- Accessibility - Responsible: João Barroso
- Special Purpose Computing Systems - Responsible: João Paiva Cardoso

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CSIG – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	9	10	7	-3
		Academic Staff	22	24	26	2
		Grant Holders and Trainees	34	38	35	-3
		Total Core Researchers	65	72	68	-4
	Affiliated Researchers			14	15	1
	Admin.& Tech	Employees	1	1	1	
		Grant Holders and Trainees				
	Total Integrated HR		**66**	**87**	**84**	**-3**
	Total Integrated PhD		**22**	**40**	**45**	**5**
Curricular Trainees			4	8	4	-4
External Research Collaborators			14	5	10	5
External Administrative and Technical Staff						
External Students				1	4	3
Total			**84**	**101**	**102**	**1**

5.10.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - CSIG – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	76	181	46	-135
PN-PICT	National R&D Programmes - S&T Integrated Projects		5	189	183
PN-COOP	National Cooperation Programmes with Industry	36	16		-16
PUE-FP	EU Framework Programmes	191	202	226	24
PUE-DIV	EU Cooperation Programmes - Other	24	109	178	70
SERV-NAC	R&D Services and Consulting - National	674	620	541	-79
SERV-INT	R&D Services and Consulting - International	3			
OP	Other Funding Programmes	15	39	16	-23
Closed Projects		-3	70	71	1
	Total Funding	**1.016**	**1.242**	**1.267**	**25**

Table 5.4 - CSIG – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	20	26	33
International conference proceedings indexed by ISI, Scopus or DBLP	67	72	87
Books (author)			
Chapter/paper in books	1	4	5
PhD theses concluded by members of the Centre	3		9
Concluded PhD theses supervised by members of the Centre		13	16

Table 5.5 - CSIG – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6 - CSIG – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	14
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	16
International events in which INESC TEC members participate in the program committees	29
Participation in events such as fairs, exhibitions or similar	8
Advanced training courses	4

5.10.8 List of Projects

Table 5.7 - CSIG – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	CE4Blind	João Barroso	01-05-2015	31-10-2016
PN-FCT	TAIL	Cristina Ribeiro	30-05-2016	29-05-2019
PN-FCT	Icarefordepression	Artur Rocha	01-06-2016	31-05-2019
PUE-DIV	StopDepression	Artur Rocha	01-04-2015	30-04-2016
PUE-DIV	SeaBioData	Artur Rocha	01-07-2015	30-04-2017
PN-PICT	FOUREYES-2	Sérgio Nunes	01-07-2015	30-06-2018
PN-PICT	SMILES-5	João Paiva Cardoso	01-07-2015	30-06-2018
PN-PICT	CORAL-SENSORS-3	Susana Alexandra Barbosa	01-01-2016	31-12-2018
PN-PICT	CORAL-TOOLS-3	Artur Rocha	01-01-2016	31-12-2018
PN-PICT	NanoStima-RL2	João Barroso	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL3-2	Ângelo Martins	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL4-3	Carla Lopes	01-07-2015	30-06-2018
PUE-FP	E-Compared	Artur Rocha	01-01-2014	30-06-2017
PUE-FP	LeanBigData-1	Alexandre Carvalho	01-02-2014	31-01-2017
PUE-FP	BEACONING	António Coelho	01-01-2016	31-12-2018
SERV-NAC	OASRN	Rui Barros	01-01-2013	31-12-2016
SERV-NAC	PWA	José Correia	17-06-2013	31-12-2017
SERV-NAC	vCardID	José Correia	01-01-2014	30-06-2017
SERV-NAC	Cap@CIDADE-1	Gabriel David	04-08-2014	30-09-2016
SERV-NAC	WiderMOS	Rui Barros	01-09-2014	30-06-2016
SERV-NAC	RTE	José Correia	01-05-2015	31-12-2016

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
SERV-NAC	DRIW2020	António Gaspar	01-09-2015	31-01-2016
SERV-NAC	SIGAMP	Lino Oliveira	01-01-2016	31-12-2017
SERV-NAC	ARQNET	José Correia	26-10-2016	30-06-2018
SERV-NAC	Consultoria	António Gaspar	01-01-2008	
OP	HDR4RTT	Maximino Bessa	30-09-2016	29-09-2018
OP	ACESSWEB	Ramiro Gonçalves	01-01-2015	30-06-2017
OP	ISEABlind	João Barroso	01-10-2016	28-02-2017

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.10.9 List of Publications

International Journals with Scientific Referees

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Books

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1. Cardoso, Joao M.P., Weinhardt, Markus, "High-Level Synthesis", FPGAs for Software Programmers, pp.23-47, 2016
2. Correia, A, Fonseca, B, Paredes, H, Martins, P, Morgado, L, "Computer-Simulated 3D Virtual Environments in Collaborative Learning and Training: Meta-Review, Refinement, and Roadmap", Progress in IS - Handbook on 3D3C Platforms, pp.403-440, 2016
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4. Rocha, P, Gomes, AM, Rodrigues, R, Toledo, FMB, Andretta, M, "Constraint aggregation in non-linear programming models for nesting problems", Lecture Notes in Economics and Mathematical Systems, vol.682, pp.175-180, 2016
5. Vaz de Carvalho, C, Escudeiro, P, Coelho, A, "Editorial", Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering - Serious Games, Interaction, and Simulation, pp.1-5

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1. Allison, C, Morgado, L, Pirker, J, Beck, D, Richter, J, Gütl, C, "Immersive Learning Research Network", Communications in Computer and Information Science
2. Silvano, C, Cardoso, JMP, Agosta, G, Hübner, M, "Proceedings of the 7th Workshop on Parallel Programming and Run-Time Management Techniques for Many-core Architectures and the 5th Workshop on Design Tools and Architectures For Multicore Embedded Computing Platforms, Parma-Ditam 2016, Prague, Czech Repub", PARMA-DITAM@Hipeac

Dissertations (PhD)

1. Azarian, A., "Task-Level Pipelining in configurable multicore architectures";
2. Barreira, J., "Desenvolvimento de aplicações de realidade aumentada coerentes com o contexto ambiental";
3. Carvalho, D., "Proposal of a novel multimodal Interaction model for users of different age groups";
4. Cruz, A. J., "Colaboração em mundos virtuais tridimensionais";
5. Freire, H., "Many-Objective Optimization with particicle swarm optimization algorithm";
6. Garcia, J., "Requirements change management based on web usage mining";
7. Jacob, J., "Estimating player performence and adaptivity in exergames and location-based games";
8. Paulino, N., "Generation of Custom run-time reconfigurable hardware for transparent binary acceleration";
9. Silva, J. M., "Usage-driven application profile generation using ontologies".

5.11 LIAAD – ARTIFICIAL INTELLIGENCE AND DECISION SUPPORT LABORATORY

Coordinator: Alípio Jorge

5.11.1 Presentation of the Centre

LIAAD accomplishes its mission within the Computer Science Cluster focusing on Intelligent and Adaptive Systems and Mathematical Modelling in Decision Support.

LIAAD aims to produce high quality cutting-edge research, to be in the international forefront of our research areas and promote transfer of knowledge and technology. This Centre is in the very strategic area of Data Science that has a growing importance in the world and is critical to all areas of human activity. The huge amounts of collected data (Big Data) and the ubiquity of devices with sensors and/or processing power offer opportunities and challenges to scientists and engineers. On the other hand, the demand for complex models for objective decision support is spreading in business, health, science, e-government and e-learning, motivating our investment in different approaches to modelling. Our overall strategy is to take advantage of the data flood and data diversification and invest in research lines that will help shorten the gap between collected data and useful data, as well as offering diverse modelling solutions.

The scientific foundations of LIAAD are machine learning, statistics, optimization and mathematics.

5.11.2 Research and Technology Development

Data Streams
Allow the treatment of continuous and voluminous streams of data generated by sensors or other sources. Actionable patterns can be found in different contexts, such as: Internet-of-Things, Industry, Transportation and the Web.

Temporal and Spatial data analysis
The ubiquitous and permanent data collection implies awareness of time and space; new algorithms are needed for prediction and monitoring of unusual events within spatio-temporal context converting predictions into useful decisions in subsequent decision making steps.

Web, Text and Media data analysis
The growth of the size and importance of the Web and social networks, and the increasing variety of contents require increasing data analysis capabilities of huge and complex data that enable powerful applications (including: information extraction, sentiment analysis, information retrieval, recommender systems, social network analysis).

Complex data analysis
Data comes in varied and new formats, containing more and more information, from domains ranging from genetics to urban mobility (including ILP, symbolic data analysis, network data, data fusion, variable selection and grouping, active learning).

Meta learning
The growing dynamics of data requires systems that are self-aware and capable of adapting to new problems with little human intervention.

Simulation and optimization
Focusing on solutions for decision problems in management science and other application areas; Exploiting meta-heuristics and optimization techniques based on genetic algorithms, ant colony systems, among others; methods using AI-based approaches, such as multi-agent framework, that enable the simulation of the society or the economy and the interplay between their agents.

Mathematical modelling

Focusing on dynamical systems and game theory: applicable to mathematical physics, mathematical biology, time series analysis, mathematical economy and finances and models of industrial organization.

5.11.3 Technology transfer

Recommender systems and personalization

We have extensive experience in recommender systems and personalization: the algorithms and the applications. We are able to put recommendation algorithms to work in production in various domains such as music recommendation, e-learning and commerce. The variety of data about products, customers, consumers coming from web browsing, shopping and movement can be exploited to understand and predict user behavior as well as to support users in coping with vast amounts of choices.

Data science in action

Data mining and machine learning are our core areas. We can help businesses and services to make sense of the growing pools of data they collect to improve their actions. We have experience in algorithm development and evaluation, data transformation and system deployment. We help companies and institutions to integrate data science and machine learning into their production flow and Business Intelligence from Business Understanding to Deployment. We currently work in domains such as telecommunications, agriculture, commerce, urban transports and power management, using a variety of data mining algorithms and techniques.

Consultancy in Data science

We are able to help companies and institutions in their effort to develop their own data science teams. We can advise on hiring specialized personnel and in help in the supervision of the data science team. We are able to identify opportunities for data valorization and provide recommendations on the best practice to follow.

Surveys and Data Analysis

We have competencies in statistical data analysis, including survey design, data collection, data cleaning and understanding, exploratory data analysis, development of predictive models and reporting. These are particularly useful for market studies, analysis of treatments and to measure any specific set of indicators.

Extracting information from text

Much of the data in companies and services is stored as text. People express their views as consumers and citizens on social networks. Relevant information emerges everyday in news, reports, scientific articles and on the Web. We are able to extract information from texts, including named entities, topics, relevant dates and sentiment. This information can be integrated in the data science workflow, exploited for decision making processes or used for producing new content.

Event and Anomaly detection

We develop algorithms for the detection of events and anomalies. We are able to design and deploy solutions in domains such as commercial fraud, telecommunications, smart cities, ecological systems and water management.

5.11.4 Knowledge valorisation chain

The following table presents the contribution of the “Research and Technology” areas to the “Technology Transfer” areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - LIAAD – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development		Status (2)	Areas of Technology Transfer --> relationships (3)				
			RecSys	Data Science	Data Analysis	Text mining	Anomaly detection
	Data Streams	I	H	H	L	M	H
	Temporal and Spatial data analysis	I		H	H	H	H
	Web, Text and Media data analysis	I	H			H	L
	Complex data analysis	I	M		H		M
	Meta learning	I		M			
	Simulation and optimization	I		M			M
	Mathematical modelling	I		M	L		M
Other areas (1)	Business Intelligence (CESE)	O	M	H			L

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contributio
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.11.5 Main Achievements in 2016

LIAAD maintained the high profile publication record in journals, conferences and books:

- 36 journal articles and 48 articles in conference proceedings. To pick up one particular case, in 2016 we had our fifth article in ACM Computing Surveys in five years (current impact factor is 5.243).
- Two edited books on Dynamical Systems and Mathematical Economics.

The organization of conferences and workshops is central for networking and the integration of researchers in the scientific communities. LIAAD researchers have participated as co-chairs in the following events:

- Mobile Data Modeling (MDM) conference in Porto;
- Dynamics Games and Science and Current Trends in Economics,
- Session 'Economic Dynamics', in the 16th SAET Conference on Current Trends in Economics, IMPA, Rio de Janeiro, Brazil;
- Special Session Dynamics and Games at the 11th AIMS Conference on Dynamical Systems, Differential Equations and Applications, Orlando, Florida, USA;
- Workshop on News Information Retrieval at ECIR (European Conference on Information Retrieval);
- Workshop ECAAS (Engineering Context-Aware Applications and Services) at Mobile Data Modeling conference, Porto;
- Workshop MobDM (Mobile Data Management) at Mobile Data Modeling conference, Porto.

LIAAD participated in national and international projects, mostly with a research focus, but also with a growing effort on knowledge transfer:

- The Maestra FP7 project moved towards its very successful closure;
- The RECAP H2020 project was accepted and started January 1st 2017;
- Privately sponsored projects PANACeA and BI4UP promoted knowledge transfer to the areas of Power Consumption analysis and Business Intelligence.

- The TEC4Sea line was continued with the participation in the projects MarinEye and CORAL.
- LIAAD was involved in 5 other national research projects.

5.11.6 Centre Organizational Structure and Research Team

The Centre has one coordinator, a management board, a management assistant and is organized in the following Areas:

- Machine Learning and Data Mining - João Gama / Luís Torgo
- Data Mining from Structured Data - Alípio Jorge / Pavel Brazdil / Rui Camacho
- Data Analysis and Statistical Methods - Paula Brito
- Modeling & Optimization - Dalila Fontes / Alberto Pinto

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - LIAAD – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees				
		Academic Staff	27	29	29	
		Grant Holders and Trainees	18	17	38	21
		Total Core Researchers	**45**	**46**	**67**	**21**
	Affiliated Researchers			5	5	
	Admin.& Tech	Employees				
		Grant Holders and Trainees				
		Total Integrated HR	**45**	**51**	**72**	**21**
		Total Integrated PhD	**28**	**37**	**41**	**4**
Curricular Trainees			17	10	5	-5
External Research Collaborators			18	15	15	
External Administrative and Technical Staff						
External Students			5	13	10	-3
Total			**85**	**89**	**102**	**13**

5.11.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - LIAAD – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	15	1	24	23
PN-PICT	National R&D Programmes - S&T Integrated Projects	30	49	127	78
PN-COOP	National Cooperation Programmes with Industry			1	1
PUE-FP	EU Framework Programmes	193	73	100	27
PUE-DIV	EU Cooperation Programmes - Other			16	16
SERV-NAC	R&D Services and Consulting - National	25	72	20	-52
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes	7	64	41	-24
Closed Projects			2		-2
Total Funding		**269**	**262**	**329**	**67**

Table 5.4 - LIAAD – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	30	44	36
International conference proceedings indexed by ISI, Scopus or DBLP	41	39	48
Books (author)			
Chapter/paper in books	12	3	5
PhD theses by members of the Centre	7	2	2
Concluded PhD theses supervised by members of the Centre		7	3

Table 5.5 - LIAAD – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6 - LIAAD – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	5
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	12
International events in which INESC TEC members participate in the program committees	15
Participation in events such as fairs, exhibitions or similar	1
Advanced training courses	3

5.11.8 List of Projects

Table 5.7 - LIAAD – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Dynamics2	Alberto Pinto	01-06-2016	31-05-2019
PUE-DIV	MarineEye-1	Luís Torgo	30-07-2015	30-04-2017
PN-PICT	FOUREYES-3	Alípio Jorge	01-07-2015	30-06-2018
PN-PICT	iMAN-4	Dalila Fontes	01-07-2015	30-06-2018
PN-PICT	SMILES-7	João Gama	01-07-2015	30-06-2018
PN-PICT	CORAL-TOOLS-5	Luís Torgo	01-01-2016	31-12-2018
PN-PICT	NanoStima-RL3-3	Rui Camacho	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL4-2	Rui Camacho	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL5-2	Carlos Ferreira	01-07-2015	30-06-2018
PN-COOP	SmartFarming-1	Carlos Ferreira	01-10-2016	30-09-2018
PUE-FP	MAESTRA	João Gama	01-02-2014	31-07-2017
SERV-NAC	BI4UP2-1	Carlos Soares	01-08-2016	31-03-2017
SERV-NAC	PANACea-1	João Gama	08-08-2016	07-03-2017
OP	ECML/ PKDD	João Gama	31-07-2014	30-06-2017
OP	MDM_2016	João Gama	01-01-2016	31-12-2017

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.11.9 List of Publications

International Journals with Scientific Referees

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2. Bessa, M, Dias, S, Pinto, AA, "Explosion of Differentiability for Equivalencies Between Anosov Flows on 3-Manifolds", Proceedings of the American Mathematical Society, vol.144, no.9, pp.3757-3766, 2016
3. Borchani, H, Larranaga, P, Gama, J, Bielza, C, "Mining multi-dimensional concept-drifting data streams using Bayesian network classifiers", Intelligent Data Analysis, vol.20, no.2, pp.257-280
4. Branco, P, Torgo, L, Ribeiro, RP, "A Survey of Predictive Modeling on in balanced Domains", ACM Computing Surveys, vol.49, no.2, pp.31:1-31:50, 2016
5. Brito, PQ, Pratas, J, "Online brochures: relationship between message strategies and communicated attributes", Anatolia, vol.27, no.1, pp.47-57
6. Brito, PQ, Rambocas, M, "Assessing the impact of mystery client traits on service evaluation", Journal of Services Marketing, vol.30, no.4, pp.411-426, 2016
7. Campos, R, Dias, G, Jorge, A, Nunes, C, "GTE-Rank: A time-aware search engine to answer time-sensitive queries", Information Processing & Management, vol.52, no.2, pp.273-298, 2016
8. Cerveira, A, de Sousa, A, Solteiro Pires, EJS, Baptista, J, "Optimal Cable Design of Wind Farms: The Infrastructure and Losses Cost Minimization Case", IEEE Transactions on Power Systems, vol.31, no.6, pp.4319-4329, 2016
9. Cordeiro, M, Sarmento, RP, Gama, J, "Dynamic community detection in evolving networks using locality modularity optimization", Social Network Analysis and Mining, vol.6, no.1, pp.15:1-15:20, Dec, 2016
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12. Duarte, J, Gama, J, Bifet, A, "Adaptive Model Rules from High-Speed Data Streams", TKDD, vol.10, no.3, pp.30, 2016
13. Fanaee T, H, Gama, J, "Event detection from traffic tensors: A hybrid model", Neurocomputing, vol.203, pp.22-33, 2016
14. Fanaee T, H, Gama, J, "Tensor-based anomaly detection: An interdisciplinary survey", Knowledge-Based Systems, vol.98, pp.130-147, 2016
15. Faria, ER, Goncalves, IJCR, de Carvalho, ACPLF, Gama, J, "Novelty detection in data streams", Artificial Intelligence Review, vol.45, no.2, pp.235-269, 2016
16. Fathi, M, Rodriguez, V, Fontes, DBMM, Alvarez, MJ, "A modified particle swarm optimisation algorithm to solve the part feeding problem at assembly lines", International Journal of Production Research, vol.54, no.3, pp.878-893, 2016
17. Galrao Ramos, AG, Oliveira, JF, Goncalves, JF, Lopes, MP, "A container loading algorithm with static mechanical equilibrium stability constraints", Transportation Research Part B-Methodological, vol.91, pp.565-581, 2016
18. Goncalves, JF, Resende, MGC, Costa, MD, "A biased random-key genetic algorithm for the minimization of open stacks problem", International Transactions in Operational Research, vol.23, no.1-2, pp.25-46, 2016
19. Goncalves, TC, Valente, JMS, Schaller, JE, "Metaheuristics for the single machine weighted quadratic tardiness scheduling problem", Computers & Operations Research, vol.70, pp.115-126, 2016

20. Kanda, J, de Carvalho, A, Hruschka, E, Soares, C, Brazdil, P, "Meta-learning to select the best meta-heuristic for the Traveling Salesman Problem: A comparison of meta-features", Neurocomputing, vol.205, pp.393-406, 2016

21. Kašpar, J, Perez, GFE, Cerveira, A, Marušák, R, "Spatial considerations of an area restriction model for identifying harvest blocks at commercial forest plantations", Forestry Journal, vol.62, no.3, 2016

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25. Moreira Matias, L, Gama, J, Ferreira, M, Mendes Moreira, J, Damas, L, "Time-evolving O-D matrix estimation using high-speed GPS data streams", Expert Systems with Applications, vol.44, pp.275-288, Feb, 2016

26. Mousa, AS, Pinheiro, D, Pinto, AA, "Optimal life-insurance selection and purchase within a market of several life-insurance providers", Insurance Mathematics & Economics, vol.67, pp.133-141, Mar, 2016

27. Nikhalat Jahromi, H, Bell, MGH, Fontes, DBMM, Cochrane, RA, Angeloudis, P, "Spot sale of uncommitted LNG from Middle East: Japan or the UK?", Energy Policy, vol.96, pp.717-725, SEP, 2016

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31. Ribeiro, RP, Pereira, P, Gama, J, "Sequential anomalies: a study in the Railway Industry", Machine Learning, vol.105, no.1, pp.127-153, OCT, 2016

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33. Rocha, A, Sousa, C, Teles, P, Coelho, A, Xavier, E, "Effect of Dialysis Day on Intradialytic Hypotension Risk", Kidney & Blood Pressure Research, vol.41, no.2, pp.168-174, 2016

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2. Abreu, S, Caldeira, A, Costa, AR, Gomes, T, Roque, LAC, "Interdisciplinary Team Work Applying working methods to a math project", 2016 2nd International Conference Of The Portuguese Society For Engineering Education (CISPEE), 2016

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Blank

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5.12 CRACS – CENTRE FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

Coordinator: Fernando Silva

5.12.1 Presentation of the Centre

The mission of CRACS, accomplished within the Computer Science Cluster, is to pursue scientific excellence in the areas of programming languages, parallel and distributed computing, security and privacy, information mining, and Web based systems with a focus on developing scalable software systems for challenging, multidisciplinary applications. The research team is currently composed by around 55 members, of which 15 are senior researchers, mostly faculty at the CS department at FCUP, and 8 post-docs. The research environment is enriched with junior talented researchers that together with senior researchers build the necessary critical mass and scientific competences to fulfil our mission.

5.12.2 Research and Technology Development

Languages and Distributed Computing

Our team leads in the design of high-level programming languages that integrate logical and probabilistic reasoning, supporting negation, tabling, and parallelism; languages for mobile distributed environments that are "correct-by-design", namely, in wireless sensor networks (WSN), aiming to simplify programming and debugging; middleware frameworks capable of supporting sensing and actuation activities in large WSN deployments, with a focus on scalability, energy efficiency and seamless management; innovative peer-to-peer middleware and cloud-computing platforms, specifically for ad-hoc networks of mobile devices; scheduling for edge-computing. A synopsis of our main intervention in this area is:

- Programming Languages Theory and Implementation
- Parallel and Distributed Computing
- Middleware for Mobile-Computing

Security and Privacy

We focus on algorithms and methodologies to improve the usability of privacy and security in software and systems, namely on user-controlled identity management systems that respect user privacy and protect personally identifiable information; secure identity cards and authentication mechanisms with a view to ensure access control to physical locations or networks, as well as to enable identity verification in online transactions or governmental services communications to guarantee its data integrity and non-repudiation properties; specialized algorithms and tools for sharing sensitive data while preserving privacy; ethical hacking and penetration testing for pre-emptive vulnerability detection. We have been collaborating with the Portuguese Data Protection Commission as consultants in national projects and with Portuguese National Security Agency on auditing systems and developing solutions to secure mobile communications. A synopsis of our main intervention in this area is:

- Identity Management Systems
- Secure Tokens for eID
- Privacy Enhancing Technologies

Knowledge in a World of Data

We work on the bridge between logic, probabilities, data structures and learning. Our focus is on applications that tie our work together with domains such as author identification, semantic relatedness, sentiment discovery, complex networks, motifs discovery, sensor data streams, medical records data, and high-throughput genomics data. A synopsis of our main intervention in this area is:

- Machine Learning and Discovery
- Big Data Applications
- e-Learning Environments and Tools

5.12.3 Technology transfer

YAP Prolog

We are a leading group on the implementation of sequential and parallel logic programming systems. Yap Prolog is a highly regarded system in the research community, especially for machine learning, being distributed by Fedora Linux distribution. It supports just-in-time compilation, multiple forms of parallelism, multithreading, tabling, constraints handling, probabilistic inductive logic programming, etc. It is widely used as a teaching, research and development tool.

Mooshak

We developed a contest management tool system that has been widely used for competitive programming in many regions, but also as a teaching tool as an automatic exercises evaluator in CS courses such as introduction to programming, data structures and algorithms, graphical interfaces, databases. It has also been used for an IEEE Xtream contest involving over 3000 students with a setup of 19 servers on the cloud.

Authenticus

We developed the Authenticus national repository of scientific publications metadata authored by researchers from Portuguese institutions. The system automatically uploads publications from multiple indexing databases, automatically associates publication authors with known researchers and institutions, provides specialised interfaces to researchers and institutions to confirm or dismiss proposed associations, allows interoperability with other CRIS systems, provides synchronisation with ORCID, both for import and export, among many other functionalities. It currently has 2,700 registered active users and over 420,000 publication records from 4 sources (ISI, Scopus, DBLP, and Crossref). It has been supported by FCT, University of Porto and INESC TEC.

FotoCatGraf

In FOTOCATGRAF, in cooperation with REQUIMTE, we developed a small, cheap, electrochemical sensor that allows the measurement of the concentrations of a class of emerging pollutants — pharmaceutical substances and their metabolites. The sensor is designed to be seamlessly integrated into wireless sensor networks to be deployed in wastewater treatment plants for automatic, high cadence, collection of data to monitor the concentration of the most harmful pollutants. The resulting data-sets can then be mined to detect patterns that allow a deeper understanding of the usage and life-cycle of these pollutants in the environment and, also, to support environmental and public health policy decisions. Currently, we are looking for an industrial partner to take over this technology.

Distributed Mobile Computing

Mobile devices have become ubiquitous and traditionally viewed as “thin clients” or “edge devices” that serve primarily as user-input devices. More recently, with their increased computing and storage capabilities, their potential is now viewed as “thick clients,” and going even further, to rethink them as “thin servers”. Given the proliferation and enhanced capabilities of mobile devices, it is now a real possibility for a “wireless cloud of nearby smartphones” to pose an interesting-enough collective computational/storage resource. Our group has expertise in the development of middleware for edge computing and for building innovative proximity-aware applications that pool nearby devices data and processing power to construct hyperlocal edge clouds. HYRAX is project in the context of the CMU-Portugal initiative that addresses the crowdsourcing of mobile devices for edge computing.

Cloud Computing Services

Our group has experience in the design and deployment reliable cloud infrastructures using OpenStack and Ovirt, comprising both storage and infrastructure-as-a-service (IaaS). We were responsible for the setup of INESC TEC Cloud-CA, a cloud comprising 280 computing cores, 1.5TB of main memory and 16TB of storage that was built to be fully redundant and fault tolerant from the network to the service layers.

Privacy Enhancing Technologies and eID

Our group has expertise in privacy enhancing technologies as described in (EU 2007), namely on the “design of information and communication systems and services in a way that minimises the collection and use of personal data and facilitates compliance with data protection rules making breaches more difficult and/or

helping to detect them". We have a long history of collaboration with the Portuguese Data Protection Authority, exemplified with the C3Priv project whose main goal was to return the control of the data to the users, and the Break-the-Glass work that originated a PhD thesis that won the Fraunhofer best PhD thesis with practical application, later its implementation on the second largest hospital won the CNPD privacy prize. Some of our researchers collaborate on the International Working Group on Data Protection in Telecommunications and are actively involved in the new European General Data Protection Regulation and may provide some guidance and consultancy on its implementation.

Regarding eID, we emphasize our work developing and implementing a fingerprint match-on-card algorithm on smartcards for the next version of the Portuguese citizen card in the context of a contract from INCM.

5.12.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - CRACS – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)								
	Status (2)	Yap Prolog	Mooshak	vCardID	Authenticus	FotoCatGraf	HLTSYS	ADYTA	INTERRELATE
Programming Languages Theory and Implementation	I	H	M		L	L			
Parallel and Distributed Computing	I	H	L		L	M			
Middleware for Mobile Computing	I					M			
Identity Management Systems	I						H		
Secure Tokens for eID	I			H				H	
Privacy Enhancing Technologies	I						H		
Machine Learning and Discovery	I	H			M				H
Big Data Applications	I	H			L				M
e-Learning Environments and Tools	I		H						

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer

(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership

(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.12.5 Main Achievements in 2016

Over the years, CRACS has been quite successful in consolidating the research team, attracting young talented researchers, keeping a good publication ratio, increasing international cooperation, and participating in program committees of reputable international conferences. Some highlights of 2016 follow:

RESULTS:

CRACS was successful with 1 new European project, Digi-NewB - Non-invasive monitoring of perinatal health through multiparametric digital representation of clinically relevant functions, a project funded with €4.5M through H2020-EU.3.1 - Societal Challenges - Health, demographic change and well-being. It involves partners from France, Finland, Ireland and Portugal.

CRACS published over 50 publications: 10 in journal, 31 in international conferences (21 of which in Proceedings by Springer, ACM, or IEEE), 3 technical books, 3 book proceedings, and 3 book chapters.

CRACS members participated in the organization and/or PCs of a good number of relevant conferences, such as ECML PKDD, ICLP, ILP, AAAI, FAB, FSCD, PADL, MOD, EPIA, StaRAI, IDEAS, CSE, FLOPS.

Regarding advanced training: 20 MSc and 1 PhD theses were concluded; there are 27 MSc and 16 PhD ongoing; 22 junior researchers were hired with project funding.

ACTIVITIES

Yap: a highly reliable and performing Prolog system developed by CRACS group since the 80s. It is a vehicle for research as well as for teaching and industry. Research achievements around Yap and logic based systems in 2016 involved:

- implementation of pruning strategies to reduce the search space of probabilistic logic programming systems.
- extension of the tabling engine based on a lock-free design to scale the execution of multithreaded dynamic programming problems.
- ExpertBayes: a Bayesian network-based system composed of an interactive user interface, and a novel algorithm that takes as input networks built by experts plus data, and refines those networks without changing much the main structure suggested by the expert.
- GPU-Datalog: a GPU-based datalog system (Yap-based)
- Tu2GPU: a GPU-based Markov Logic Network system (GPU-datalog based)
- an extension to the LM concurrent forward-chaining linear logic programming language, named Coordinated Linear Meld (CLM), which allows the programmer to coordinate the execution of parallel programs by specifying arbitrary scheduling and data partitioning policies in a declarative way (in cooperation with CMU).

Logtalk: With continued sponsorship from a US company, Kyndi Inc., highlights for 2016 include runtime performance improvements (notably, code inlining), improved reflection API, library updates, a dead code scanner developer tool, QuickCheck support for the unit testing tool, improved test automation support, a "doclet" tool, a threaded engines API, significant updates to existing developer tools, new examples, extended test suites, and documentation improvements.

Hyrax: the development of the Hyrax middleware to support the programming of crowd-sourcing applications continued throughout 2016. The link layer, supporting multiple wireless protocols, is now robust and has been distributed to project partners. Work started on the network layer for which a specification was in place by the end of 2016. Several prototype applications and services were developed on top of the link layer, namely User Generated Replays (streaming), P3-Mobile (computing) and Ephesus (storage).

REMINDS: an international project to design and develop a system that automatically crawls and identifies potential relevant information, from a journalistic perspective, in social media, by filtering personal, trivial or fake information, and focusing on trendy or controversial topics.

FOTOCATGRAF: the hardware prototype was completed and debugged and all the software for control and operation of the sensor was developed. We performed several tests with the equipment using test probes on calibration solutions. The results were similar to those obtained with bulky (and very expensive) voltammetry equipment at the Chemistry Department. We started looking for an industry partner that might develop the prototype into a final product.

5.12.6 Centre Organizational Structure and Research Team

The Centre is coordinated by Fernando Silva, who ensures scientific coordination jointly with Luís Antunes. The Centre is organized in the following Areas:

- Languages and Distributed Computing - Responsible: Luís Lopes and Ricardo Rocha
- Security and Privacy - Responsible: Luís Antunes
- Knowledge in a World of Data - Responsible: Inês Dutra and Vítor Santos Costa

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - CRACS – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	2	2	2	
		Academic Staff	12	13	14	1
		Grant Holders and Trainees	33	31	41	10
		Total Core Researchers	**47**	**46**	**57**	**11**
	Affiliated Researchers			1	2	1
	Admin.& Tech	Employees	1	1	1	
		Grant Holders and Trainees		1	1	
	Total Integrated HR		**48**	**49**	**61**	**12**
	Total Integrated PhD		**17**	**18**	**23**	**5**
Curricular Trainees			1	2	1	-1
External Research Collaborators			10	6	11	5
External Administrative and Technical Staff						
External Students				2	1	-1
Total			**59**	**59**	**74**	**15**

5.12.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3-CRACS – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT	153	160	141	-19
PN-PICT	National R&D Programmes - S&T Integrated Projects			172	172
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	23	11	67	55
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	171	277	114	-162
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes				
Closed Projects				2	2
Total Funding		**347**	**448**	**497**	**48**

Table 5.4 - CRACS – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	9	9	9
International conference proceedings indexed by ISI, Scopus or DBLP	30	36	29
Books (author)	1	1	
Chapter/paper in books	2	4	3
PhD theses concluded by members of the Centre	5	3	1
Concluded PhD theses supervised by members of the Centre		2	1

Table 5.5 - CRACS – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6 - CRACS – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	1
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	4
International events in which INESC TEC members participate in the program committees	18
Participation in events such as fairs, exhibitions or similar	1
Advanced training courses	

5.12.8 List of Projects

Table 5.7 - CRACS – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-FCT	Authenticus	Fernando Silva	22-04-2013	31-12-2016
PN-FCT	Hyrax	Fernando Silva	01-04-2014	31-03-2018
PN-FCT	REMINDS	Álvaro Figueira	27-04-2015	10-11-2017
PN-FCT	FOTOCATGRAF	Luís Lopes	01-06-2015	31-05-2018
PN-FCT	ELVEN	Vítor Santos Costa	01-07-2016	30-06-2019

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-PICT	FOUREYES-4	José Paulo Leal	01-07-2015	30-06-2018
PN-PICT	SMILES-3	Fernando Silva	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL3	Luís Antunes	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL4	Luís Antunes	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL5-3	Luís Antunes	01-07-2015	30-06-2018
PUE-FP	Digi-NewB	Luís Antunes	01-03-2016	29-02-2020
SERV-NAC	vCardID-2	Fernando Silva	01-01-2014	30-04-2017
SERV-NAC	PANF	Fernando Silva	15-04-2015	31-12-2016
SERV-NAC	vCardID2-1	Fernando Silva	01-12-2016	31-03-2017
SERV-NAC	Consultoria	Fernando Silva	01-01-2010	

Type of Project:

PN-FCT	National R&D Programmes - FCT
PN-PICT	National R&D Programmes - S&T Integrated Projects
PN-COOP	National Cooperation Programmes with Industry
PUE-FP	EU Framework Programme
PUE-DIV	EU Cooperation Programmes - Other
SERV-NAC	National R&D Services and Consulting
SERV-INT	International R&D Services and Consulting
OP	Other Funding Programmes

5.12.9 List of Publications

International Journals with Scientific Referees

1. Alves, Sandra, "Report on FSCD 2016: 1st International Conference on Formal Structures for Computation and Deduction", SIGLOG News, vol.3, no.4, pp.50-54, 2016
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Blank

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5.13 HASLAB – HIGH-ASSURANCE SOFTWARE LABORATORY

Coordinators: Alcino Cunha and Manuel Barbosa

5.13.1 Presentation of the Centre

HASLab is focused on the design and implementation of high-assurance software systems: software that is correct by design and resilient to environment faults and malicious attacks. HASLab accomplishes its mission within the Computer Science Cluster, anchoring its research on a rigorous approach to three areas of Computer Science: Software Engineering, Distributed Systems, and Cryptography and Information Security. The contributions of HASLab to these areas range from fundamental research on formal methods and algorithms, to applied research on developing tools and middleware that address real-world demands stemming from long-term collaborations with industry.

5.13.2 Research and Technology Development

In 2016, HASLab conducted research in the following areas:

Software Engineering

Our research on Software Engineering focuses mainly on developing formal methods for system design and program verification, in order to achieve high-quality software. In particular, we develop formal languages and tools for specification, verification (model checking), and design of complex systems, including stochastic, continuous, and systems where human-computer interaction plays a central role. This work is supported by a strong research line on the structural and foundational aspects of computer science. We also develop static and dynamic (automatic) analysis techniques for checking several software quality aspects, for example execution safety or energy consumption, and for automatic testing and debugging, namely fault localization.

Distributed Systems

Our work on Distributed Systems focuses on dependable data management for cloud computing and data science environments. In particular, we are interested in combining the scalability of NoSQL systems with the functionality of relational and transactional database management systems. Our contributions encompass the development of new techniques and mechanisms for data replication and distribution, including conflict-free approaches to eventual consistency with conflict-free replicated data types, query processing focused on analytic workloads, secure data processing in untrusted infrastructures, and operational management of performance and reliability. The main challenge is thus to make novel data management technologies as safe and usable as practice as the well-known and trusted SQL technologies.

The support of scalability is grounded on efficient dissemination protocols and data collection. This is based on topologies that are both resilient and effective in dissemination speed and load, and when appropriate, in stochastic data aggregation techniques that reduce the communication load while providing a global view of the system with controlled accuracy.

Cryptography and Information Security

Our work in Cryptography and Information security covers both fundamental and applied topics, and also the challenge of bridging theory and practice. At the theoretical level, we conduct research in provable security and machine-assisted cryptography, where the goal is both to develop the theoretical foundations of rigorous security analysis of cryptographic protocols, and to design formal verification techniques that permit verifying security proofs. At the applied level, we focus on high-efficiency and high-security implementations of cryptography, with an emphasis on providing high-assurance as to the functional and non-functional properties of cryptographic implementations. A major challenge that we address at this level is to provide domain-specific languages and tool support that guarantee the preservation of theoretically proven properties from high-level specifications to low-level implementations. Privacy enhancing technologies for securely storing data and computing in the Cloud are the most prominent application scenarios we have recently addressed.

5.13.3 Technology transfer

In 2016 HASLab offered the following technology transfer and consultancy services:

Requirement specification and validation

Early validation of requirements is key to ensure the success of a software project. We have members with a vast experience on using formal methods to specify and validate requirements (and on reliable system design methodologies in general) that can provide early feedback to all stakeholders about potential inconsistencies and critical scenarios. We can also provide consultancy in the process of developing domain specific languages and tools for requirement elicitation and validation. Finally, one important technology transfer area is the analysis of security requirements in software applications, namely those involving complex trust models, such as those arising in the Cloud, and the use of cryptography for more than securing communications and data at rest.

Algorithm design and implementation

We can provide consultancy in the design of algorithms for several complex and critical domains, for example, distributed data synchronization and aggregation, secure implementations of high-speed cryptographic modules for embedded devices, and complex implementations of advanced privacy enhancing protocols for the Cloud. We can also provide implementations of such algorithms with high correctness and efficiency guarantees, and, when applicable, implementations that are correct-by-construction obtained by refinement of formal specifications.

Evaluation of critical software components

We have expertise on evaluating the implementation of critical software components in order to check their conformance to functional and non-functional requirements, for example, security, execution safety, energy consumption, scalability or usability. We can also provide consultancy in the process of software certification required in several critical domains, for example, medical devices or aerospace. In the area of cryptographic software development, we can provide independent validation of correctness and non-functional properties such as the deployment of side-channel countermeasures.

Polyglot data management

The use of multiple data management technologies side-by-side is increasingly common in practice. Besides the traditional SQL database management systems, applications rely on novel systems such as MongoDB or HBase for storage, and on Hadoop or Spark for query processing. In particular, the technologies based on the Hadoop stack have been proven useful in a variety of application domains. We have experience in deploying and operating these systems and can provide support in their implementation in new scenarios and the optimization of existing applications. Moreover, we have experience in integrating and combining multiple technologies in the scope of the same application.

Cloudification services

The deployment of applications on today's technological landscape is moving towards the cloud. The industry largest companies have started to migrate their infrastructure to a cloud environment, seeking to reduce the operational costs and reaping the benefits of resource allocation on demand. Whether the transitions are made to a public service provider, a private cloud or a hybrid-model there is always the problem of integrating an application on the cloud environment. It is not simply a matter of deploying an application on a virtualized environment, there are always concerns regarding the application’s configuration, components interaction, resource monitoring and automatic resource allocation. From years of research and by collaborating with the industry, we gathered the experience required to accelerate the transition of applications to the cloud.

In 2016, one of the main application areas was eGovernment, with two consultancy projects with government agencies involving requirement specification and validation, algorithm design and implementation and evaluation of critical software components. We also had a consultancy project with a major cloud service provider that required our competences in the topics of polyglot data management and cloudification services.

5.13.4 Knowledge valorisation chain

The following table presents the contribution of the "Research and Technology" areas to the "Technology Transfer" areas, giving some insight into the operation of the knowledge valorisation chain relevant to the Centre.

Table 5.1 - HASLab – Table of relationships between the areas of Research and Technology Development and the areas of Technology Transfer

Areas of Research and Technology Development	Areas of Technology Transfer --> relationships (3)					
	Status (2)	Requirement specification and validation	Algorithm design and implementation	Evaluation of critical software components	Polyglot data management	Cloudification services
Software Engineering	I	H	M	H	L	L
Distributed Systems	I	L	H	M	H	H
Cryptography and Information security	I	M	H	M	L	M

(1) Existing areas in other Centres of INESC TEC (name in brackets) new areas to be created internally or external partnerships relevant for the development of one or more areas of Technology Transfer
(2) I - Internal; O - Other Centre of INESC TEC; C – To be created internally; E – External partnership
(3) "blank" – no direct relationship / contribution
L – Low or weak relationship / contribution; M – Medium relationship / contribution;
H – High or strong relationship / contribution; F – Future predicted relationship / contribution

5.13.5 Main Achievements in 2016

In 2016, HASLab has continued to perform fundamental and applied research that satisfies the quality standards of the top rated journal and conferences. In particular, we had 2 papers published at top venues, rated A* by the popular computer science CORE Australian ranking, namely 1 article at the IEEE Transactions on Software Engineering presenting a "A Survey on Software Fault Localization" and 1 paper at the USENIX Security Symposium about "Verifying Constant-Time Implementations". For the first time, we also had an article at the Communications of the ACM, the monthly journal of this association that reaches a very large audience worldwide, explaining "Why logical clocks are easy".

Concerning prizes, HASLab members obtained the best paper award at the Fast Software Encryption conference and a HASLab researcher also received the Inria-CNIL Award for Security and Privacy in 2016, an annual prize that distinguishes scientific articles focusing on the protection of privacy and personal information. This latter prize was awarded to a new system that allows verifiable computations by third parties, preventing any part of the original data from being divulged, with the exception of their authenticity, a work first published at the IEEE Security and Privacy Conference in 2015.

In terms of projects, 2016 was marked by the successful conclusion of the FP7 project PRACTICE, where HASLab led the formal verification activities that were undertaken to obtain high-assurance implementations of cryptographic systems. Two new European H2020 projects where HASLab is involved were also accepted in 2016: LightKone - Lightweight Computation for Networks at the Edge – with a total funding of €3.5M and the goal of developing a scientifically solid and validated model to perform distributed computing in edge networks; and CloudDBAppliance - European Cloud In-Memory Database Appliance with Predictable Performance for Critical Applications – with a total funding of €5M and the goal of building a European-level database platform that relies entirely on cloud technologies, promoting the concept of "Database as a Service", i.e. a database viewed as a service with high availability in the cloud.

Finally, 2016 was also marked by the launch of SafeCloud Photos, the first mobile application developed by HASLab researchers globally available at the App Store and Google Play Store. This application, an outcome of

the European project SafeCloud, is a Cloud storage application focused on ensuring the maximum privacy of uploaded photos. The application launch occurred in the Open Day HASLab 2016, an event targeted for the software industry that was attended by over 70 participants and that focused on the theme "Software Quality". The SafeCloud Photos business idea was also on display at the 2016 Web Summit, and was highlighted by Observador journal as one of the top five business ideas of this event.

5.13.6 Centre Organizational Structure and Research Team

The HASLab is coordinated by Alcino Cunha and Manuel Barbosa and is organized in the following areas:

- Software Engineering - Responsible: Alcino Cunha
- Distributed Systems - Responsible: José Orlando Pereira
- Cryptography and Information Systems - Responsible: Manuel Barbosa

The Centre research team present composition and evolution is presented in Table 5.2.

Table 5.2 - HASLab – Research team composition

Type of Human Resources			2014	2015	2016	Δ 2015-2016
Integrated HR	Core Research Team	Employees	2	2	2	
		Academic Staff	12	13	14	1
		Grant Holders and Trainees	33	31	41	10
		Total Core Researchers	**47**	**46**	**57**	**11**
	Affiliated Researchers			1	2	1
	Admin.& Tech	Employees	1	1	1	
		Grant Holders and Trainees		1	1	
		Total Integrated HR	**48**	**49**	**61**	**12**
		Total Integrated PhD	**17**	**18**	**23**	**5**
Curricular Trainees			1	2	1	-1
External Research Collaborators			10	6	11	5
External Administrative and Technical Staff						
External Students				2	1	-1
Total			**59**	**59**	**74**	**15**

5.13.7 Activity indicators in 2016

The following tables present the main indicators of the activity developed in 2016 – participation in projects under contract, scientific production, IP valorisation and knowledge dissemination. The information on publications for 2016 has been obtained from different indexing sources (ISI, SCOPUS and DBLP) gathered by the Authenticus platform, and also from CORE (Computing Research and Education Association of Australasia).

Table 5.3 - HASLab – Project funding

Funding Source		Total Income (k€)			
		2014	2015	2016	Δ 2015-2016
PN-FCT	National R&D Programmes - FCT				
PN-PICT	National R&D Programmes - S&T Integrated Projects			132	132
PN-COOP	National Cooperation Programmes with Industry				
PUE-FP	EU Framework Programmes	306	436	340	-96
PUE-DIV	EU Cooperation Programmes - Other				
SERV-NAC	R&D Services and Consulting - National	21	130	99	-31
SERV-INT	R&D Services and Consulting - International				
OP	Other Funding Programmes		9		-9
Closed Projects					
	Total Funding	**327**	**576**	**571**	**-5**

Table 5.4 - HASLab – Summary of publications by members of the Centre

Type of Publication	2014	2015	2016
Papers in international journals indexed by ISI, Scopus or DBLP	21	27	43
International conference proceedings indexed by ISI, Scopus or DBLP	65	48	55
Books (author)			
Chapter/paper in books	4		2
PhD theses concluded by members of the Centre	2	4	3
Concluded PhD theses supervised by members of the Centre		5	3

Table 5.5 - HASLab – Summary of IP protection, exploitation and technology transfer

Type of Result	No.
Invention disclosures	0
Software copyright registrations	0
Patent applications	0

Table 5.6 - HASLab – Summary of dissemination activities

Type of Activity	No.
Participation as principal editor, editor or associated editor in journals	6
Conferences organized by INESC TEC members (in the organizing committee or chairing technical committees)	16
International events in which INESC TEC members participate in the program committees	61
Participation in events such as fairs, exhibitions or similar	17
Advanced training courses	2

5.13.8 List of Projects

Table 5.7 - HASLab – List of projects

Type of Project	Short Name	Leader	Starting date	Ending date (planned)
PN-PICT	SMILES	Carlos Baquero	01-07-2015	30-06-2018
PN-PICT	CORAL-TOOLS-7	Alcino cunha	01-01-2016	31-12-2018
PN-PICT	NanoStima-RL1-4	José Creissac Campos	01-07-2015	30-06-2018
PN-PICT	NanoStima-RL3-4	Manuel Barbosa	01-07-2015	30-06-2018
PUE-FP	CoherentPaaS	Rui Carlos Oliveira	01-10-2013	30-09-2016
PUE-FP	Practice	Manuel Barbosa	01-11-2013	31-10-2016
PUE-FP	LeanBigData	Rui Carlos Oliveira	01-02-2014	31-01-2017
PUE-FP	SafeCloud	Rui Carlos Oliveira	01-09-2015	31-08-2018
PUE-FP	UPGRID-2	Rui Carlos Oliveira	01-02-2015	31-01-2018
PUE-FP	CloudDBAppliance	Rui Carlos Oliveira	01-12-2016	30-11-2019
SERV-NAC	vCardID-3	Rui Carlos Oliveira	01-01-2014	30-06-2017
SERV-NAC	vCardID2	Rui Carlos Oliveira	01-12-2016	31-03-2017

Type of Project:

PN-FCT National R&D Programmes - FCT
PN-PICT National R&D Programmes - S&T Integrated Projects
PN-COOP National Cooperation Programmes with Industry
PUE-FP EU Framework Programme
PUE-DIV EU Cooperation Programmes - Other
SERV-NAC National R&D Services and Consulting
SERV-INT International R&D Services and Consulting
OP Other Funding Programmes

5.13.9 List of Publications

International Journals with Scientific Referees

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2. Arriaga, A, Barbosa, M, Farshim, P, "Private Functional Encryption: Indistinguishability-Based Definitions and Constructions from Obfuscation", IACR Cryptology ePrint Archive, vol.2016, pp.18, 2016
3. Baquero, C, Preguiça, NM, "Why Logical Clocks are Easy", ACM Queue, vol.14, no.1, pp.60, 2016
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6. Barbosa, M, Portela, B, Scerri, G, Warinschi, B, "Foundations of Hardware-Based Attested Computation and Application to SGX", IACR Cryptology ePrint Archive, vol.2016, pp.14, 2016
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16. Fortes, Nuno, Moreira, AntonioCarrizo, Saraiva, Joao, "Determinants of Consumer Intention to Use Online Gambling Services: An Empirical Study of the Portuguese Market", IJEBR, vol.12, no.4, pp.23-37, 2016
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18. Harrison, MichaelD., Campos, JoseCreissac, Masci, Paolo, Curzon, Paul, "Templates as heuristics for proving properties of medical devices", EAI Endorsed Trans. Creative Technologies, vol.3, no.8, pp.e1, 2016
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6 TEC4 INITIATIVES

6.1 Overview

INESC TEC intends to present its competencies on the market based on a new structured model that facilitates the targeting of potential clients and the communication with companies and stakeholders. This strategic initiative is being leveraged by the Industrial Partnerships Service and it is supported by a new multidisciplinary approach organized in thematic areas, called TEC4 ("TEChnologies FOR …") that have a strong link with the regional and national smart specialization strategy.

The TEC4 initiatives address regional and national challenges by mapping the short- and medium-term domain needs with the INESC TEC scientific roadmaps. Typically, three distinct parts compose each TEC4:

- A concrete market domain, represented by businesses and associations;
- A multidisciplinary scientific community dedicated to the challenges of that market domain;
- A technological R&D infrastructure that supports the scientific and innovation activities and is able to offer high added value services to businesses that cannot be found in the market.

Each TEC4 must have its own strategic agenda, according to their market domain, addressing three pillars: the stakeholders and partnerships perspective, the scientific roadmap and the technological R&D infrastructure evolution - to keep up with the state-of-the-art and support the roadmap.

The TEC4 initiatives bring together the R&D Institutions, businesses and associations, increasing synergies and critical mass to address real world challenges. The short-term objectives of the TEC4 initiatives are the creation of innovative products and services with high export potential, based on internationally competitive research and innovation capabilities, contributing to the resilience and growth of the Portuguese economy. The long-term objectives of the TEC4 comprise the identification of scientific and technical challenges, embracing multiple disciplines, involving and exploiting the full potential of INESC TEC in application domains that are easily understood and incorporated by businesses. Creating and maintaining these virtuous innovation cycles within each TEC4 is the main medium to long-term challenge.

6.1.1 Current Initiatives

Currently, INESC TEC is leading six TEC4 initiatives, in different stages of maturity and devoted to the following domains:

- TEC4Sea – sea activities and economy
- TEC4Media – creative industries and tourism
- TEC4Agro – agro-food and forestry
- TEC4SIndustry – production technologies, manufacturing, retail, distribution, logistics and transport
- TEC4Energy – energy related activities and economy
- TEC4Health – health and well-being

The application domains addressed by the TEC4 have the advantage of mapping directly in regional and national priority domains, aligning and consolidating internal R&D competencies around economic pillars, well understood by businesses. Furthermore, attracting international partners to the TEC4 initiatives, supports the INESC TEC internationalization strategy, facilitates the national companies an easy access to international partners and potentiates the attraction of foreign direct investment into the Region and the country.

6.1.2 Methodology

The TEC4 initiatives are operationalized through collaborative and multidisciplinary platforms, coordinated by INESC TEC, but open to other scientific institutions. These collaborative and multidisciplinary platforms, putting together R&D entities, businesses and associations, supported by R&D infrastructures, create a unique environment to develop scientific activities that serve the businesses' innovations needs.

Each TEC4 follows an implementation plan covering different maturity states:

- Identification of market segments where INESC TEC competencies can create value;

- Identification of internal research lines with highest potential impact in businesses – based on the assessment of market needs;
- Identification of the R&D infrastructure (i.e., laboratories, equipment, demonstration facilities and other technical means) supporting the offer of high added value services to businesses;
- Identification of new potential partners and stakeholders that can bring added value to the TEC and support its innovation cycle;
- Definition/alignment of the strategic agenda of each TEC and the creation of its advisory board;
- Establishment of collaboration plans with other institutions and running of the projects.

Given their current maturity levels and the results obtained, the TEC4Sea and TEC4Media are described below.

6.2 TEC4SEA

Coordinator: Eduardo Silva

6.2.1 Motivation

The oceans have been seen as an opportunity to support the future challenges driven by global economic growth and increasing demand. This will change the landscape of maritime industries in the coming decades, in terms of established and emerging industries (See the Table 6.1).

Established	Emerging
Capture fisheries	Marine aquaculture
Seafood processing	Deep- and ultra-deep water oil and gas
Shipping	Offshore wind energy
Ports	Ocean renewable energy
Shipbuilding and repair	Marine and seabed mining
Offshore oil and gas (shallow water)	Maritime safety and surveillance
Marine manufacturing and construction	Marine biotechnology
Maritime and coastal tourism	High-tech marine products and services
Marine business services	Others
Marine R&D and education	
Dredging	

Table 6.1 - Established and Emerging Ocean Industries (copied from OCDE Report[2])

Driven primarily by developments in global population, economic growth, trade and rising income levels, climate and environment, and technology, the rapid expansion of economic activity in the oceans has the potential to outperform the growth of the global economy as a whole until 2030, both in terms of added value and employment. Particularly strong growth is expected in marine aquaculture, offshore wind, fish processing, and shipbuilding and repair. Ocean industries also have the potential to make an important contribution to employment growth. Deep-sea mining is also gaining momentum. Increasing political interest on this matter has been driven by the increasing demand for natural resources supported by economic growth and growing population. Extraction rates are expected to accelerate further over the next two to three decades.

Portugal has the 3rd largest Exclusive Economic Zone (EEZ) of the EU and the 10th largest EEZ in the world. With the new reality brought by the Continental Shelf Extension proposal, currently under appreciation by the United Nations Commission on the Limits of the Continental Shelf (CLCS), the Portuguese territory becomes approximately 4 million km2 wide (roughly equivalent to 91% of the European Union's land area), with the vast majority of this North Atlantic area being constituted by deep and ultra-deep sea. Thus, the two main contextual challenges to the national capability for both exploration and exploitation of the Portuguese Sea are the referred dimension and depth difficulties.

TEC4Sea is fully aligned with international and National trends, and lies on the assumption that sustained innovation in the maritime sector can only be achieved by joining researchers, end users, SMEs and public agencies in a single organization with enhanced links to closest stakeholders.

[2] "OECD (2016)", The Ocean Economy in 2030, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264251724-en

6.2.2 TEC4Sea Presentation

Vision: Within TEC4SEA, INESC TEC aims at becoming a worldwide institution of reference concerning R&D technologies and solutions to overcome the deep-sea challenges, as well as empowering the Sea Economy through sustainable approaches for exploring and exploiting living and non-living ocean resources.

TEC4Sea has ambitious goals that imply:

- To establish an entity able to address all steps of the market value chain, ranging from research to innovation with focus on the creation of value by R&D+I;
- To gather a fairly diversified set of multidisciplinary competences and resources, in complementary engineering and scientific fields related with addressed ocean engineering market segments, solidly put in place through a well-designed and coherent plan;
- To put together a "big picture" (stating the Blue Economy importance and driving top-down policy) mapping the opportunities along the value chain and the "small picture" to engage the researchers, SMEs and cluster organisations which can integrate these perspectives;
- To establish and strengthen a network of stakeholders, from different types such as SMEs, Large Industry, Governmental organizations, research Centres, University and NGO's, streamlining and developing the Sea Research Business activity in all steps of the value chain.

TEC4Sea addresses these goals through three dimensions:

- Infrastructure: recognized by FCT roadmap of strategic infrastructure in consortium with CINTAL from University of Algarve;
- Research: TEC4Sea's research lines (Networked autonomous systems for ocean environments), including, marine wireless communications, power, acoustics, marine robotics and autonomous systems and hyperbaric sensors;
- Innovation: While research and technology development is the main focus, the TEC4Sea vision is also driven by its usefulness to the local community, where the stronger impacts are expected, as they shall effectively support the regional/national Sea economy. TEC4Sea promotes and spreads the best practices for industry-embedded research and technology transfer, actively involving the industrial partners in the research activities, in order to insure the appropriate uptake and full benefit from the developed maritime technology, including advanced training, accelerating the integrated scientific and economic development of the region.

6.2.3 Objectives for the short and medium term

Taking into consideration existing estimations/forecasts, the short-term objectives are:

- Align INESC TEC's research lines with common objectives related with TEC4Sea goals;
- Reinforce INESC TEC network with SMEs, public agencies and others R&D institutes;
- Increase INESC TEC participation in projects with SMEs, contributing to the strengthening of the Portuguese industry related with sea business;

The challenge of boosting long-term development prospects of emerging ocean industries and their contribution to growth and employment, while managing the ocean in a responsible and sustainable way can only be achieved by managing different orthogonal fronts (referring OCDE Report), namely:

- Foster greater international co-operation in maritime science and technology as a means to stimulate innovation and strengthen the sustainable development of the ocean economy;
- Strengthen integrated ocean management.

It is becoming clear that scientific and technological advances are expected to play an important role in the future of oceans, addressing simultaneously the environmental challenges and the development of ocean-

based economic activities. In fact, many technological innovations have the potential to influence the ocean economy in areas such as, advanced materials, subsea engineering and technology, sensors and imaging, satellite technologies, computerization and big data analytics, autonomous systems, biotechnology and nanotechnology (for example, seabed mining companies are all looking to robotics for their subsea operations, renewable ocean energies are making increasing use of advances in new materials and sensors; fisheries, maritime safety, ocean observation and environmental assessment will continue to benefit from several technological innovations (satellite, communications, remote sensing, navigation, etc.).

The following impacts can be expected from its middle- to long-term running activity:

- Reinforced current Portuguese Ocean R&D+I sector and integration of new technology research areas led by the Portuguese scientific community, with distinguished tradition and achievements in Ocean Engineering but still lacking the capacity to compete globally in some key areas, by taking benefit from the particularly attractive maritime area of Portugal for technology testing, based on the characteristics of the North Atlantic Ocean and the energy it encloses;
- Better governance of the North Atlantic marine ecosystem, namely by reinforcing the knowledge base of North Atlantic fragile ecosystems, especially of deep-sea habitats, through the development of cross-cutting technologies with Sea application;
- Reinforced positioning of Portuguese research and industrial stakeholders in Ocean Engineering to compete globally in the Sea Economy, as the SME engagement within the Sea Economy value chains will be facilitated, and it will become easier to attract important funding and investments in this area;
- Reinforced institutional academic and research cooperation in the different fields of Ocean Engineering;
- Increase of the global expertise on Ocean Engineering, either throughout the attraction of new researchers or researchers from core complementary research areas, but also by creating advanced training mechanisms;
- Reduced gap between the research and innovation capabilities of Portugal against other European countries leading in Ocean Engineering research, such as UK, Norway or Spain.

6.2.4 Main Achievements in 2016

In 2016 several achievements were made regarding the TEC4SEA context:

Promotion and dissemination activities:

- Business2Sea: within this fair and exposition a set of results of the TEC4SEA initiative were exposed to national and international entities. The collaboration protocol with APDL was redesigned (with a broader scope).
- OceansMeetings: results of the TEC4SEA initiative were exposed to national and international entities.
- REX2016: the participation for the 5th year in the Robotics Exercises in collaboration with the Portuguese Navy reinforced the links and the visibility of the TEC4SEA team and competencies within this military branch.

New initiatives:

- Coral: the multidisciplinary research project was started, bringing together engineers and biologists to address 27 complementary activities.
- Deepfloat: this project aims at developing innovative components for advanced control capabilities, fundamental to support deep underwater applications.
- Sidenav: this project aims at developing a demonstrator that validates and applies technology to enable the exploitation of mineral resources in deep-sea waters:
- MareCom: this project aims at developing new and affordable broadband IP-based communication technologies, both ship-to-coast and ship-to-ship, thus extending the Internet coverage from land.

Structural initiatives:

- OCEAN.PLUS: this initiative was the seed to the new structured and multidisciplinary collaboration strategy that shall guide the near future ambition. New partnerships were established towards the new goals.
- SeaFactory: this project addressing metal constructions in marine/sea environments, involves 28 different entities, contributes to strengthen a network of partners/stakeholders.
- Marinntic: this Interreg project aims to develop a set of strategies to incorporate and explore the usage of ICT technologies in SMEs working in the Sea Economy.
- ProtoAtlantic: this Interreg project aims at strengthening the transfer of innovation results to facilitate the emergence of new products, services and processes for SMEs working in the Sea Economy.
- TEC4SEA infrastructure: this is the main structural initiative that shall support the main R&D activities of TEC4SEA.

Ending initiatives:

- Endure and Bluecom+ (ending at the beginning of 2017): the two EEA Grants projects, demonstrated with success, represented two main achievements concerning underwater wireless energy transmission and offshore wireless communications built upon Wi-Fi based long range technologies, respectively.

Table 6.2 - Mapping of achievements with main ambitious goals

Address the complete value chain	Gather multidisciplinary competences and resources (supported by a coherent plan)	Engage researchers, Businesses and cluster organisations	Establish and strengthen the network of stakeholders
OCEAN.PLUS	Coral	Deepfloat	Business2Sea
SeaFactory	TEC4SEA	Sidenav;	OceansMeetings
TEC4SEA		MareCom;	REX2016
		Marinntic	
		ProtoAtlantic	

6.3 TEC4MEDIA

Coordinator: Cristina Guimarães

6.3.1 Motivation

The Media, Cultural and Content industries have demonstrated resilience to the economic and financial crisis by increasing the number of enterprises that, through innovation processes, adjusted their value proposition according to the new big trends (emergence of platforms, automation of jobs, semantics and language technology, big data and user-driven creation) and new consumer settings where the "on-line" is paramount.

Books, press, software and games, advertising and broadcasting were the leading innovative and technological improved sub-sectors that most contributed to a new ecosystem, now called as "New European Media" that has been guiding this sector in core activities and spill over effects and cross-sectorial fertilisation that can be observed in the increasing "digital world" in several settings (manufacturing, e-commerce, healthcare, tourism, just to name a few).

Finding alignment with the European research agenda by membership in New European Media (NEM Initiative) Platform, INESC TEC research groups participate in projects gathered by the mirror platform- NEM Portugal. The NEM platform, gathering hundreds of European key players in media industries, both content producers and technology providers, has been a key player in the European innovation ecosystem to help turn Europe into a leading Innovation Union. NEM Portugal, at national level, is taking a holistic view, identifying the pathway to commercial deployment of research, providing strategic insights into market opportunities and needs, and mobilising and connecting innovation actors within Portugal in order to enable Portuguese companies (not only SMEs, but also economic groups) and stakeholders to gain competitive advantage in European and global markets. Workgroups were formed to gather contributions and to produce a national view on issues being discussed, as well as inputs to the European position papers and white documents. Additionally NEM Portugal has been working together with the supporting clusters, TICE.PT and ADDICT, to foster the interaction of creative and technological companies with the academia in the preparation of new services and products.

6.3.2 TEC4Media Presentation

The TEC4Media faces the real economy challenges throughout state-of-the art research and knowledge value chain focused on results transferable to the digital media and the creative industries, including content and fashion industries, within a range of economic activities which are concerned with the generation or exploitation of knowledge and information, namely:

- Advertising, architecture, visual arts, design (including product and fashion design), film, music, performing arts, editing and publishing, archives, libraries, culture heritage and tourism, books and press, toys and games, newspapers, TV and radio, software and video games, education industry, including public and private services.

Vision: TEC4Media aims to place INESC TEC as the key research institute in addressing the above application areas specific challenges.

6.3.3 Objectives for the short and medium term

TEC4Media overall goals are:

- To foster the development and introduction of novel audio-visual and multimedia broadband services and applications to the benefit of citizen and enterprises. It aims at having a significant impact on the European economy in the context of the Lisbon objectives, bearing in mind the renewed goals as set up by the Commission Communication "i2010";
- To build a technical innovation focused ecosystem fostering networking with large Industry, SMEs (with and beyond sectorial clusters' members), research centres, universities and NGO's, governmental organizations feeding the knowledge creation value chain;

In a short term:

- To pursue the goals of the strategic research agenda that serves specific technological needs of this sector transforming the means by which multimedia content is created, distributed and consumed in a world where users are becoming “prosumers” (content creators and consumers concomitantly).

Expected Impact:

By connecting innovation actors within Portugal in order to enable Portuguese companies, of above sectors list, and stakeholders to gain competitive advantage in European and global markets, TEC4Media will contribute to economic strengthens of a growing sector.

We will work on scientific advancements that are crucial for economical and application areas of this domain, namely in the challenges related to personalization and the digital age. We will make use of multidisciplinary resources and assets to address relevant topics, including digital games, immersive media, natural interfaces, digital arts, media creation and transformation. Such topics will potentially give rise to new media products relevant for cultural creation, dissemination and consumption. Based on our strong collaborations between academia and industry, we will contribute to a stronger articulation between creative and cultural initiatives and the industries of the region. This research line recognizes the region’s strong knowledge and will contribute to increase training in ICT as well in activities associated with creativity. Moreover, it will foster a greater intersection between ICT and cultural and creative industries. Outcomes of TEC4Media will provide important contributions towards the transformation of value chains, enabling a better understanding of consumer behaviours and consequently meeting their expectations by providing richer digital experiences.

6.3.4 Main Achievements in 2016

The main actions, that brought together research and industry of this particular sector and sub-sectors, in 2016, were:

- 71 interface actions with industry: meetings to understand sector technological and innovation challenges and to present INESC TEC competences promoting collaboration (3 co-promotion projects submitted with 6 external partners; 1 individual project submitted; one structural – “mobilizador” – submitted with 25 external partners and 15 associated partners);
- Organization of trimestral events under NEM Portugal initiative gathering all members (49 SMEs and 3 Broadcasters) on the following subjects: - Digital Economy; LiveMeans Linkup - real-time metadata to sync multiscreen “call-to-actions”; Multiplatform Media; Tourism and Digital Contents;
- Follow up of the “Four eyes” project deliverables and demonstrations and participation in seminars to discuss results and feel the media, creative and content industries ecosystem and its challenges;
- Submission of cross sector sectorial project – CHIC-Cooperative Holistic View on Internet and Content – in evaluation process (with positive feed-back from the evaluators of National Innovation Agency);
- Organization and hosting the international NEM Summit 2016 which was held in Porto on 23-25 November 2016, welcomed around 150 participants from 20 European countries. The NEM Summit program accommodated three plenary and seven parallel sessions with more than 40 presentations and talks, including four panel discussions and the 22nd NEM General Assembly, as well as 15 exhibitions;
- Meeting with the research groups in order to promote and enhance the infrastructures serving TEC4Media, namely:
    (i) Multimodal Acknowledgeable multiSenSory Immersive Virtual Environments Lab -MASSIVE is a laboratory devoted to the multidisciplinary study of the relationship between virtual reality technologies and the different dimensions of human performance. Our mission is to make use of virtual reality technology to enhance human abilities in order to address global challenges and improve the quality of life. Our vision is to become a world-reference laboratory within the field of multisensory virtual reality, perceptual equivalence, human performance, and technology that creates innovative solutions in a wide set of areas of applications such as training and certification, health, education, or entertainment;

(ii) The Sound and Music Computing Lab - The lab hosts research in Applied Computing, Arts and Humanities, and Sound and Music Computing. This lab supports research not only in audio synthesis and computational processing of sound, but also in automatic and procedural music generation e.g., for use in interactive computational systems, 3D audio spatialisation for integration in virtual environments, among other application contexts. It is well-equipped with sound and audio specific equipment, include a multi-loudspeaker setup, and is acoustically prepared for the associated activities and for audio content production and post-production;

(iii) Graphics, Interaction and Gaming Lab - The Computer Graphics and Virtual Environments Laboratory (CG&VE) is equipped to face the new challenges on areas such as Immersive Environments, Digital Games and User Experience, but also to deepen the knowledge in Computer Graphics on areas such as Image Rendering and Visualization;

(iv) U.Porto Media Innovation Labs - MIL is a Center of Excellence created in the University of Porto to address the challenges that exist in developing a strongly interdisciplinary domain such as Digital Media. MIL is designed as a network within the university, leveraging the already existing capacity in different fields of knowledge such as Communication, Technology and Design. MIL manages several audiovisual resources, namely a digital TV studio with control room and a pre-screening auditorium, and audio recording booths.

- Attending webinairs on European calls such as: “"European funding opportunities for the audiovisual sector", among others.

7 SPECIAL PROJECTS

7.1 CARNEGIE MELLON PORTUGAL PROGRAM

Coordinator: João Claro

The Carnegie Mellon Portugal Program (CMU Portugal) is a platform for education, research and innovation that brings together Portuguese universities, research institutions and companies, and Carnegie Mellon University (CMU). Its mission is to place Portugal at the forefront of innovation in key focused areas of Information and Communication Technologies (ICT), by promoting cutting-edge research, world-class graduate education and a close collaboration with the Portuguese industry.

Launched in 2006, the partnership was renewed in 2012, for five more years, until 2017. The activities of the CMU Portugal Program are financed by the Fundação para a Ciência e a Tecnologia (FCT), supported by the Conselho de Reitores das Universidades Portuguesas (CRUP), and co-financed by industry partners and by CMU.

The Program has become a close and productive partnership, shaping minds, advancing knowledge in ICT and in the contexts where it is used, with the potential to improve the lives of people and organizations, fostering cultural change in universities and companies, placing people and organizations in international networks, and serving as a catalyst for innovation, entrepreneurship and economic growth. In its ten years of existence, it has established in Portugal a successful international innovation engine in ICT, and is building on the achievements of its first years to carry out an ambitious Roadmap, crafted by the Program community, for its Phase II.

Currently the coordination of the Program in Portugal is hosted at INESC TEC. Based out of INESC TEC, the Program's National Director, Prof. João Claro, and executive team carry out the planning, management and coordination of the activities of the partnership in Portugal, including the promotion of the cooperation between CMU and the Portuguese institutions. The executive team also works in close integration with INESC TEC's support services and staff on the Program's administrative, legal, and financial management.

The Program's collaborative network involves 15 Portuguese universities, represented by CRUP, four Associate Laboratories in the area of ICT and many other research institutions in Portugal, 19 CMU Departments, over 120 companies, and over 400 faculty and senior researchers in Portugal and at CMU.

This collaborative network has focused its activities on:

- talent development – through 8 ongoing dual degree Ph. D. Programs, one ongoing dual degree Professional Master's Program, a Faculty Exchange Program, and an Undergraduate Internship Program;
- collaborative research – through 25 completed R&D projects, 12 ongoing Entrepreneurial Research Initiatives, and 10 recently completed Early Bird Projects, selected in competitive calls, involving multiple Portuguese universities and research institutions, CMU, and companies;
- industry partnerships – through multiple forms of engagement, including the advanced education and collaborative research activities;
- entrepreneurship support – through inRes, an entrepreneurship-in-residence initiative.

The Program has evolved to become a highly dynamic collaborative network of people and organizations, that together act in a sustainable manner as an international innovation engine: integrating a spectrum of R&D activities, from more upstream research, expanding the body of knowledge and looking at enabling the real-world solutions of the future, to more downstream R&D, in very close connection with industry and markets, enabling the immediate next generation of real-world solutions; encouraging and supporting the commercialization of R&D results; and developing the talent with the leadership and the advanced knowledge and skills required to be able to do all this in a sustainable manner, now and in the future.

7.1.1 Main Achievements in 2016

The main activities developed during 2016 included:

- Preparation and coordination of the Project Review Meetings for the Entrepreneurial Research Initiatives, led by a panel of international renowned experts;
- Public presentations of the Entrepreneurial Research Initiatives, together with a demos and posters session;
- Presentation of the Program's scientific achievements at "Ciência 2016" in Lisbon, and organization of the demo session of the Program's research projects;
- Organization of the workshop "ERIs Intellectual Property Working Session 2016", with the twofold objective of (1) providing an opportunity for ERIs to get to know each other and to identify areas of collaboration, and (2) informing ERIs on topics related to Technology Transfer, especially in international collaboration contexts;
- Promotion of the Ph. D. Students "Orientation Day", creating an opportunity for the dual degree Ph. D. students to get to know the Program better, network with other students, share their experiences about life in Portugal and at CMU, and debate a specific topic of interest, in this edition a range of public policy issues in which technology details matter, and technology cannot be treated as a black box;
- Organization of leadership meetings with the Board of Directors and the Scientific Directors;
- Support and management of the admission of new dual degree doctoral students, and student transfers throughout the year.
- Participation in multiple events, such as "Caixa Empreender Award" with Caixa Capital, in Lisbon, "Software-specific challenges in technology transfer", an international workshop promoted by ASTP Proton, in Lisbon, promoting the inRes initiative as an example of an accelerator, and "Websummit", in Lisbon, one of Europe's largest events of entrepreneurship, technology and innovation.

Throughout 2016, the CMU Portugal Program managed its three mobility programs, supporting 10 research internships at CMU for young Portuguese researchers, under the Undergraduate Internship Program initiative, seven faculty exchanges, promoting a positive exchange of culture and experiences at CMU, under the Faculty Exchange Program initiative, and supported four entrepreneurial teams, providing them a preparation period in Portugal, followed by a seven-week immersion in the U.S.A., closing with a final public presentation of the results back in Portugal, under the inRes initiative.

The team also carried out all the strategic and operational management of the Program, throughout the year, in the following key areas: management of the ongoing education, research, and innovation & entrepreneurship activities; design and implementation of new instruments; institutional and operational mobilization and coordination of the Program stakeholders, in close contact with FCT, CRUP, and multiple higher education institutions, research institutions, companies, and innovation & entrepreneurship support organizations; communication to the Program's community and the public in general of the Program's initiatives, results, and impact; development of the resources and configuration of the processes for the management and coordination of the Program.

7.2 DIGITAL COMPETENCE INITIATIVE

Coordinator: Pedro Guedes de Oliveira

In May 2016, the Ministry of Science Technology and Higher Education (MSTHE) created a taskforce the goal of which is to conceive and promote a national programme to increase the number of graduates in ICT at the higher education level (Desp. Nº 6931/2016). To lead the taskforce, the MSTHE nominated Pedro Guedes de Oliveira and the group includes Francisco Vaz, former vice-rector of the University of Aveiro, José Maria Azevedo, former Inspector General of the Ministry of Education and presently with the Northern Regional Coordination and Development Commission, Pedro Veiga who coordinates the National Centre for Cybersecurity and Sofia Marques da Silva, from the CIIE – Centre for Research and Intervention in Education, Faculty of Psychology and Education Sciences, of U.Porto. The secretarial and administrative support was assigned to Lucília Fernandes and the group includes Ana Reis, a young researcher recently awarded a degree in Information Sciences.

In order to support the activities of the group, a contract that will last until the 31 of October, 2017, was signed between FCT and INESC TEC.

7.2.1 Main Achievements in 2016

Since the goals of this project are to foster an increase in the number of qualified professionals in the areas of ITC, there aren't quantifiable results yet but what was done was to create the conditions so results can appear in the next years.

- The work started with a pilot set of Polytechnic Institutes (PI): Bragança, Cávado e Ave, Leiria, Setúbal e Beja;
- We developed the concept of Community Network around each PI, and started building it, involving secondary schools and different types of local associations in order to inform and motivate young secondary students for ICT degrees;
- We started working with these 5 PI in applying project based learning (PBL) methodologies to TeSP courses (TeSP stands for High Level Professional Technicians) and 8 courses in IT were redesigned according to it;
- We developed an online questionnaire that was sent to a large number of companies, both directly and through Enterprise Associations (ANETIE, APDC, AEP), to understand their present situation and future HR needs, both in quantity and quality, in the area of ICT.
- Various meetings with companies (large and small) in ICT took place, in order to better design the project towards its goals;
- We held talks with IEFP (the institute for employment and professional training of the Ministry of Labour) and ANQEP (the national agency for professional qualification and training) that are instrumental, the first in re-qualifying professionals for ICT and the latter in the technical education of youngsters, at the secondary level;
- The group joined CPED (Portuguese coalition for digital jobs) and led the last meeting of the group that took place in Lisbon, in December.
- A sub-group dedicated to the gender gap in ICT was also started, to analyse how we could attract more girls to the area;
- Under a contract with a software house, we started the development of a platform that will be available in the web to disseminate information and allow the dialog both between each PI and its constituency as well as among IPs;
- At the same time the script for a short movie to promote and disseminate information for young students, about ICT was developed and a contract was signed with a movie producer;
- Finally, in October, contacts with other 4 PI were established (Tomar, Viseu, Guarda e Castelo Branco) so that in 2017 all the PIs will be included in the project.

8 SUPPORT SERVICES

8.1 LEGAL SUPPORT SERVICE

Manager: Maria da Graça Barbosa

Table 8.1-AJ – Service team composition

	Type of Human Resources	2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	1,9	0,9	0,7	
	Academic Staff				
	Grant Holders and Trainees		1	2	1
	Affiliated Researchers				
	Total Integrated HR	**1,9**	**1,9**	**2,7**	0,8
	Total Integrated PhD				
External Collaborators					
	Total	**1,9**	**1,9**	**2,7**	0,8

8.1.1 Presentation of the Service

- The Legal Support service provides legal advice and appropriate action on most of the legal matters emerging within the INESC TEC universe, namely in the areas of human resources, institutional relations, project contracts and public procurement for goods, services and works. The service is committed to always defend the institution's best interests, not only preventively, ensuring that the institution is compliant with national, European or other applicable legal frameworks, but also in order to repair any damage or minimize costs.

8.1.2 Highlights in 2016

The following aspects can be highlighted in the Legal Support Service activity during 2016:

- Intensive contractual activity, either under national, European or international financed projects or direct contracts with several national and foreign companies and institutions;
- participation in the associations promoting several Portugal 2020 Competitivity Clusters (automobile, shoes, textile, space & defense);
- Intensive public procurement activity, both as contracting entity and as tenderer, including the launching of two open procedures for acquisition of services;
- Information and implementation of procedures for the new national legal framework of scientific employment;
- active participation in the drafting process and discussions on the Conflict of Interests Policy and the Intellectual Property Regulation (still ongoing);
- training, awareness promotion and internal information on legal subjects with relevant or high impact to INESC TEC, namely the European Regulation on Personal Data Protection, which entered in force on the 24th may 2016, to be applied from 25th May 2018 onwards;
- Implementation of the ticket system for most of the requests to the service, enabling a better control of the time to answer and workload management.

8.2 FINANCE AND ACCOUNTING SERVICE

Manager: Paula Faria

Table 8.1-CF – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	5	4,3	3,8	1
	Academic Staff				
	Grant Holders and Trainees	2	2	3	1
	Affiliated Researchers				
	Total Integrated HR	**7**	**6,3**	**6,8**	0,5
	Total Integrated PhD		1	1	
External Collaborators					
Total		**7**	**6,3**	**6,8**	0,5

8.2.1 Presentation of the Service

The Accounting and Finance service is responsible for coordinating and executing the accounting activities, for fulfiling all fiscal obligations and for managing INESC TEC´s cash flow and ensure the availability of enough funds to meet the payments due. In this context, the service acts as a mediator between the institute and external parties, according to the guidelines provided by the Board. From an administrative perspective, it is also responsible for the purchasing and travel processes and for managing the institute insurances and fixed assets.

8.2.2 Highlights in 2016

The year 2016 was a very complex year regarding the substantial increase of the Institute's activity and the internal switches in Accounting and Finance service's team. The Finance and Accounting Service had the challenge to guarantee that all the internal processes were well fulfiled and to provide along the training of new elements team and did it successfully.

8.3 MANAGEMENT CONTROL SERVICE

Manager: Marta Barbas
Assistant Manager: Vanda Ferreira

Table 8.1-CG – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	5,7	6,7	7,8	1,1
	Academic Staff				
	Grant Holders and Trainees	1		1	1
	Affiliated Researchers				
	Total Integrated HR	**6,7**	**6,7**	**8,8**	2,1
	Total Integrated PhD				
External Collaborators					
Total		**6,7**	**6,7**	**8,8**	**2,1**

8.3.1 Presentation of the Service

The Management Control service is responsible for coordinating and executing the activities inherent to budgetary planning and control, and also to producing, coordinating and disseminating management information in order to make sure that all resources are obtained and used effectively and efficiently so as to fulfil the purposes of the institution. The service is also responsible for funded projects continuous reporting to funding agencies and the respective reimbursement of expenses. Monitoring funded projects for compliance with funding agencies terms and conditions by working closely with researchers and providing training whenever necessary.

8.3.2 Highlights in 2016

Although the number of funded projects remains nearly 100 since 2014, in 2016 INESC TEC participated in larger projects and more demanding in terms of reporting.

In order to face this challenge, the “reporting” team was reinforced through the recruitment of two people, one since June and another since December.

Support tools of projects payment reports were improved.

Monitoring of the process of ineligible expenses (“trabalhos a mais”) under INESC TEC new building funding.

KPIs’ clearance for BestCase project (collection; data processing and management).

*Monitoring and data processing for Universidade do Porto projects database (project’s form for new and older projetcs).

8.4 HUMAN RESOURCES SERVICE

Manager: Maria da Graça Barbosa
Assistant Manager: Margarida Gonçalves

Table 8.1-RH – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	3,1	3,1	3,3	0,2
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**3,1**	**3,1**	**3,3**	**0,2**
	Total Integrated PhD				
External Collaborators					
Total		**3,1**	**3,1**	**3,3**	**0,2**

8.4.1 Presentation of the Service

The Human Resources service coordinates and executes all activities pertaining to human resources administrative management and to the implementation of HR related policies, according to the applicable law, internal regulations and guidelines provided by the Board.

Specific duties include follow-up and management of INESC TEC's insurances related to people, namely Health Insurance, Personal Accidents and Work Accidents, as well as the follow-up and control of the services rendered by the hired company in the area of Safety and Health at Work.

8.4.2 Highlights in 2016

The following aspects can be highlighted in the service activity during 2016:

- Collaboration in the definition of the HR strategic support and global activity indicators of INESC TEC;
- Collaboration in important evolutions concerning HR processes in intranet and its integration with the HR database software application (PHC), such as: the "New Collaborator" Workflow; implementation of "historical record" in PHC; automatic transfer of information submitted in the "New Collaborator"and "Collaborator movements" to PHC; automatic generation of contracts and reports;
- Participation in the New Collaborators Welcome Sessions;
- Preparation of the internal production of INESC TEC cards (Clock in card);
- Coordination and control of the Health Mobile Unit (External occupational safety and health services).

8.5 MANAGEMENT SUPPORT

Manager: Maria da Graça Barbosa
Assistant Manager: Isabel Macedo

Table 8.1-AG – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	1,1	1,2	1,2	
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**1,1**	**1,2**	**1,2**	
	Total Integrated PhD				
External Collaborators					
Total		**1,1**	**1,2**	**1,2**	

8.5.1 Presentation of the Service

The Management Support service promotes the coordination between the Board, R&D Centres and support services, guaranteeing process integration so that the institution provides a coordinated, coherent response. The service also prepares and assures the operationalization of the decision-making process at several levels, from the Board of INESC TEC to other empowered bodies at the institution.

8.5.2 Highlights in 2016

The following aspects can be highlighted in the service activity during 2016:

- Support in the final definition and generation of the strategic and global activity indicators of INESC TEC, as well as participation in the definition of a model of activity indicators for the Support services;
- Collaboration in the project for the development of INESC TEC new website. Included the co-guidance of the internal workgroup for INESC TEC new website requirements specification;
- Definition and implementation of a new tool for the follow-up of topics, issues and actions of the Board members;
- Support to INESC TEC participation in other entities and companies, including the adhesion to the new associations MOBINOV, AEDCP, CITEVE, APICCAPS and EES-UETP.

8.6 SECRETARIAL COORDINATION

Manager: Grasiela Almeida

8.6.1 Presentation of the Service

The Secretarial Coordination is responsible for managing the group of secretaries of Centres and Services at INESC TEC in order to guarantee that all typical procedures are coherent, to make sure that all internal rules and procedures are followed in close collaboration with the different organization and management services and also to assure a continuous process of improvement of support tools and applications.

The Coordinator provides feedback to the Board on performance and also supervises the group, anticipating the institutions needs and scheduling secretaries to accommodate absence periods.

This service also verifies the constant update of the existing protocols necessary for the current activity of the secretariat group (hotels, renting and travel agencies, among others) and the creation of new protocols, if necessary.

8.6.2 Highlights in 2016

The past year consisted in a period of change regarding not also the management but the whole team as well.

Regarding the first, the Coordination has been allocated to a new manager and, therefore, the year reflected an adaption and learning period which took over the second semester leaving diminutive time for innovative enterprises. Nonetheless, this doubled-team has successfully assured all its responsibilities, as previously presented in 8.6.1.

In terms of the Secretariat team, an expansion period arose, mirroring also the institutions' evolution, since INESC TEC had the need to hire 3 new assistants. This demanded additional activities of recruitment, training and monitoring, resulting in a renewed team.

8.7 FUNDING OPPORTUNITIES OFFICE

Manager: Marta Barbas

Table 8.1-SAAF – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	0,3	0,3	0,2	
	Academic Staff				
	Grant Holders and Trainees			1	1
	Affiliated Researchers				
	Total Integrated HR	**0,3**	**0,3**	**1,2**	**0,9**
	Total Integrated PhD				
External Collaborators					
	Total	**0,3**	**0,3**	**1,2**	**0,9**

8.7.1 Presentation of the Service

The Funding Opportunities Office aims at identifying the relevant funding opportunities to support INESC TEC Research, Development and Innovation activities, always aligned with the mission and objectives of the Institute. This service will also support and supervise the development and submission of proposals to different funding programmes, always in collaboration with the R&D Centres and with the other Business Development Services.

8.7.2 Highlights in 2016

During 2016, the service was still in an embryonic phase and, in June, a person was hired in order to reinforce the team and allow the service re-organization.

Close follow-up of some flagship proposals submission (Teaming H2020; Infraestruturas de Investigação Inseridas no Roteiro Nacional de Infraestruturas de Investigação de Interesse Estratégico).

8.8 INDUSTRIAL PARTNERSHIPS SERVICE

Manager: Augustin Olivier

Table 8.1-SAPE – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	4	4	4	
	Academic Staff				
	Grant Holders and Trainees			1	1
	Affiliated Researchers				
	Total Integrated HR	**4**	**4**	**5**	**1**
	Total Integrated PhD		2	2	
External Collaborators		2	2	2	
Total		**6**	**6**	**7**	**1**

8.8.1 Presentation of the Service

The Industry Partnership Service aims at strengthening INESC TEC's market position and achieving higher industry contract revenues.

The service is responsible for building strong relationships with partners, identifying business opportunities, negotiate and close industry contracts for innovative projects based on INESC TEC R&D competencies and maintain an extensive knowledge of market trends and conditions. Plan different strategies and marketing contents highlighting INESC TEC added value and differentiation, prospect for new industry partners, organize and set up business meetings and increase INESC TEC business network.

This service is also responsible for lunching and managing strategic initiatives with high impact in the institution. The TEC4GROWTH strategic initiative is an example of the Service added value.

The main actions will be divided in four activities described below.

8.8.1.1 Highlights in 2016

8.8.1.2 Activity 1: Leadership of strategic initiatives

Strategically, INESC TEC intends to present its competencies on the market based on a new multidisciplinary approach organized in thematic areas, called TEC4 ("TEChnologies FOR …"). This new concept was matured during 2016, was further structured, presented and approved by the INESC TEC board.

Each TEC4 shall focus on a specific market domain, addressing three pillars: the stakeholders and partnerships perspective, the scientific roadmap and the technological R&D infrastructure evolution - to keep up with the state-of-the-art and support the roadmap.

New initiatives to support the internal (global) management of R&D and R&D lines were realized:

1. The identification of the TRL levels of all projects and PhD's;
2. Establishment of maturity evaluation tools for R&D lines;

An important milestone led by SAPE was the definition of the strategy and submission of the TEC4SEA project to the "FCT Research Infrastructures Roadmap" call. This multidisciplinary infrastructure is the basis of INESC TEC strategy to the Sea.

8.8.2 Activity 2: Networking and promotion activities for knowledge transfer

The networking and promotion activities consume a considerable amount of resources of this service. During 2016, the following initiatives were "promoted":

- the OpenDay CTM: SAPE helped organize this external OpenDay that attracted more that 34 companies;
- Seminars participation: SAPE was invited to give talks in 22 Seminars and Conferences (from Green Business Week to European Summit on Innovation for Health and Active Aging);
- Seminars organization: SAPE was responsible for the organization of 5 Seminars/Conferences (e.g., NEM Summit, III Conferência Inova-Ria – Smart Ruris);
- Fairs and exposition: SAPE was responsible for the INESC TEC presence in 4 events with B2B sessions (TechDays, Business2Sea, AgroGlobal, BizFeira);

Moreover, an internal evaluation of fairs and events where INESC TEC should be present to disseminate the R&D results, both national and international, was led by SAPE. The results of this evaluation shall serve as guidelines for future participations.

Also related with networking activities, an evaluation of the most relevant Industrial Clusters and Associations in Portugal, considering INESC TEC positioning, was performed. As a result of this identification and evaluation, several Cluster and Associations experienced a stronger involvement of INESC TEC representatives. In future, a more focused presence of INESC TEC in Clusters and Association shall be considered.

8.8.3 Activity 3: Value Creation

Establishing multidisciplinary and complex projects with industrial partners is part of SAPE's mission. During 2016, a total of 51 project proposals were submitted. During 2016, a total of 19 projects were approved involving a global funding of 4 685 728€. Considering project submissions made during 2015 and 2016, we are still awaiting the results of 34 submissions.

The market sectors of the approved projects range from Energy, Sea, Health, Industry, Agriculture, Media, among others.

8.8.4 Summary of main results

	Highlights 2016	Value
	New Strategic Initiatives	2
	Promotion and dissemination initiatives (exhibition/fairs, seminars, ...)	32
	Submitted proposals	51
	Approved projects projects	19
	Total funds raised / Direct contracts (K€)	4.686/699

8.9 TECHNOLOGY LICENSING OFFICE

Manager: Catarina Maia

Table 8.1 - SAL – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	1	1	1	
	Academic Staff				
	Grant Holders and Trainees	1	2	1	1
	Affiliated Researchers				
	Total Integrated HR	**2**	**3**	**2**	**1**
	Total Integrated PhD				
External Collaborators					
Total		**2**	**3**	**2**	**1**

8.9.1 Presentation of the Service

The mission of the Technology Licensing Office is to protect and license technology developed at INESC TEC. To carry out its mission, the office works in close collaboration with the Legal Support Service and the Industrial Partnerships Service. The office's responsibilities consist of establishing and managing INESC TEC's processes related to: internal scouting and dissemination of research results that can be protected by Intellectual Property (IP) rights; market and state of the art assessment; definition of IP strategy; technology licensing; negotiation and monitoring of licensing contracts.

8.9.2 Highlights in 2016

During 2016, Catarina Maia, Service Manager, achieved the status of Registered Technology Transfer Professional by the Alliance of Technology Transfer Professionals. She is the second person in Portugal to achieve such registration.

Ricardo Moreira gained the Inteum Scholarship addressed to young technology transfer professionals, to attend ASTP-Proton's Annual Conference, which took place in Copenhagen.

The service almost doubled the number of original patent applications, and led the internationalization of patents, one of which entered regional phases in the Big 5 patent offices (Europe, USA, Japan, China and South Korea).

The service also applied for a new financing stream for patent internationalization (Aviso 17 Portugal 2020, for internationalization of patent filings). During 2016, the approval rate for these applications was 100%, accounting for a total of approved funding of 41 thousand Euros.

Most importantly, INESC TEC, together with Honda and the University of Porto, was granted the US patent US2014067385, on a "Sound processing device, sound processing method, and sound processing program".

8.10 INTERNATIONAL RELATIONS OFFICE

Manager: Vladimiro Miranda

Table 8.1 - GRI – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees				
	Academic Staff				
	Grant Holders and Trainees		1	1	
	Affiliated Researchers				
	Total Integrated HR		**1**	**1**	
	Total Integrated PhD				
External Collaborators			3	3	
Total			**4**	**4**	

8.10.1 Presentation of the Service

The International Relations Office (IRO) is established under the dependency of the Board to systematically and regularly organise the internationalisation of activities in selected countries. The Office focus specifically on identifying opportunities, concentrating knowledge on research and industrial foreign markets, promoting the attraction of foreign researchers to INESC TEC and acting in general as a facilitator of contacts and relations between research groups in INESC TEC and foreign researchers.

The IRO is a structure constituted presently by two Offices: the Brazil Office and the India Office. These Offices should act as mediators, facilitators or cooperation brokers. The human resources acting in this framework are recruited among the diverse structures of INESC TEC to give specific contributions and do not constitute a full-time dedicated resource.

8.10.2 Brazil Office: Highlights in 2016

The Brazil Office, acting as a broker or facilitator and as an aid to the Board in Latin America matters, does not have the responsibility over projects or contracts. The main activities of the Brazil Office were the following, distributed among a diversity of actions:

- following up the activity in INESC P&D Brazil (IB) and keep regular meetings with the IB secretariat and administration;
- tracking the direct relation of INESC TEC with Brazilian partners and assist the Board in these contacts;
- assisting the INESC TEC Centres in the contact with IB and in proposing/implementing R&D contracts;
- assisting Brazilian visitors to INESC TEC;
- providing assistance to the relations of INESC TEC with other Latin American countries;
- providing a sense of community and attachment to INESC TEC of the Brazilian researchers in the institution.

The Brazil Office is in charge of the initiatives “Café e Pão de Queijo”, cultural events that promote the understanding of roots and cultural backgrounds among Brazilian and Portuguese researchers. Four events were organized. Such actions target primarily the community of Brazilian researchers at INESC TEC, are developed in Portuguese language and have received participation of researchers from the Portuguese and Spanish speaking communities. The number of Brazilians working permanently in INESC TEC is around 40, not counting other Brazilian researchers remaining for short duration visits (under 3 months).

8.10.3 India Office: Highlights in 2016

The India Office, acting as a broker or facilitator and as an aid to the Board in India matters, does not have any responsibility over projects or contracts. Its main activities in 2016 were the following:

- Continuing the study of the India system of research and education and reinforce the knowledge on key partners and actors, legislation and opportunities;
- Launching initiatives to attract Indian students and post-docs to INESC TEC;
- Building bridges with important actors in India and the India industry and act as a facilitator between such partners and INESC TEC Centres, to the point of achieving the signature of MoUs and other agreement instruments formalizing a cooperation framework.

In 2016, successful contacts were established with the University of Goa, the IIIT Bangalore and TATA industries, which open the door for further development in 2017. The number of Indian nationals in INESC TEC was of only 5 in 2016, thus justifying the effort to increase the relations between the institution and partners in such an important country, demographically and in science terms.

8.11 COMMUNICATION SERVICE

Manager: Sandra Pinto

Table 8.1 - SCOM – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	2	2	3	1
	Academic Staff				
	Grant Holders and Trainees	1	2	3	1
	Affiliated Researchers				
	Total Integrated HR	**3**	**4**	**6**	2
	Total Integrated PhD				
External Collaborators			1		1
	Total	**3**	**5**	**6**	1

8.11.1 Presentation of the Service

The Communication Service collaborates with the Board in order to define the institution's communication strategies and image. Its main activities are: the planning, implementation, organisation and coordination of both internal and external communication in accordance with the regulations and procedures established, promoting the image and prestige of the institution.

8.11.2 Highlights in 2016

- Steps were taken to create a new INESC TEC website. Two members of SCOM integrated a working group that prepared the document "Design and specification of the new INESC TEC website" and a company was hired to carry out this important task.
- The efforts made to achieve greater visibility in the media have led to a more sustained presence of INESC TEC in the main Portuguese media outlets. A clipping service hired for this purpose accounted for 953 news pieces in 2016, 71 more than in the previous year and 649 more than two years ago. The AAV - Automatic Advertising Value return was approximately 7 million euros (€ 6,914,551.11), while in the previous year, the AAV had been close to 4 million euros.
- With regard to Social Networks, the year 2016 was marked by the creation of INESC TEC pages on Instagram and Google+. The institutional presence on Facebook, LinkedIn, Twitter and YouTube was also reinforced with daily posts, totalling 885 in 2016.
- Facebook: 50.000 visualizations per month; engagement up to 30%; the number of followers increased 34% last year (from 2749 to 4147). LinkedIn: 770 new followers in 2006 – a total of 4204; unique reaches/posts per month – 700 people; engagement of 1,37%. Instagram: 380 followers; engagement of 16,03%. Twitter: the number of followers triplicated in a year - from 600 to 2261; 30.000 monthly visualizations on average.
- It is also worth mentioning the creation of an INESC TEC showcase page on LinkedIn to disseminate employment opportunities. This page currently has 362 followers.
- In 2016, INESC TEC participated in various events that promoted the image of INESC TEC abroad, such as the Ocean Business Week, CTM Open Day, International Conference on the European Energy Market (EEM2016), TechDays, Agroglobal, Business2Sea and EMAF exhibition.
- For the first time, an annual event was created, exclusively organised by INESC TEC, and open to the public: the “Fórum INESC TEC do Outono”. The 2016 edition focused on the theme "The Factory of the

Future: what paths for the industry of the 21st Century?". This event, which featured SCOM in the organising committee, had a tremendous impact and brought a lot of attention to the quality of the presentations and debates, the number of entrepreneurs and managers present.

- In order to strengthen internal cohesion, in 2016 SCOM continued to promote group activities for employees, such as the photo contest, the football tournament, the “magusto” and the multicultural party.
- In its mission to support the R&D Centres, it is important to stress the European project UPGRID, where SCOM was in charge of coordinating and implementing two WP; the Enterprise European Network, where SCOM disseminated the activity of the Network in INESC TEC’s channels; integrated projects NanoSTIMA, TEC4Growth and Coral, for which SCOM defines images and proposed website structures; project StrongMar, which included the creation of a logo, application to different material and creation of infographics; and project GReSBAS, for which SCOM developed a logo that was then applied on a website.
- It is also worth noting the production of promotional videos for events and exhibitions. A total of 38 videos were produced in 2016.
- When it comes to communication material, several flyers and roll-ups were produced for various Centres, as well as stickers, templates, facts sheets, brochures, booklets, t-shirts and vinyl outdoor banners.
- Equally important is the collaboration with Ciência Viva to disseminate science with younger generations, namely as part of the initiative “Ocupação Científica nas Férias – Jovens Ciência Viva nos Laboratórios”. Other activities include the institutional participation in events such as the European Researchers’ Night, FEUP’s Semana Profissão Engenheiro and the Mostra da U.Porto.
- INESC TEC’s monthly newsletter (BIP) is available in Portuguese and in English on INESC TEC’s website. With the English version being disseminated quarterly to Universities in 25 countries, it is one of the institution’s most effective communication instruments. In fact, using the AWStats statistics system, it is possible to see that people from 108 countries have visited the newsletter’s website, with Portugal, Brazil, USA, United Kingdom, Germany and France being the most frequent, in a total of 380,613 page hits and 78,306 visitors.
- For the first time in INESC TEC, monthly sessions were organised to welcome new employees. These sessions were devised by SCOM, in collaboration with the Human Resources. Each session features two members of SCOM and the head of the HR service.
- Considering that the Media are increasingly using researchers for their interviews and news reports, SCOM organised two Media Training sessions to strengthen the communication skills of INESC TEC researchers.
- A training session on "Writing Academic Articles in English" was also organised. The goal of this session is to improve the writing skills of INESC TEC researchers.

8.12 NETWORKS AND INFORMATICS SERVICE

Manager: João Neves

Table 8.1 - SCI – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	3	3	2	1
	Academic Staff				
	Grant Holders and Trainees	1	1		1
	Affiliated Researchers				
	Total Integrated HR	**4**	**4**	**2**	2
	Total Integrated PhD				
External Collaborators					
	Total	**4**	**4**	**2**	2

8.12.1 Presentation of the Service

The Communications and Informatics Service manages INESC TEC's communication network infrastructure (data and VoIP) and network services, including e-mail and printing services.

8.12.2 Highlights in 2016

The following aspects can be highlighted in the service activity during 2016:

- Tuning and performance improvement of Wi-Fi infrastructure;
- Reduced response time for the connection of systems to the network;
- Quick response to security issues, thus avoiding denial of services;
- High availability of network and services.

8.13 MANAGEMENT INFORMATION SYSTEMS SERVICE

Manager: José Carlos Sousa

Table 8.1 - SIG – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	3	3	3	
	Academic Staff				
	Grant Holders and Trainees			2	2
	Affiliated Researchers				
	Total Integrated HR	**3**	**3**	**5**	**2**
	Total Integrated PhD				
External Collaborators					
Total		**3**	**3**	**5**	**2**

8.13.1 Presentation of the Service

The Management Information Systems Service is in charge of the development and maintenance of INESC TEC's management information system.

8.13.2 Highlights in 2016

The following aspects can be highlighted in the service activity during 2016:

- New process to register projects proposals;
- Partial automation of the human resources assessment process;
- Human resources processes with automatic data integration;
- Collect theses and dissertations from associate institutions, with data completion;
- Internal integration with Authenticus publications, with auto generated reports;
- Automation of the grants announcement process.

8.14 SYSTEMS ADMINISTRATION SERVICE

Manager: Jaime Dias

Table 8.1 - SAS – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees			3	3
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR			**3**	**3**
	Total Integrated PhD				
External Collaborators					
Total				**3**	**3**

8.14.1 Presentation of the Service

The Systems Administration Service is responsible for managing servers, computer systems and collaborative applications, for providing support to end-users and for Research and Development. This Service is also responsible for managing the INESC TEC Living Lab, in collaboration with Centres and other Services, to enable INESC TEC's building and infrastructures as real life testbeds while promoting R&D results.

8.14.2 Highlights in 2016

The Systems Administration Service was created in 2016. Therefore, the SAS team had to provide helpdesk support and maintenance of servers already in production while planning and deploying new infrastructures. Next, we list the main achievements in 2016.

Deployment of the Ticket service. It was the first service deployed. It is essential to SAS and other services to interact with INESC TEC collaborators while enabling activity tracking. Although the Ticket service was online only since the March, the SAS team resolved more than 800 requests.

8.15 INFRASTRUCTURE MANAGEMENT SERVICE

Manager: Jorge Couto

Table 8.1 - SGI – Service team composition

Type of Human Resources		2014	2015	2016	Δ 2015-2016
Integrated HR	Employees	4	3,6	5,1	1,5
	Academic Staff				
	Grant Holders and Trainees				
	Affiliated Researchers				
	Total Integrated HR	**4**	**3,6**	**5,1**	1,5
	Total Integrated PhD				
External Collaborators			1		1
	Total	**4**	**4,6**	**5,1**	0,5

8.15.1 Presentation of the Service

The Infrastructure Management Service assures the support services necessary for the adequate management and maintenance of INESC TEC buildings infrastructures.

8.15.2 Highlights in 2016

In the service activity during 2016 the following achievements can be identified:

- Rationalization and optimization of the air conditioning system with the aim of improving comfort levels and reducing costs of operation;
- Development of safety prevention actions and fire fighting procedures. A fire drill took place to test the adequacy of these procedures;
- Improve internal processes allowing better maintenance and support services with the existing resources;
- Increase the number of corporate cars for general use to reduce the costs with car renting.